Grounded Principles for Open Design Pedagogy

Design Perspectives on Early Years Pedagogy with Digital Technologies

Jaana Brinck
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Aalto University publication series
DOCTORAL THESES 55/2024

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ISBN 978-952-64-1719-6 (pdf)
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)

Graphic design: Content, Päivi Kekäläinen
Images: Cover, +Andscape

Unigrafia Oy
Helsinki 2024

Finland
Abstract

In the past few decades, researchers have shown growing interest in design in the context of teaching and learning in the 21st century. Accordingly, design has been introduced as a method to implement and develop teaching and learning practices that are more active, evidence-based, and interdisciplinary, as well as to confront real-life situations and problems. Moreover, in the current world, skills and competencies to utilise and benefit from various digital technologies are increasingly important for an individual to fully participate in society. Socialisation into digital media culture starts from an exceedingly early age, and digital environments are an integral part of children’s everyday sociocultural environment. Thus, digital tools should be integrated in early years pedagogy.

Consequently, this research explores the ways in which pedagogical practices should be designed to apply digital technologies in early childhood design education. The pedagogical dimensions of design practice are investigated in real-life educational context by conducting two design experiments, which highlight participatory design in pedagogical development and focus on developing practices that support the pedagogical use of digital tools and enhance children’s participation in their everyday lives.

To study the phenomenon, this research project conducted a participatory design process in a kindergarten in the Helsinki area for over one year, entailing 22 workshops involving research participants: teachers, daycare assistants, a pre-service kindergarten teacher, children, and pedagogical specialists. The research process was guided by a grounded theory method in which the aim is a data-driven and open-ended research process, and to actively learn from the interaction and collaboration with the research participants.

The research process included three sub-studies that have been reported in three academic publications; in addition, a technology prototype was designed, implemented, and tested—an augmented reality sandbox for early childhood learning.

As an overall contribution, this thesis developed grounded principles for open design pedagogy, a set of principles which is called the 4Ts of open design pedagogy. The thesis provides important perspectives on the ways that digital tools should be taken into early years pedagogy in a pedagogically meaningful manner. The main finding of this thesis is that open design pedagogy should foster learning contexts that are designed around the principles of togetherness, tools, trust, and time.

Keywords Early childhood education, open design pedagogy, design principles, digital technology, grounded theory, educational design research

ISSN (printed) 1799-4934  ISSN (pdf) 1799-4942
Location of publisher Helsinki  Location of printing Helsinki  Year 2024
Tekijä
Jaana Brinck

Väittöskirjan nimi
Avoimen muotoilupedagogiikan ankkuroidut suunnitteluperiaatteet:
Muotoillunäkökulmia digitaalisia teknologioita hyödyntävän varhaiskasvatuksen pedagogiikkaan

Julkaisija
Taiteiden ja suunnittelun korkeakoulu

Yksikkö
Taiteen ja median laitos

Sarja
Aalto University publication series DOCTORAL THESES 55/2024

Tutkimusala
Uusi media

Väitöspäivä
22.03.2024

Kieli
Englanti

Monografia
Artikkeliväitöskirja

Tiivistelmä

Tutkimuksessa kertatakseen muotoilupedagogiikan suunnitteluperiaatteita, joiden avulla digitaaliset työkalut voidaan integroida varhaiskasvatuksen pedagogisesti mielekkäällä tavalla. Muotoilun ja pedagogiikan ulottuvuus tutkitaan tosielämän opetuskontekstissa tekemällä kaksi muotoilukokeilua (design experiments), joissa hyödynnetään osallistavaa muotoilua sellaisen pedagogiikan kehittämisessä, joka tukee digitaalisten työkalujen pedagogista käyttöä ja edistää lasten osallisuutta.


Tämän tutkimuksen tuloksena esitettään avoimen muotoilupedagogiikan suunnitteluperiaatteet. Nämä periaatteet ohjaavat pedagogiikan suunnittelua ottamaan digitaaliset työvälineet mukaan varhaiskasvatuksen pedagogisesti mielekkäällä tavalla. Avoimen muotoilupedagogiikan tulisi edistää sellaisia oppimiskonteksteja, jotka ovat suunniteltu yhteisyyden (togetherness), työvälineiden (tools), luottamuksen (trust) ja ajan (time) periaatteiden ympärille.

Avainsanat
Varhaiskasvatus, avoin muotoilupedagogiikka, suunnitteluperiaatteet, digitaalinen teknologia, ankkuroitua teoria, koulutuksellinen muotoilututkimus


ISSN (painettu) 1799-4934 ISSN (pdf) 1799-4942

Julkaisupäiväka Helsingi Painopaikka Helsingi Vuosi 2024

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Design Perspectives on Early Years Pedagogy with Digital Technologies

Jaana Brinck
Acknowledgements

I could not have accomplished this thesis alone. I owe my gratitude to many people who have supported me, impacted on my growth as a researcher and as a human being, and enabled the progress and finalisation of this work.

First of all, I wish to warmly thank my thesis advisors, Teemu Leinonen and Mira Kallio-Tavin, for their support, advice, and overall introduction to the academic community—its conventions and its practices. I could not have had greater guidance over the years. Thank you for not giving up on me during the times that I have been engaged in duties other than my thesis. In every stage of the work, I have been able to rely on your support. Thank you for believing in me and giving me confidence in those moments that I doubted myself. Over the years, with your support, I have been able to develop my own voice and a personal way in which to conduct academic research.

The design workshops and data collection for this thesis were conducted as part of a project called *Insights into Early Childhood Education* for the City of Helsinki, funded by the Finnish National Agency for Education. During the fieldwork and data collection, I was working as a project researcher for over one year, during which I was able to engage with practitioners/educators, children, and pedagogical specialists.

The shared moments and discussions—which we engaged in as a project team—with Johanna Sommers-Piirinen, Jerkka Laakkonen, Heli Hemilä, and Maria Lehtinen provided many insights and inspiration about the many ways to incorporate digital tools into early years pedagogy. Their professionalism, insightful thoughts, and many ideas have impacted the content of this thesis.

Moreover, I wish to warmly thank all the participants in this research whom I met at the kindergarten, both children and educators. The welcoming, warm, and open attitude towards a complex and open-ended research and design process—an ambiguous quest—has made this work possible. These many discussions and encounters have been the foundation on which this research was built. Furthermore, I warmly thank the participating children, teachers, and pedagogical specialists for engaging in this study with me.

I wish to thank the people of Aalto Fablab, who made the building of the +Andscape prototype possible: Niklas Pöllönen and Jason Selvarajan. It was a thrilling and inspiring journey involving the exploration of unknown
technical and pedagogical opportunities, and had great results. Likewise, huge thanks are owed to Solomon Embafrash, who welcomed a group from the kindergarten to Aalto Fablab.

I wish to thank Hanna Kapanen from the Design Museum Helsinki, who accepted the +Andscape prototype to be exhibited in their exhibition, for welcoming children with such warmth and allowing me to explore and investigate a phenomenon of design.

Moreover, I have learned a lot from the people I wrote with. My gratitude goes to my co-authors: Teemu Leinonen, Lasse Lipponen, Mira Kallio-Tavin, Henriikka Vartiainen, and Nitin Sawhney. In addition to my thesis advisors, Lasse Lipponen has provided me with invaluable guidance on academic writing during the process of co-writing two of the original publications that contributed to this thesis.

My deep gratitude also goes to the members of the Learning Environments Research Group (LeGroup) for welcoming me as part of an academic community of peers in which I was able to be insecure, learn, and discuss based on shared interests. Their companionship carried through the Covid-19 isolation and supported me during the tough times. It has been a great honour and fun to work with you: Eva Durall, Iida Hietala, Jana Pejoska, Merja Bauters, Marjo Virnes, Avner Peled, and all the others that I have met over the years as part of LeGroup. Our shared moments have made all the hard work worthwhile.

My warmest thanks to Maurice Forget for our many writing clinic sessions to improve my academic writing in English. Also, great thanks to Päivi Kekäläinen, who helped to turn the manuscript into a book.

I also wish to thank my colleagues at Aalto University, who have kept my spirits up and supported me immensely during recent times that have been, in many ways, challenging.

And most of all, my gratitude goes to my beloved family, Timo, Oskari, and Anni, for your deep love and care that have surrounded and protected me for so many years. Thank you for your understanding during those times when the learning process and the writing of this thesis immersed me in solitude. Thanks for keeping the house—and me—in one piece! Each moment counts in this short life, and we should not waste one second of joy and togetherness.
List of Abbreviations

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<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AR</td>
<td>Augmented reality</td>
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<tr>
<td>DE1</td>
<td>Design experiment 1</td>
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<tr>
<td>DE2</td>
<td>Design experiment 2</td>
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<tr>
<td>DBR</td>
<td>Design-based research</td>
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<td>DOP</td>
<td>Design-oriented pedagogy</td>
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<td>DP</td>
<td>Design principles</td>
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<tr>
<td>ECEC</td>
<td>Early childhood education and care</td>
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<tr>
<td>EDR</td>
<td>Educational design research</td>
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<tr>
<td>FNAE</td>
<td>Finnish National Agency for Education</td>
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<tr>
<td>GT</td>
<td>Grounded theory</td>
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<tr>
<td>ICT</td>
<td>Information and communications technology</td>
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<tr>
<td>LCD</td>
<td>Learning by collaborative designing</td>
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<tr>
<td>LI</td>
<td>Learning by inventing</td>
</tr>
<tr>
<td>MKO</td>
<td>More knowledgeable other</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for economic co-operation and development</td>
</tr>
<tr>
<td>ODP</td>
<td>Open design pedagogy</td>
</tr>
<tr>
<td>PD</td>
<td>Participatory design</td>
</tr>
<tr>
<td>RBD</td>
<td>Research-based design</td>
</tr>
<tr>
<td>STEM</td>
<td>Science, technology, engineering, mathematics</td>
</tr>
<tr>
<td>STEAM</td>
<td>Science, technology, engineering, art and design, mathematics</td>
</tr>
<tr>
<td>ZoP</td>
<td>Zones of participation</td>
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<tr>
<td>ZPD</td>
<td>Zone of proximal development</td>
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This doctoral thesis is based on the following three journal articles, which are referred to in the text by their Roman numerals (Publications I, II, and III).

**Publication I:**

**Publication II:**

**Publication III:**
Author’s Contributions

Publication I: Main author  
_Zones of participation—A framework to analyse design roles in early childhood education and care (ECEC)_  
In this journal article, my contributions included planning the design project, conducting fieldwork, collecting and processing data, and documenting participant activities. I conducted the main analysis and wrote the paper. Teemu Leinonen provided feedback and developed the analysis framework together with me, and made some written contributions to the article. Lasse Lipponen and Mira Kallio-Tavin provided feedback and made some written contributions to the article.

Publication II: Second author  
_Augmented reality sandboxes: Children’s play and storytelling with mirror worlds_  
I was the second author on this journal article. I conducted fieldwork, collected and processed data, and documented participant activities. I performed the main analysis and contributed to designing the final coding frame with Teemu Leinonen and Henriikka Vartiainen. Teemu Leinonen had the original idea for the research, developed the theoretical framework, designed the initial coding frame, analysed and confirmed the main analysis, and wrote the paper with Jaana Brinck. Henriikka Vartiainen contributed to developing the theoretical framework, analysing data, and writing the paper with Jaana Brinck. Nitin Sawhney contributed to the paper through some earlier research related to the research theme.

Publication III: Main author  
_Open design pedagogy: Revealing openness in early childhood education with digital technology_  
In this journal article, my contribution was planning the design project, conducting fieldwork, collecting and processing data, and documenting participant activities. I conducted the main analysis and wrote the paper. Teemu Leinonen provided feedback and developed the analysis framework together with me, and made some written contributions to the article. Lasse Lipponen and Mira Kallio-Tavin provided feedback and made some written contributions to the article.
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Figures 20 and 21 are adopted from the Design Puzzle material (i.e., SuunnitteluPalat, Brinck, 2018): illustrations: Pia Myllymäki, graphic design: Katja Engberg.
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It goes with a child’s own study, so what is this thing and then it started from there.

(Excerpt from data, personal communication, educator’s statement, 2017)
Design research, in its essence, aims for improvement. It identifies and defines its development goals through both theory and practice. In this way, it connects its outcomes, i.e., the designs, to benefit people in the field, i.e., end-users, customers, patients, and practitioners (Koskinen et al., 2011; McKenney & Reeves, 2019). To design research-based solutions for everyday challenges, it is necessary for a researcher to engage deeply with the research environment to understand both the practical and theoretical implications that affect the context of the research. My research motivation is to identify and address the challenges that ubiquitous digital technologies pose to pedagogical practices in early childhood education and care (ECEC), and to investigate the ways that participatory design (PD) facilitates the development of solutions to these challenges. Thus, I start this thesis by framing the design problem by approaching it openly from different perspectives (see Collins, 2010; Edelson, 2002).

For me as an artist, art educator, designer, and researcher, this research motivation stems from recent developments in both the educational field and design research. This combination creates an inspiring and creative space for exploring, testing, and developing design pedagogies. The immense increase in the use of digital technologies in education creates an urgent need to develop corresponding pedagogical approaches and practices in all stages of education and in teacher training (Braun et al., 2020). This challenge of digitalisation of education has been acknowledged and globally addressed by policymakers, governmental education authorities, and academia. It has in turn led to numerous actions: future education foresight (Braun et al., 2020), scenarios (OECD, 2018), white papers (Griffin et al., 2012; Jenkins, 2009), curriculum renewals (e.g., National Core Curriculum for Early Childhood Education and Care, FNAE, 2022), and the development of new approaches to interdisciplinary teaching in schools (Blikstein & Krannich, 2013; Davies et al., 2023; Tuhkala et al., 2019; Vartiainen & Enkenberg, 2013). In addition, academic educational research contributes to the discussion of technology-enhanced learning (Davies et al., 2023; Dufva, 2018; Hjorth et al., 2015; Iversen et al., 2015).

The term education entails the institutional aspect of the education system and the individual learner perspective. The foundational meaning of education was defined already by John Dewey as a “social continuity of life
“(Dewey & Hinchey, 2018, p. 4). Biesta (2015) implies that education always involves a risk that should be embraced by both teachers and students. This risk refers to seeing students as subjects with agency instead of objects to be moulded or disciplined. Likewise, educational processes do not work in a machine-like way, but via dynamic interactions between people.

There is an identified gap between learning for life and teaching in schools; accordingly, studies suggest that learning should be active, evidence-based, and interdisciplinary, confronting real-life situations and problems (Griffin et al., 2012; Ito et al., 2013; Vartiainen, 2014; Vartiainen & Enkenberg, 2013).

Education is a culturally mediated, diverse process (Cole, 1998), which cannot be homogenised or generalised about in its goal to serve all communities and classrooms. Wells and Claxton (2002), as well as Cole (1996), discuss cultural relativism in education, which refers to cultural diversity that occurs both locally and globally. At the local level, teachers and students bring their own individual identities, perceptions of values, and biases into the classroom encounters. At the global level, as cultures and societies are immensely diverse, the appreciation of skills and knowledge differs, which results in appreciation of the learning content and formulation of culturally informed national curricula.

Kallio-Tavin (2018) discusses cultural encountering in the context of visual art education in schools. Visual art education can enable dialogic cultural encounters by encouraging people to reflect on complex cultural diversity within oneself, thus get in touch with the variety of cultural identities that each of us bring to encounters with others. Kallio-Tavin (2018), as well as Räsänen (2015), identifies many aspects of culture that can be addressed and reflected through art education, such as language, gender, world view/belief system/religion, age, ability, ethnicity, location, and social group. These aspects of each person's intrapersonal cultures are, in visual art education, taken in dialogue with the external culture, such as the world of visual arts and visual cultures in the environment.

As Griffin et al. (2012) demonstrate by defining the 21st-century skills needed for a future workforce (not learners per se) and making reference to learners as human capital, the motives for curriculum development are not informed purely by educational ideals, nor the pursuit for understanding cultural diversity; rather, there are economic and political implications entailing risk for homogenised educational objectives (Biesta, 2015; Illeris, 2017; OECD, 2020). Biesta (2022) criticises policy makers and politicians for supporting a system that is valuing education by constant measuring, such as PISA\(^1\) scores. A lack of insight and proactivity makes educators and students

---

1 PISA is the OECD's (Organisation for Economic Co-operation and Development) Programme for International Student Assessment. PISA measures 15-year-olds' ability to use reading, mathematics, and science knowledge and skills to meet real-life challenges (see more PISA - PISA [oecd.org]).
subject to top-down definitions of learning objectives and learning outcomes, which are measured by student test scores. This system supports educational trajectories that are predefined rather than proactive; the system is not really criticised nor questioned by policy makers or politicians (Biesta, 2022).

In addition to being politically informed and culturally specific, education is also time-bound. The current generation (elders) aims to equip future generations (the young) with the minds and understanding necessary for the uncertain demands of future societies (Wells & Claxton, 2002). In this sense, “the goals of education are relative to the future which the ‘elders’ of that particular society foresee” (Cole, 1996 as cited in Claxton, 2002, p. 23). As well as the future, conceptions of our history modify our thoughts about the contents, attitudes, skills, and knowledge that should be passed on to future generations.

As the world is nowadays facing critical challenges, such as the climate crisis, technology and media turbulence, and political, economic, and energy instability, it is impossible to have clear foresight into the skills and knowledge that the younger generation will need to thrive (or simply cope) in the future (Claxton, 2002). The uncertainty creates an urgency for learning for life, not just for an exam or a degree, and not only for the young but for all ages (Lemke, 2002). An attention shift is required in education: from particular sets of skills and knowledge to the development of a mind to learn (Wells & Claxton, 2002).

Contrary to the idea that a person should constantly improve oneself for the sake of societal needs, Biesta (2018) criticises the ideal of omnipresent, inevitable, and ongoing demand for learning that we all should welcome and pursue. He states that the learning age of our times requires us to learn “throughout our lives, both extended in time (the idea of lifelong learning) and extended in space (the idea of life-wide learning, that is, learning that permeates all aspects of our lives)” (p. 244). According to him, this requirement is a part of a (commonly adopted) discourse that actually derives from the exercise of power. Educational goals should not be homogenised to align with this discourse, but should be critically reflected upon in local communal contexts to identify the sincere meaningfulness in learning, and the meaningful challenges that these educational goals should address.

Design practice provides an array of tools for identifying, framing, and collaboratively solving the complex, fluid, and multifaceted development challenges of society (Jyrämä & Mattelmäki, 2015; Keinonen et al., 2013; Koskinen et al., 2011). Its methods are scalable from personal and local circumstances (Niinimäki & Kallio-Tavin, 2013) to the societal and global scale, e.g., finding solutions for the United Nations’ Sustainable Development Goals² (Spencer, 2021).

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² THE 17 GOALS | Sustainable Development (un.org)
Digitalisation of societies and digitalisation of education has been identified as not only a great challenge but also a great resource for learning in the 21st century. The changes in digital society generate pressure to collaboratively create new knowledge and educational practises in fluid physical and virtual environments (OECD, 2022). According to Stocchetti (2020), digital technologies are not politically or economically neutral—nor free of power struggles—in contemporary societies. He refers to education as the most important social activity and actor in society that is able to empower people to either endorse or reject the pervasive impact of digital technologies, and imagining and making of alternative futures for the ubiquitous technologies impacting our lives.

In this research, the term *ubiquitous technology* refers to how digital technologies impact almost all aspects of our lives, from a very early age. The impact can be implicit or explicit. The term is understood to mean the multiple and pervasive ways that interactive digital systems are integrated in multiple levels of our lives (Mendoza et al., 2023). According to Mendoza et al. (2023), “ubiquitous and pervasive technologies have created new forms of interaction, which expand to the physical environment” (p. 343). They refer to Weiser’s description of ubiquitous technology (from 1991) in which interaction with digital technologies (equipment) disappears and technologies extend to impact the invisible spheres of human lives. For example, people interact with each other through technology.

Nowadays, these invisible or disappearing digital technologies extend their impact on our lives on many levels: for example, in the form of the Internet of things (e.g., robot vacuums, web-based toys, and cars), and the increase in the use of artificial intelligence (e.g., automated governmental decision-making, automated diagnostics in healthcare, and automated recruiting in workplaces).

The impact of ubiquitous technologies extends from access to technologies (the haves or the have-nots) to the skills and competencies of utilising and benefiting from them (Heeks, 2022). Lack of skills and competencies impacts an individual’s broader social environment and creates exclusion, e.g., the pervasive requirement to use web-based platforms to manage one’s daily life, such as bank- and credit-based finances, booking movie tickets, contacting healthcare providers, and interacting with teachers in schools. Lack of skills and competencies also creates insecurity and vulnerability, as it creates challenges in identifying criminal acts in the digital environment, and exclusion from the value chains that digitalisation creates (Heeks, 2022).

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3 A Finnish technology company, DNA, conducted a survey in 2021 to investigate how many Finnish seven-year-olds owned a mobile phone. The survey showed that almost every seven-year-old child had their own mobile phone. Moreover, up to 87% of 5–6-year-olds used a mobile phone. In most cases, they were smartphones. The survey concluded that children of 5–7 years old have parents who were using mobile phones as young themselves, and thus digital technologies are understood as a natural part of everyday life.
According to Paavola et al. (2012), the complexity of modern society requires interdisciplinary approaches and shared expertise to solve multifaceted problems. To address this challenge, a group of educational scholars developed a variety of *pedagogical solutions that employ design methods* (Davies et al., 2023; Kangas & Seitamaa-Hakkarainen, 2018; Seitamaa-Hakkarainen et al., 2012; Vartiainen & Enkenberg, 2014) to address the challenges of instruction in interdisciplinary school teaching. They particularly emphasise the use and creation of various tools and artefacts to solve complex problems, and also commonly promote collaboration with peers and participation as active agents in diverse expert communities (Vartiainen et al., 2019). Instruction is organised to support problem-solving, shared expertise, and open-ended learning tasks. On these accounts, it is not surprising that design has been proposed as a promising framework to develop pedagogies for 21st-century learning and to introduce digital technologies for learning in a pedagogically meaningful way (Ito et al., 2013; Seitamaa-Hakkarainen et al., 2012; Vartiainen & Enkenberg, 2013).

### 1.1 Research Context

As we cannot assume that children and young people can develop digital media skills on their own (Helsper & Eynon, 2010), educators have a key role to play in incorporating digital technologies in learning (Brinck et al., 2023). Here, adults who are designing pedagogy benefit from recognising the social nature of learning (Biesta, 2022; Vygotsky, 1978; Wenger, 1999) and the multiple opportunities to design pedagogical activities and learn digital media skills together with the children. Designing pedagogical activities that employ digital technologies provides a solid starting point to develop one’s own digital skills and pedagogical practices as an educator (Brinck et al., 2020, 2023; Vartiainen & Enkenberg, 2013).

Accordingly, Resnick (2017) discusses how kindergarten-style learning can be beneficial to people of all ages. He proposes a *lifelong kindergarten* as a solution for people of all ages to develop their creative capacities to thrive in times of rapid change. This view extends to learning about digital technologies; he states that “playing’ with technology should involve not just interacting with it, but designing, creating, experimenting, and exploring with it” (p. 126). Resnick calls for creative learning, passion, and playfulness—all characteristics of learning in kindergarten—in learners throughout their lives.

The research context of this thesis is Early Childhood Education and Care (ECEC), in which each daily activity is understood as a pedagogical event (e.g., meals, clothing, play, and naptime). Thus, the pedagogical approach is intertwined with all actions and interactions between adults and children. A fruitful interaction with young children requires a special pedagogical attitude.
from the educators, because the means of interaction are fundamentally different. An adult holds the position of power in this relationship, which is a great responsibility and requires ethical conduct in each situation. To truly listen to a child and enable them to voice their opinions, an educator must understand the multiple ways that children communicate; spoken expression is only part of it.

These special circumstances of ECEC form a rich research context in which to explore pedagogy. For this reason, this research focuses on developing pedagogy, particularly the educator’s pedagogical approaches and practices. Subsequently, this thesis highlights the significance of a learning community and emphasises the intergenerational learning together perspective rather than focusing only on children’s learning.

The research activities of this thesis align with the curriculum guidelines of the Finnish National Agency for Education (FNAE, 2017). The national core curriculum for early childhood education and care, first implemented in 2017, aims to address ubiquitous technology and the changing landscape of learning in the following way:

The role of information and communication technology in daily life is examined and considered with the children, and the instruction includes familiarisation with different ICT devices, services and games. Digital documentation is utilised in games, exploration, physical activity as well as in experiencing and producing art. Opportunities for experimenting and personally and collaboratively producing things using information and communication technology promote creative thinking, teamwork skills and literacy in children. The personnel guide the children in versatile and safe use of information and communication technology. (p. 40)

The abovementioned viewpoints are the foundation for selecting ECEC for the design and research context of this thesis. To study the phenomenon of participatory designing pedagogies that utilise digital tools, I conducted two design experiments, which employed participatory design to involve teachers, daycare assistants, a pre-service kindergarten teacher, children, and pedagogical specialists to design and implement learning activities employing digital technologies. The entire design process entailed 22 workshops in a kindergarten in the Helsinki area in 2017–2018⁴ (see appendices). The research process was guided by the grounded theory (GT) method (Corbin & Strauss, 2015), in which the aim is a data-driven and open-ended research process, and to actively learn from interaction and collaboration with research participants (Flick, 2014).

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⁴ The design process and research activities are listed in detail in the appendices of this thesis. In addition, each publication describes the research design, research questions, and findings within their particular scope.
The two design experiments entailed three sub-studies with their own research questions and were reported as journal articles (Publications I, II, and III). In addition, one technology prototype of an augmented reality sandbox was designed with the research participants, and then built and tested in an authentic environment (+Andscape prototype).

1.2 Research Aim and Research Questions

The aim of this empirical investigation is to explore the ways in which pedagogical practices should be designed to apply digital technologies in early childhood design education. In this research, digital learning is broadly understood as a learning process that is facilitated by digital tools and/or engaged with digital environment(s).

This research addresses a research gap by utilising design methods for developing design principles for pedagogy in early childhood education. The participatory design model Edukata (Toikkanen et al., 2015) was adopted for designing everyday learning activities. The use of the Edukata design model in this study was the first time that it had been applied to the early childhood education context (see Section 3.2.3).

The research contribution of open design pedagogy refers to a set of design principles (see Section 3.2.4 and Chapter 4) that are grounded in empirical investigation and derived from the data (see Chapters 3 and 4). The term groundedness means that the research is informed by, and strongly based on, an empirical investigation that is formed around a systematic, yet flexible, process of data-driven analysis. The concepts that are derived from the data also direct the sampling process and guide the planning of further research activities (see the GT process and theoretical sampling in Chapter 3). In this research, the concept of grounded principles for open design pedagogy refers to a set of design principles with a strong empirical origin—through which they have been initially identified and refined by conducting a grounded theory process. These principles guide educators to design pedagogy for learning with digital tools in ECEC.

In this research, the concept of open design pedagogy (ODP) was created to refer to a design pedagogy in which the foundation is the openness of the educator and the learning process. The ODP has been conceptualised through a GT process, and introduced in Publication III of this thesis. Furthermore, this thesis continues to elaborate the conceptualisation of the ODP by identifying the initial design principles (from Publications I, II, and III), and developing them further into refined grounded principles for open design pedagogy as a proposal to take digital technologies into early years pedagogy (see Chapter 4).

In a broad sense, the term technology entails both non-digital and digital technologies. According to Lakhana (2014), in its simplest form, the
word technology means the application of mechanical and material tools. Correspondingly, the term educational technology applies tools to problems in education. In this research, the technologies utilised are mainly digital. They are used in an educational context with small children. The digital technologies employed in this research entail tablet computers, mobile phones, a digital camera, a video projector, a laser cutter, a 3D printer, and an augmented reality sandbox. These technologies were not pre-defined, but initiated based on the challenges, opportunities, and resources identified in discussions between educators in design workshops.

This thesis forms a synthesis that is based on the initial design principles identified in the sub-studies and reported in Publications I, II, and III. These initial design principles are further developed as grounded principles for open design pedagogy.

For the purpose of forming this synthesis, I set three main research questions:

• RQ1: What are the design principles for designing pedagogical practices that apply digital technologies to early childhood design education?
• RQ2: How can these be further developed into grounded principles for open design pedagogy?
• RQ3: What are the grounded principles for open design pedagogy?

I answer these questions in Chapter 4 of this thesis. The research questions of the original publications (see Table 1) serve as sub-questions, and for those, the publications provide full insight. The original publications are included at the end of this thesis.
Table 1

<table>
<thead>
<tr>
<th>Thesis</th>
<th>Main research questions</th>
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<tr>
<td></td>
<td>RQ1: What are the design principles for designing pedagogical practices that apply digital technologies to early childhood design education?</td>
</tr>
<tr>
<td></td>
<td>RQ2: How can these be further developed into grounded principles for open design pedagogy?</td>
</tr>
<tr>
<td></td>
<td>RQ3: What are the grounded principles for open design pedagogy?</td>
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</table>

<table>
<thead>
<tr>
<th>Publication</th>
<th>Research questions by the original publications (sub-questions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>I/RQ1: What are the design roles and how can they be described?</td>
</tr>
<tr>
<td></td>
<td>I/RQ2: Are the roles fixed or is there movement between the roles?</td>
</tr>
<tr>
<td></td>
<td>I/RQ3: Are there co-occurrences between adults and children accessing certain roles?</td>
</tr>
<tr>
<td>II</td>
<td>II/RQ1: What type of inquiry and stories emerges with AR play within mirror worlds (using the +Andscape AR sandbox)?</td>
</tr>
<tr>
<td></td>
<td>II/RQ2: What observations, discoveries, and explanations do children perform collaboratively while playing with a mirror world?</td>
</tr>
<tr>
<td></td>
<td>II/RQ3: What type of play and storytelling do children create together within a mirror world?</td>
</tr>
<tr>
<td>III</td>
<td>III/RQ1: What are the characteristics of pedagogical activities that supported pedagogical use of technology?</td>
</tr>
<tr>
<td></td>
<td>III/RQ2: How can educator’s pedagogical approaches be described behind those activities?</td>
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The research questions addressed by the original publications (the sub-questions of this thesis) and corresponding findings (see Table 2) are synthesised by investigating the main research questions of this thesis in the following way.

- RQ1: What are the design principles for designing pedagogical practices that apply digital technologies to early childhood design education? To answer this question, the three original publications were further analysed to identify the (initial) design principles as a basis for developing refined grounded principles for open design pedagogy (as reported in Chapter 4, Section 4.1.1).
- RQ2: How can these (the initial design principles) be further developed into grounded principles for open design pedagogy? This requires developing a method (i.e., the principle-focused elaboration method) for refining the principles as grounded principles for open design pedagogy. This process is presented in Chapter 4, and particularly in Section 4.1.
• RQ3: What are the grounded principles for open design pedagogy? is addressed in Section 4.2, which describes the grounded design principles for open design pedagogy.

In forming the synthesis, I investigated the publications as an additional iteration of the analysis; the aim was to create a holistic understanding rather than merely summarising the research questions and findings of the original publications as such. It is also important to note that this process of synthesising the findings of the original publications to affirm the holistic contribution of this thesis (i.e., the grounded principles for open design pedagogy) should not overlook the stand-alone merits and findings of each original publication.

1.3 Scope of Research and Summary of Original Publications

This research is transdisciplinary in that it integrates different disciplinary traditions so as to go beyond disciplines and form a new unity of knowledge (Nicolescu, 2014). In particular, the synthesis of this thesis is formed at the crossroads of the knowledge domains of art and design education, technology-enhanced learning, and design to gain new understanding about pedagogies with digital technologies in ECEC (Figure 1).

The formation of the principles for open design pedagogy requires a combination of distinct disciplinary knowledge; they cannot be thoroughly examined or understood from one disciplinary perspective only.

Subsequently, the original publications of this thesis have been published in academic journals in the fields of design, art and design education, and digital media. Publication I reports design roles in participatory design and was published in the journal CoDesign, International Journal of CoCreation in Design and the Arts. Publication II explores children’s play with augmented reality (AR) in the context of progressive inquiry learning and was published in Digital Creativity. Publication III focuses on educators’ pedagogical approaches and was published in IJETA, the International Journal of Education through Art.

This thesis constitutes a synthesis of these publications and develops grounded principles for open design pedagogy.

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5 According to Nicolescu (2014), “Multidisciplinarity concerns itself with studying a research topic in not just one discipline only but in several at the same time ... Interdisciplinarity has a different goal than multidisciplinarity. It concerns the transfer of methods from one discipline to another. Like multidisciplinarity, interdisciplinarity overflows the disciplines, but its goal still remains within the framework of disciplinary research ... Transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines, and beyond all disciplines. Its goal is the understanding of the present world; one of the imperatives of which is the unity of knowledge”. (p. 187)
**Publication I, Zones of participation**—A framework to analyse design roles in Early Childhood Education and Care (ECEC) applied grounded theory (GT) analysis to study a participatory design process in pedagogy development in the early childhood education context. For this sub-study, I conducted a participatory design (PD) process, including 15 workshops, in a kindergarten in Finland together with adults and children. The investigation examined whether and how children’s participation can be enhanced through PD practices.

The GT analysis elicited different roles for the participants as prominent indicators of the level of interaction and the quality of the participatory process. The main contribution of this study were the zones of participation (ZoP), which conceptualise the roles the participants played during the design process and the ways in which they were able to move between these roles. ZoP can be seen as a framework to assess the quality of participation in the design process by identifying participants’ access to different ZoP.
Publication II, Augmented reality sandboxes: Children’s play and storytelling with mirror worlds explored children’s collaborative play and storytelling with an interactive augmented reality (AR) sandbox, +Andscape. The analysed data presented children’s free-form play with the AR sandbox. The children’s play was recorded, and the video data were analysed for the children’s observations and explanations in the context of progressive inquiry learning, which manifested in play and stories.

The study concluded that the AR sandbox, by mixing real-life events and mirror worlds, initiated inquiry that connected the social, material, and virtual worlds through collaborative play and storytelling. Through embodied experiences, the children engaged in playful exploration with technology, whereby they made multisensory connections within and across multiple modalities. The children could also connect their interests, previous knowledge, and experiences to the situation and jointly change the process and environment of action.

Publication III, Open design pedagogy: Revealing openness in early childhood education with digital technology analysed the empirical data from the design workshops from another perspective, i.e., to identify the characteristics of educational activities that utilised digital technologies in early childhood education and reveal the educators’ pedagogical approaches.

The findings of this study show that pedagogical activities entailing playful interaction with technology and the production of tangible artefacts, accompanied by visual documentation and reflection, support the effective use of technology in early childhood education. The educators’ open approach towards the use of technology also played a significant role in the positive outcomes experienced by the educators and children. In this publication, the concept of open design pedagogy was initially discovered.

The research questions and findings of the original publications are summarised in Table 2. The publications are included at the end of the thesis in full.

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Author’s contribution: For this prototype, I had the initial idea to build an augmented reality sandbox and I functioned as the design lead for the project. I also conducted design workshops for children in kindergarten. Teemu Leinonen and I organised a design workshop for adult participants, and together created the final design of the features. Niklas Pöllönen and Jason Selvarajan built the prototype and designed the technology for it, including developing the functional code for the design features. The prototype is described in Publication II.
### Table 2
**Original Publications, Research Questions, and Main Findings**

<table>
<thead>
<tr>
<th>Publication</th>
<th>Article</th>
<th>Research questions</th>
<th>Findings</th>
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<tbody>
<tr>
<td>I</td>
<td>Jaana Brinck, Teemu Leinonen, Lasse Lipponen &amp; Mira Kallio-Tavin (2020)</td>
<td>RQ1: What are the design roles and how can they be described? RQ2: Are the roles fixed or is there movement between the roles? RQ3: Are there co-occurrences between adults and children accessing certain roles?</td>
<td>The grounded theory analysis elicited different roles from the participants as prominent indicators of the interaction in and quality of participatory process. These roles were further elaborated as <em>zones of participation</em> (ZoP) that included the Zone of audience, Zone of whisperer, Zone of actor, and Zone of director. The analysis showed that there are significant co-occurrences between participant groups accessing different zones.</td>
</tr>
<tr>
<td>II</td>
<td>Teemu Leinonen, Jaana Brinck, Henriikka Vartiainen &amp; Nitin Sawhney (2021)</td>
<td>RQ: What type of inquiry and stories emerges with AR play within mirror worlds (using the +Andscape AR sandbox)? RQ1: What observations, discoveries, and explanations do children perform collaboratively while playing with a mirror world? RQ2: What type of play and storytelling do children create together within a mirror world?</td>
<td>The play and storytelling included aspects of creative inquiry and imagination with strong emotional commitment. The mirror world created connections to children's everyday life experiences that were evidenced when the children played with the colour-changing sand and the circulating light/sound dot patterns by integrating them with stories about their surrounding sociocultural environment. When introducing AR and mirror worlds for children, the focus should be creating a platform for active participation, play, and collaborative exploration.</td>
</tr>
<tr>
<td>III</td>
<td>Jaana Brinck, Teemu Leinonen, Lasse Lipponen &amp; Mira Kallio-Tavin (2023), Open design pedagogy: Revealing openness in early childhood education with digital technology, <em>International Journal of Education through Art</em>.</td>
<td>RQ1: What are the characteristics of pedagogical activities that supported pedagogical use of technology? RQ2: How can educator’s pedagogical approaches be described behind those activities?</td>
<td>The findings of the qualitative data-driven analysis show that pedagogical activities entailing playful interaction with technology and tangible artefacts, accompanied by visual documentation and reflection, supported the pedagogical use of technology. This was realised through educators’ approach to pedagogical openness. We call the approach <strong>open design pedagogy</strong>.</td>
</tr>
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</table>
In addition to the findings that are reported in the publications, this thesis also reports an original research contribution in the form of a set of design principles, i.e., *grounded principles for open design pedagogy*. These design principles are identified and refined through the synthesis of the original publications, and thus, each of the publications contributes to answering the main research questions from their own perspectives. To form the synthesis, the publications are investigated from a holistic point of view to answer the main research questions of this thesis (see Table 1). The process of creating the synthesis is described in Chapter 4.

Although the publications investigate the same phenomenon, the synthesis also reveals distinct emphases of the different publications (see Figure 17). Publication I highlights *Promoting active participation*, *Following children's ideas*, and *Fluid roles in pedagogical activities*. Publication II highlights *Playful interaction with technology* and *Versatile use of tangible artefacts*. Publication III highlights *Reflection* and *Working openly in conditions of uncertainty* as important pedagogical approaches. These pedagogical approaches are the foundation of the open design pedagogy.

### 1.4 Children as Research Participants and Ethical Considerations

This research involves participants in the research activities. Thus, ethical considerations are critical to ensure that participation in the research activities does not cause any risk, stress, or harm to the participants (Finnish National Board on Research Integrity, 2019). Fulfilment of this objective requires responsibility and thoughtfulness from a researcher. In particular, it is essential in cases in which the research involves vulnerable groups, as in this case (children).

Learning and designing with children require an adult to notice the ways in which young children engage, explore, and interact with the world. According to Ackermann (2004), Piaget’s theory presents children’s as having their own views of the world and a logic of their own that is different from adults'. These views evolve through acting in the world, which means that conceptual changes in thinking happen through interaction with others and the world. Most naturally, children investigate the world through play, by embodied and creative means (Bruner, 1983; Leinonen et al., 2021; Piaget, 1962).

This thesis understands a child as an active actor and agent of their own life from a very early age. They construct their lives in interaction with their sociocultural environment (Corsaro, 2018; Karila & Lipponen, 2013). On this
point, Salminen (1994) insightfully describes a child’s perspective on the world, which “is new and strange for a child and provides an abundant amount of strange, scary, and exhilarating encounters that the meaning of which a child aims to clarify” (p. 40). In my view, Salminen’s statement implies that one of the most important objectives in early childhood education is to provide children with opportunities to make connections with the world: to touch, to manipulate, to smell, and to change things in the world. This empowers children and helps them to perceive themselves as active contributors in a world where every action has an impact.

As I am conducting the research activities in the field of education and design to develop pedagogy, the objectives of pedagogy and research align, intertwine, and create synergy. This means that not only a research approach, i.e., gaining understanding and creating new knowledge about a phenomenon, but also a pedagogical attitude is present in all encounters with the research participants, including data collection and analysis. In this respect, I share the view of Kallio-Tavin (2013), who states that pedagogical situations are encounters between equals—eschewing hierarchical top-down relationships. In these encounters, I see myself as a learner who is part of a collaborative and intergenerational group, not only as an educator or researcher. These kinds of pedagogical encounters require an omnipresent ethical attitude, which involves respecting and listening to one another, and appreciating diverse views and means of expression.

Subsequently, the ethical approach towards conducting the research requires a researcher to conduct the research with rigour; to ensure that participants understand the rules and expectations of their involvement; and to be aware of their freedom to withdraw from the research at any time. This includes clarity about the informed consent that is required of participants (if children, of their guardians). Moreover, confidentiality and an atmosphere of trust are important (Corbin & Strauss, 2015). Ethical standards must be abided by in every phase of the research and in every encounter with the research participants. These standards involve the whole lifespan of the research, such as planning, preparing, conducting, analysing, and reporting the research.

Involving children in research means not only abiding by rules such as not causing harm or avoiding risk, but actively seeking ways to enhance children’s wellbeing (Nutbrown, 2018b). In this thesis, my aim was to enhance children’s participation in their everyday lives and thus eventually to ensure their basic rights (UNICEF, 1989) by supporting their agency in the matters important to them (Brinck et al., 2020, 2023; Leinonen et al., 2021).

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8 Translation from Finnish by the author.

9 It was only in 1989 that the United Nations Convention on the Rights of the Child (UNCRC) was signed; 196 countries have become State Parties to the Convention as of October 2015.
In the field of developmental psychological research with children, Woodhead and Faulkner (2008) discuss ways in which child participants are positioned in the research—whether subjects, objects, or participants. They state that the objectified child refers to the traditional scientific discourse in which the child is a research subject under observation and data collection. They refer to the 1991 guidelines of the British Psychological Society, which initiated the turn towards discussing the position of a subject participating in the research. They state that discussing research subjects as participants yields the highest standards of ethical considerations and respect towards the participants, including valuing the time they invest in the research.

In this research, ethical considerations are highlighted in all phases, to underline 1) the initial motives for which participants engage in the research, 2) the positioning of the participants in the research, 3) the interaction between the researcher and the participants, 4) how to empower the participants to impact the direction of the research, 5) a rigorous approach to the research, and 6) the communication of the research progress and outcomes. Here, I focus on the ethics of research with children, but these basic ethical principles apply equally to research involving adult participants.

For this research, the involvement of participants was a necessity. In this case, it was not feasible to investigate the phenomenon of the pedagogical use of digital tools in ECEC—to develop pedagogy—based only on abstract theoretical investigation, nor to conduct the research alone. Completion of the task required collaboration with others in their authentic sociocultural environment. To this end, I needed to engage with a community of practitioners and learners in kindergarten, i.e., ECEC educators and children.

As I was initiating the research, I acknowledged that it was not straightforward to gain access to the research environment (i.e., ECEC). It required, as a preliminary step, developing my research plan, requesting a research permit, and designing informed consent forms to be approved by the City of Helsinki. As I obtained permission to conduct research in a kindergarten, I genuinely valued the trust invested in me. I also felt gratitude for the contact with a community willing to participate in my research.

At the beginning of the research process, informed consent was obtained from the adult participants and children’s guardians. I also spoke with the children about their participation in the study. As the research was following the objectives and values of the curriculum and entailed pedagogical designing of everyday activities in kindergarten, there was no conflict of interest nor additional pressure on the educators and children. Nevertheless, to participate in research activities that aimed to develop pedagogy required educators to reflect on their previous experiences. This extended to their commitment, willingness, and openness to develop their pedagogical practices further.

For some children, engaging in activities with a new person, a visitor and a researcher, produced shyness. Here, my previous pedagogical experience
was valuable, as it gave me confidence to approach the children with playfulness and with an attitude of listening. My aim was to provide them with opportunities to voice their opinions and be active, mentally and physically (instead of aiming for strict control of the situation). I also participated fully in the activities with the children. In addition, I was responsible for data collection and analysis. Thus, I had a dual role; along with being a researcher, I also positioned myself as an educator, alongside the kindergarten teachers. Later on in this thesis, when I mention educators, I include myself in that group.

To account for my considerations of ethics as a qualitative researcher in this particular research context, I provide an excerpt from my research notes from June 2017, after Workshop 5. The following excerpt grounds my ethical considerations in an authentic research environment and a certain research activity.

Workshop 5 entailed a parkour trip to a nearby beach. During the outing, children took turns leading the way, and we (the educators) documented the trip by taking photographs. At the end of the workshop, we collaboratively reflected on the documentation.

For clarity, I have italicised and bolded the parts of the excerpt that I continue to discuss further concerning ethics.

**Excerpt 1**
An Excerpt from the Research Notes after Workshop 5, 3.6.2017

*We went with the children* on a parkour trip around the kindergarten. The activity was familiar in Matt’s [an educator] group. Originally, the parkour trip was developed because it was considered necessary to strengthen children's gross motor skills. What was new here was to take cameras with us to document the activity via photos and video.

The idea of parkour and going on an “adventure” came from the adults of the group and sounded good. The terrain we crossed was really challenging. There were unstable rocks, water, height differences, as well as a couple of public playgrounds. We [the children and educators] walked on stone embankments, park benches, and beach stones, running and jumping. The weather was sunny but windy and cold.

Teacher Matt led the group at the beginning and then *the children took turns leading; there was always someone who wanted to be first.* Peter [a child] found stones to jump on at the seaside. His foot slipped in the water but that didn’t stop him. There were a few stumbles and falls on the rocks, but *the children continued* walking briskly.

*We [the educators] asked the children if anyone wanted to take a photo.* Rose [a child] wanted to, but when she tried, I quickly noticed that filming the movement was too demanding for her at that point. It was difficult to
catch anyone at all in the frame (a jump is over in a second). The backlighting also caused problems. Sometimes, the figures could only be seen as a dark silhouette against the horizon. In any case, the children’s concentration seemed to be on the movement, not taking photos. The terrain was very challenging to walk on. So, Julia [an educator] and I continued to document the children’s moving and jumping on stones.

Suddenly, the sky turned black, and it became really cold. However, despite the threat of rain, we headed to a public playground at the end of the trip, where we shot a Stop Motion animation. In the animation, the children, Julia, and Matt [the educators] “disappeared” behind the blue climbing stand. The freezing rain started, and we ran back to the kindergarten. On the way, Rose [a child] asked, “shall we look at the pictures now?”

Note: At the beginning of our trip, as we gathered at the gate, Rose [a child] asked: “Oh, can’t we play now?” I was wondering, at this point, how does a child experience play? Jumping on rocks, climbing on playground equipment, a picnic... these can be activities full of fun but, if it’s organised by an adult, is it missing the element of play?

Figure 2
Visual Documentation Extracted from the Research Notes After Workshop 5
As I retrospectively read this research note from years ago, I not only took in the content of the activity, but also what it reveals about my attitude as a researcher and educator through the tone in which I wrote and my choices of expression. The statements in the excerpt reveal opportunities for children’s agency, which is indicated by the children’s initiative during the activity and the flexibility with which the course of the activity was amended accordingly. For this activity, my position as a researcher was to participate in the same way as the kindergarten teachers, and thus I was deeply engaged in and contributed to the pedagogical activities, i.e., not merely as an observer. As an active agent, I was responsible not only for the documentation and data collection, but also for enabling participants to be active contributors and agents during the activities.

The activity was initiated with the objectives defined by the educators, i.e., to strengthen children’s gross motor skills and utilise digital tools for the documentation of the activity (by letting the children take photographs).

The statement in the excerpt “We went with the children...” reveals that, inherently, there are two groups participating: we (the educators, i.e., adults) and the children. We, the educators, entered into the activities with certain objectives in mind, but it was also essential to let the children take initiative and make their own contribution to the activity. In later stages of our research process, discussions focussed on exploding the dichotomy of positioning ourselves as adults and children and thinking rather of one diverse group of actors; however, in reading this early research note, I see that this aim was not yet realised.

The ethical approach is visible in the statements in which the children are asked about their willingness to document the trip, rather than forcing it, as it proved to be too demanding for them. Initially, in Workshop 5, one of our objectives as educators was to utilise digital tools, i.e., tablet computers and mobile phones, and preferably let the children document the activity themselves. However, combining a challenging physical activity with digital documentation proved to be too demanding for the children. Thus, it was not forced. Clearly, children were more engaged with movement, speed, and adventurous physical activity by the seashore. Here, I needed to lay aside my ambitions as a researcher to obtain data that the children had produced themselves. I needed to let go of my pre-defined ideas about the data collection and modify the course of the activity according to the children’s needs. This meant giving the children room to focus fully on physical movement they enjoyed.

The research note above reveals the ways in which both the adult and child participants initiated actions during our activity. The children were making decisions, asking questions, and proposing next steps to which others agreed.

In the context of child- or adult-initiated activities, it is notable the way in which Rose [a child] framed their question, “Oh, can’t we play now?”, at the
beginning of the activity. This occurred as we (the educators) were gathering the children to start the parkour trip. This question indicates that Rose anticipated that an adult-initiated activity is not play. This question implied that they considered the adult-initiated activity to be work rather than play, even before she knew what was about to happen next. Later, during and after the trip, Rose was participating eagerly and seemingly enjoying the activity.

Commonly, research with children is informed by an adult agenda (i.e., policy, academic, or professional) rather than the children's agenda (Nuttbrown, 2018a; Woodhead & Faulkner, 2008). Breathnach et al. (2017) studied five-year-old children's perceptions of activities in kindergarten. Their findings showed that children framed their activities within adult agendas as work or play. The activity itself might have been similar whether it was initiated by adults or children, but the context made a difference in children's minds. Breathnach et al. (2017) referred to child-initiated activities as inside play. Based on this finding, they emphasised planning pedagogical activities with children—rather than for children—as an opportunity for educators and children to identify together ways to support children's agency.

In the excerpt above, another question posed by Rose shows her initiative: “Shall we look at the pictures now?” With this question, our collaborative visual reflection that followed the parkour trip gained deeper substance.

For me as a researcher and educator, the abovementioned excerpt indicates that our activity entailed agentic opportunities and enabled participation. It also revealed some of the ethical considerations involved in interaction with the research participants. Below, I clarify the ethical considerations regarding academic research that involves human participants.

Despite the many challenges, I felt a responsibility to conduct my research with rigour and also to complete it. I highly valued the time that the participants invested, as well as their deep and reflective thinking, the openness they showed in their discussions during the data collection and the contributions that they provided to the direction of the research activities. In this thesis, the participants also impacted the formulation of the research questions, as key concepts emerged through the data analysis and were elaborated and refined through shared activities and discussion in the workshops.

While I was conducting this study as a doctoral researcher, I also faced many practical professional challenges. The most significant concern was a lack of continuous funding, which affected the ways in which I was able to proceed with the research, causing difficulties with communicating progress and results to the participants and community involved. Subsequently, the design of the structure and timetable of the research activities was also challenging due to the fragmentation of the funded periods of my research.

Moreover, the academic publishing process and the extensive time required for the final publication created challenges for communicating about the research to the people involved. Regrettably, the timeframe of the
academic research community does not line up with that of the community of practitioners, and particularly the ECEC environment. Thus, to communicate the findings back to the community is still an ongoing endeavour. Nevertheless, I have presented the preliminary results of this research in training sessions organised by the City of Helsinki for the ECEC educators.

1.5 The Structure of the Thesis

To allow a reader to effortlessly follow the progress and get an overview of the entire research process and the theoretical framework to which it connects, in this introductory chapter I summarise the overall findings of this thesis.

This thesis developed a set of grounded principles for open design pedagogy called the 4Ts of open design pedagogy: togetherness, tools, trust, and time. These principles guide a practitioner (educator) to design learning activities together with the learners. The activities employ cultural tools and artefacts, which can be used and/or created in the time-bound process of an activity. The principles encourage a practitioner to rely on an open-ended and inquiry-oriented learning task, and thus trust—in both the community of learners and the design learning process—becomes a necessity.

These principles were formulated in the context of early childhood education and thus are meant to guide the design of learning activities in the ECEC context by ECEC practitioners. In particular, they provide insight into the ways in which digital tools should be incorporated into early years pedagogy in a meaningful manner.

Nevertheless, in further studies, the design principles of open design pedagogy should be tested, reflected upon, and put into practice, not only by ECEC practitioners but also in other contexts that require people to learn together.

In Chapter 1, I have described the background and the research context of this thesis. Also, I have summarised the research questions and main findings of the original Publications I, II, and III, which report the sub-studies of this thesis. Each of these publications entail their own research questions and findings, highlighting some aspects of open design pedagogy (see Table 2).

In Chapter 2, I continue to present the theoretical foundations, which highlight design in the educational context and technology-enhanced learning.

In Chapter 3, I discuss the methodological foundations and clarify the methods that have guided this thesis. Here, I also present the entire research process. The original publications (i.e., sub-studies) report their own particular research designs.

In Chapter 4, I proceed to present the synthesis and overall research contribution of this thesis and the rationale behind it. This chapter also describes the principle-focused analysis process, which has been developed for
the purposes of this thesis and implemented to form a synthesis. This analysis process starts with a meta-analysis of the original Publications I, II, and III, aiming at the identification of the initial design principles (DP). These initial DPs are then conceptualised as core categories and placed into discussion with theory. The synthesis is confirmed by revisiting the raw data, i.e., performing one more iteration of the analysis, to validate the findings. For the synthesis, in Chapter 4, I continue to present the grounded principles for open design pedagogy as the main contribution of this thesis.

Next, in Chapter 5, I discuss these principles in relation to theory. I continue to present the implications for research and practice, and address the limitations of the thesis.

In Chapter 6, I conclude this thesis by summarising the contribution and providing perspectives for further research. The original publications are presented at the end of this thesis.
In the group activity, does it really matter who are the adults and who are the children, if there is a common goal to work for? What if we don’t position ourselves as adults and children... [but as a group of designers]?

(Excerpt from data, personal communication, educator’s statement, 2017)
2 THEORETICAL FOUNDATIONS: Perspectives on Design Pedagogies

In this chapter, I investigate the theoretical foundations for design pedagogies. The investigation highlights learning by design (i.e., design pedagogy and design learning) in a technology-enhanced learning context.

2.1 Perspectives on Design in Education

In the past few decades, researchers have shown growing interest in design in the context of teaching and learning in the 21st century. A number of scholars have presented design as an approach to educational research (Cobb et al., 2003; Collins et al., 2004; diSessa & Cobb, 2014; Edelson, 2002; Gravemeijer & Cobb, 2013; McKenney & Reeves, 2019). Accordingly, design has been introduced as a method to implement and develop teaching and learning practices (e.g., Heikkilä et al., 2017; Hjorth et al., 2015; Kangas, 2014; Seitamaa-Hakkarainen et al., 2010; Vartiainen & Enkenberg, 2013).

Design research in the educational field aims to narrow the gap between academic research and educational practice. However, designing teaching and learning is challenging due to the complexity and messiness of the phenomenon (see e.g., Conole, 2010; Toikkanen & Keune, 2014; Toikkanen et al., 2015). It is a risk that aiming to clarify this messiness may lead to oversimplified, schematic representations of teaching (Toikkanen et al., 2015).

As a solution to this challenge, Toikkanen et al. (2015) propose participatory design—empowering teachers with the autonomy to design and implement learning activities according to their local classroom practices and social environment. This kind of open space for innovation is critical, avoiding oversimplified solutions and top-down definition of the ways in which the instruction should be organised.

To address these challenges in the design of teaching and learning, and to bridge the gap between visionary ideas and classroom practice, Toikkanen et al. (2015) developed a participatory design model, Edukata, as part of the Innovative Technologies for an Engaging Classroom project, iTEC, 2010–2014 (see also Chapter 3, Section 3.2.3).

During the iTEC project, European Schoolnet worked with the education ministries, technology providers, and research organisations to transform the
way that technology is used in schools. Within iTEC, by employing design research and work, a concept of learning activities was developed and further tested in over 2500 classrooms around Europe (Van Assche et al., 2015).

However, as the educational innovations in the iTEC project were developed, implemented, and evaluated widely in European schools (see Lewin & McNicol, 2015), the need for further validation of the methods was identified. For this reason, in this thesis, the Edukata design model was implemented in the context of early childhood learning for the first time (Brinck et al., 2020).

The concept of design entails both planning (in Finnish: suunnittelu) and creating novel, aesthetic elements, entities, or practices (in Finnish: muotoilu) (Koskinen et al., 2011). This thesis is connected to the latter understanding of design, in which the term is understood as an open-ended inquiry process to improve current conditions by creative, and in this case, participatory means together with the practitioners. The aesthetical and functional aspects are intertwined in iterative and reflective process of creating solutions, i.e., designs, which in this thesis takes the form of a research-based set of design principles to inform pedagogical practice in ECEC.

The term design originates from many disciplinary traditions and has a variety of meanings when used by researchers and practitioners. In general, design practice is systematic in its methods—e.g., workshops, observations, and documentation—but flexible in that the progression of the process is neither linear nor pre-defined, but rather cyclical and iterative, and developed in dialogue with participants and also by reflecting on the process.

Design thinking (Cross, 2011) and a Designerly way of knowing (Cross, 2007)10 are both established terms in the design field used to describe the ways in which a designer approaches the design environment and so-called wicked problems openly and iteratively in order to gain understanding of the user perspective and eventually frame the design problem (Choi et al., 2022; Cross, 1982; Mattelmäki et al., 2014; Steen et al., 2014). Accordingly, Ylirisku (2013) argues that the formulation, or rather process of construction, of a design problem extends from the framing of a problem to the process of communication and learning through collaboration.

Although design methods and design thinking are established and have been widely investigated by scholars in educational settings (Blikstein & Krannich, 2013; Davies, 2023; Guaman-Quintanilla et al., 2018; Hjorth et al., 2015; Iversen et al., 2015; Kangas & Seitamaa-Hakkarainen, 2018; Korhonen et al., 2023; Lor, 2017; Rusmann & Ejsing-Duun, 2022; Seitamaa-Hakkarainen

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10 This terminology is common in design practice and research. Nevertheless, I choose not to use these terms in this thesis, except for the brief introduction of the term. This is to delineate the scope of this thesis and maintain conciseness.
et al., 2012), few studies exist on design methods developing pedagogical practices in the ECEC context.

When Smith et al. (2015) introduced design thinking and digital fabrication for children, they focussed on children’s practices and abilities designing with digital technology. They also point out that studies of PD with children present a parallel, but unlinked, motivation: children are engaged as designers of future technologies, together with design researchers.

As she discusses design from an educational perspective, Kangas (2014) identifies three dimensions of design: the social dimension, the material dimension, and the embodied dimension. The social dimension highlights interaction as a source of shared expertise and new perspectives; the material dimension presents various artefacts (e.g., materials) as a communicative resource that function as mediators between people; and the embodied dimension underlines the designer’s corporal and embodied connection to the material world.

Design practice in education is by no means a new phenomenon. Traditionally, in schools in Finland, teaching that addresses design as a pedagogical method relates to the visual arts and crafts. However, in the 21st century, the discussion of design learning and design pedagogy shifted in a new direction, particularly addressing the increase in interest in developing pedagogies for utilising digital technologies in learning in an interdisciplinary setting (Blikstein & Krannich, 2013; Hakkarainen & Seitamaa-Hakkarainen, 2023; Hjorth et al., 2015; Iversen et al., 2015).

The Finnish National Agency for Education (FNAE) provides the national core curricula for formal education. At the highest national level, the FNAE defines the role of design in formal education for ECEC, pre-primary education, basic education, general upper secondary education, and vocational education. Based on the national curricula, the municipalities, individual schools, and kindergartens form their own locally informed curricula to engage with the local circumstances and special interests of each organisation.

In Finland, teachers have a position of autonomy in their classrooms so choose the ways that they implement the curricula and have the power to design the pedagogical methods best suited to their teaching philosophy and style, the student body and the local learning environment (Kallio-Tavin, 2015). For successful interaction with the students as well as the execution of pedagogy, the teacher’s sense of agency plays a vital role in the classroom, as Lipponen and Kumpulainen (2011) excellently summarise:

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11 The Finnish National Agency for Education provides also national curricula for basic education in the arts, but not for any other nonformal learning providers.
12 In Finnish higher education, course-level curricula are defined by the study programmes. Beyond professional design education, the design methods and particularly design thinking have attracted interest, e.g., in engineering and management education (see Guaman-Quintanilla et al., 2018).
Teacher professional agency is needed to create meaningful and engaging learning environments that extend beyond traditional contexts and practices, to develop and to implement innovative teaching methods, and to integrate the recent theoretical knowledge into classroom practice and school development as well as in multiprofessional work. (p. 817)

A recent critique of organised subject-based teaching shifts the focus from teacher-led pedagogical practices to more student-oriented, participatory, and inquiry-based learning designs (Ito et al., 2013; Lonka, 2018). In this form of participatory learning, design methods provide an established means to organise instruction to facilitate students to collaboratively solve complex, real-life problems beyond disciplinary boundaries (Hatanpää, 2016; Vartiainen, 2014).

Discussion of employing design methods in the interdisciplinary setting of learning has sparked interest among education providers (Hatanpää, 2016). For example, Arabia\textsuperscript{13} comprehensive school in Helsinki has a specialisation in design learning, which means that design methods are used in all subjects in grades 1–9. According to their local curriculum, the design methods for learning promote interdisciplinary investigation. The teacher’s role in this is to facilitate the learning process and to support learners’ creative problem-solving ability. The development of the student’s own vision and understanding of entities from different perspectives is highlighted (City of Helsinki, 2021).

The literature shows a special interest in design as a means to employ digital technologies in learning in a pedagogically meaningful manner (Kangas & Seitamaa-Hakkarainen, 2018; Smith et al., 2015; Tuhkala et al., 2019). An interdisciplinary learning-by-design approach that merges technology education with other subjects is relatively new in educational research, dating back only a few decades (Kangas & Seitamaa-Hakkarainen, 2018). In their study of teachers’ conceptions of design, Heikkilä et al. (2017) summarise it descriptively:

Design-driven education is defined as project-based learning where a learner is actively involved in the planning, implementation and evaluation of the learning activities. It emphasises the comprehensive, phenomena-based and creative nature of learning and recognises that ICT can enhance these kinds of learning processes. (p. 473)

\textsuperscript{13} Arabia comprehensive school is located in Helsinki, Finland, and is named based on the traditional Finnish ceramic factory that was located in the area; the name does not refer to any nation.
2.2 Perspectives on Learning

In his well-known book, *Communities of Practice: Learning, Meaning, and Identity*, Wenger (1999) makes a provocative statement about educational design:

Learning cannot be designed. Ultimately, it belongs to the realm of experience and practice. It follows the negotiation of meaning; it moves on its own terms. It slips through the cracks; it creates its own cracks. Learning happens, design or no design.

And yet there are few more urgent tasks than to design social infrastructures that foster learning. ... In fact, the whole human world is itself fast becoming one large organization, which is the object of design and which must support the learning we need in order to ensure there is to be a tomorrow. (p. 225)

At the same time as the educational environment is facing a substantial change, it is important to critically reflect on the fundamentals in education—research-based understanding of the ways in which humans learn. Learning can be approached and understood from many perspectives and theories (Cherewka, 2019; Sawyer, 2022; Strauch & Al Omar, 2014), and many overlapping models of learning exist (cf. Engeström, 2018; Hakkarainen & Seitama-Hakkarainen, 2023; Illeris, 2018; Seitamaa-Hakkarainen et al., 2010; Vartiainen, 2014; Wenger, 2009), which underlines the complexity of the concept. Consequently, I present below some foundational conceptions of learning from the learning sciences.

**Behaviourism** understands learning as a change in behaviour, which can be modified by practice strategies. The instruction is motivated by enabling students to obtain the knowledge transmitted by their teachers (Land & Jonassen, 2012). In contrast, **constructivism** understands learning as involving “the active creation of mental structures, rather than the passive internalisation of information acquired from others or from the environment” (Nathan & Sawyer, 2022, p. 31). Knowledge and new understanding are constructed based on existing knowledge, e.g., initial ideas, misconceptions, and beliefs. Since the writings of its originator, Jean Piaget, constructivism has developed with variations, e.g., the socio-constructivist approach by Lev Vygotsky. The socio-constructivist approach underlines that “the knowledge construction process is inherently mediated by social interaction, including the use of language” (Nathan & Sawyer, 2022, p. 31).

Papert’s (1980) seminal work on children’s learning in technology environments argues that the construction of tangible artefacts activates learning. This interpretation of **constructionism** by Papert and Harel (1991) builds on constructivism and Piaget’s model of children as “builders of their own intellectual structures” (Papert, 1980, p. 7). The choice of the word *builder* is intentional, as Papert emphasises the approach of *learning through making*. In this respect, constructionism describes
how people’s ideas get formed and transformed when expressed through different media, when actualised in particular contexts, when worked out by individual minds. The emphasis has shifted from general laws of development to individuals’ conversation with their own representations, artefacts, or objects-to-think with. (Ackermann, 2004, p. 21)

Learning scientists aim to clarify an array of complex processes that facilitate learning. Traditionally, the cognitive sciences have addressed the learning mind as an “abstract information processor, whose connections to the outside world were of little theoretical importance” (Wilson, 2002, p. 625). Contrary to this, according to sociocultural perspectives on learning, these cognitive processes are inherently connected with social situations, i.e., situated cognition, and occur in a variety of learning environments, which are understood holistically to include the learner, other individuals, and materials and tools in the environment (Nathan & Sawyer, 2022). Hannafin et al. (1999) extend the concept of open learning environments to situations that promote “divergent thinking and multiple perspectives over a single ‘correct’ perspective” (p. 117). Given the open-endedness of the learning environments, they refer to various learning goals and the means to obtain them. Some of the values guiding such situations (which enhance the openness of the learning environments) are personal inquiry; divergent thinking and multiple perspectives; learner autonomy; mediating learning through personal experience and theories; hands-on experiences involving relevant problems; and providing the tools and resources for solving such problems (Hannafin et al., 1999).

Theories of embodied cognition emphasise the understanding of the mind in connection with an organism’s embodied interactions with the environment as a basis for learning (Abrahamson & Lindgren, 2022; Shapiro & Spaulding, 2019; Wilson, 2002). Embodied cognition connects closely with the recent research areas of 4E cognition, i.e., embodied, embedded, enactive, and extended (Shapiro & Spaulding, 2019). All 4Es could be interpreted as embodied cognition.

According to Shapiro and Spaulding (2019), embedded cognition assumes that cognitive tasks can be facilitated, and that cognitive abilities can thus be enhanced by interacting with an appropriately organised environment. Accordingly, the cognitive load can be reduced, for example, by categorising and specifying workflows and responsibilities, instead of operating in an unstructured environment. Extended cognition further highlights that the cognitive processes take place external to the nervous system or person’s body, and the environment extends to the operation of cognitive systems. Enactive cognition holds that sensorimotor activity activates and constitutes cognition. Mental processes and non-mental processes are merged, and cognition emerges from sensorimotor activity.
The focus in learning theories has shifted in parallel to societal changes, such as the development of new technology in the 21st century (Illeris, 2017; Paavola et al., 2012; Papert, 1980). Many contemporary educational scholars (Engeström & Sannino, 2021; Hakkarainen & Seitamaa-Hakkarainen, 2023; Hilppö et al., 2016; Ito et al., 2013) have identified a sociocultural approach to learning as a key framework to address the challenges that 21st-century learning faces. The sociocultural approach is also shared by the learning researchers working on developing design pedagogies with the objective of employing digital technologies in learning (Brinck et al., 2020; Hakkarainen & Seitamaa-Hakkarainen, 2023; Kangas, 2014; Seitamaa-Hakkarainen et al., 2012; Vartiainen, 2014).

Sociocultural perspectives of learning originate from the work of the Russian psychologist Lev Vygotsky (1978). His seminal work on culturally mediated action, which emphasises the social and cultural nature of human learning, is widely recognised in contemporary academic research (Cole, 1996; Engeström, 2018; Wells & Claxton, 2002). A sociocultural approach to learning identifies social and cultural actions as central to learning (Vygotsky, 1978). As described in Vygotsky’s basic mediated-action triangle (Figure 3), human action builds on the interconnectedness of the actor(s) participating in the activity, i.e., the subject(s); the target or outcome of the action, i.e., the object; and the medential means, i.e., the tools and artefacts that actors use for acting on the object. Tools and artefacts can emerge in various forms, physical or psychological, and their use is always social (Vygotsky, 1978; Wells & Claxton, 2002; Wertsch & Rupert, 1993).

Figure 3
The Basic Mediated-Action Triangle by Vygotsky with Subject, Object, and Mediating Tools and Artefacts, Based on Engeström (2018, p. 54)
According to Wertsch and Rupert (1993), the actions are mediated by cultural tools, which “are culturally, historically, and institutionally situated” (p. 230). Wertsch (1993) clarifies that the term mediation refers to a culturally and socially interconnected process in which tools and artefacts enable individuals to act and make an impact on the world. He continues to discuss how the fundamental assumption of sociocultural theory is that “what is to be described and explained is human action” (p. 8). Tools and artefacts shape the action of the subject who uses them and are also themselves shaped by the user(s) (Daniels et al., 2007; Vartiainen, 2014). By focusing on the action (of an actor), mediation prioritises the agency of a learner. Wertsch and Rupert (1993) follow Wertsch et al. (1993) as they point out: “mediational means play such a central role in a Vygotskian approach that it is appropriate to understand agency (i.e., who it is that carries out action) as mediated agency, or ‘individual(s)-operating-with-mediational-means’” (p. 230).

Illeris (2017) provides us with an intentionally general definition of learning. Learning can broadly be defined “as any process that in living organisms leads to permanent capacity change and which is not solely due to biological maturation or ageing” (p. 3). Illeris (2018) elaborates this definition by presenting three dimensions of learning: Content, incentive, and interaction dimensions. The content dimension is described to “contribute to building up the understanding and the capacity of the learner” by increased understanding, knowledge, and skills (p. 4) and “constructs meaning and ability to deal with the challenges of practical life and thereby an overall personal functionality is developed” (p. 4). The incentive dimension provides and directs mental energy from emotions, feelings, motivation, and volition to enhance the learning process. It balances mental and bodily processes and thus develops personal sensitivity. The two dimensions of content and incentive gain impulses from action, communication, and cooperation, i.e., interaction processes, which are constantly “integrated in the internal process of elaboration and acquisition” (p. 4). This leads to the third dimension of learning, the interaction dimension (Illeris, 2018), which results in activity and participation. According to Illeris, “It serves the personal integration in communities and society and thereby also builds up the sociality of the learner” (p. 5).

Atkinson (2019) discusses teaching and learning in the context of art and design pedagogy, as he explores the paradox of the term art education through the concepts of transcendence and immanence. He refers to a pedagogy of immanence as relying on the unknown, which requires a learning situation that is not pre-defined. By contrast, a pedagogy of transcendence works from established criteria, and thus pre-defines the content of learning, practice, and learner ability.

As Atkinson (2019) writes of paradox, he refers to a such art pedagogical programs, which approach the content of learning, practice, and the learner ability with pre-described criteria. The paradox emerges from the conflict
in relation to the conception of art as “a force whose inherent value is to rupture existing frameworks and identities of practice; it is disobedient to them” (p. 1). Furthermore, instead of obtaining predefined criteria for art pedagogies, Atkinson proposes a reversal of pedagogy, which refers to pedagogy without criteria. It recedes from the pre-framed pedagogy that builds on established structures, knowledge, and practice; rather, it provides a space for a pedagogical position in which “the immanence of a learner’s mode of learning [is] viewed as a particular mode of existence” (p. 1). He continues to state that the immanence of learning aims for a pedagogical position in which the content and practice of teaching and learning emerge through the learner’s experiences and what they perceive as meaningful, i.e., what matters to them. This kind of pedagogical approach requires one to “comprehend how something matters for a learner in a learning encounter” (p. 5). It is challenging for a teacher as it deals with emotions and sense-making, which are developed in each situation and learning encounter (Atkinson, 2019).

Atkinson (2022) also discusses the pedagogy of interstices, which has its foundations in pedagogical encounters of trust and uncertainty. This approach “incorporates a shift from the idea of knowledge as eliminating uncertainty towards accepting uncertainty and contingency as part of the process of learning that leads to expansion of knowledge” (p. 213). To this extent, the most ground-breaking pedagogical encounters occur when children or students do not abide by established conventions and values. This is risky and for a teacher creates challenges, but it is also an adventure. It calls for tolerance of uncertainty and is built on encounters of trust. However, it is also rewarding as it opens up new possibilities and new directions for learning (Atkinson, 2022).

Biesta (2022) refers to Roth (2011) as he writes of encountering the new and unknown, which exposes us to vulnerability. The act of allowing us to be affected requires openness from a person towards the experience of not knowing and the uncertainty it inevitably awakens. Biesta continues to refer to Roth, who states that this kind of openness “precedes knowing, sense making, and interpretation” (p. 94). Only on this basis can new knowledge be constructed—through thinking, classification, and reflecting on the experience. The openness towards not-knowing is a foundation for freedom and agency, as it allows a person to define the moments of passiveness that in turn enable them to be affected (Biesta, 2022).

Lave and Wenger (1991) state that “learning is an integral part of generative social practice in the lived-in world” (p. 35). According to them, all encounters between humans entail actions that are realised in the context of an activity in a social world. Lave (2009) explores this view on learning as she describes each everyday activity as socially situated, i.e., it happens in the social world and always involves changes in knowledge and action. She states that learning occurs in these culturally designed settings of life through changing
participation in social (everyday) activities; or, as she concludes, “participation in everyday life may be thought of as a process of changing understanding in practice, that is, as learning” (p. 201).

According to Wenger (1999), this kind of everyday participation in social world forms communities of practice, which are an integral part of most of our daily lives. These communities constitute various informal everyday groups, such as families, workers, students, hobbyists, or bands. Lave and Wenger (1991) and Wenger (1999) state that participation in communities of practice is not static or localised but varies with the changing position of participants and their identity formation. This they call legitimate peripheral participation. By participation they mean an “encompassing process of being active participant in the practices of social communities and constructing identities in relation to the communities” (Wenger, 2009, p. 210).

An example of this kind of community of practice is visual culture learning communities (VCLC), which are self-organised visual interest and production groups usually formed by young adults. These online communities reach a transnational level and act as peer learning and expertise-sharing communities (Freedman et al., 2013; Karpati et al., 2017). Also, Jenkins (2009) discusses the Internet’s ability to create a participatory culture. He frames participatory culture as “a culture with relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one’s creations, and some type of informal mentorship whereby what is known by the most experienced is passed along to novices” (p. xi). For a participatory culture to function, it is necessary for members to believe that their contributions matter, and to be interested in the ways in which their contributions are received in the community (Jenkins, 2009). Skills for the production of media content and media literacy are essential for learning how to advance from merely consuming media to creatively participating in digital networks.

Jenkins (2009) points out that there is no guarantee of skills acquisition by the youth on their own. On the contrary, the myth of digital natives, as expressed by Prensky (2001), implies that just by being born into the digital world one develops the skills necessary for fully participating in digital culture. In addition to technical abilities, the skills needed for full participation include an understanding of how the media shapes perceptions and socialisation into a media maker’s ethical standards (Jenkins, 2009). The ability to benefit the value chain that digitalisation creates, as well as individual user skills and knowledge about the digital environment, play an important part in how people participate in society, also beyond the digital sphere (Heeks, 2022).

The statement by Jenkins (2009) about the most experienced passing on their knowledge to a novice participant resonates with the theory of zone of proximal development (ZPD), which was originally introduced by Vygotsky (Del Rio & Alvarez, 2007). ZPD is defined as a zone in which a less experienced subject can perform and act with the aid of a more knowledgeable other (MKO).
An MKO is an enabler (such as a more experienced peer, teacher, or parent) who provides support and guidance to make learning possible. Wood et al. (1976) proposed the concept of *scaffolding* to describe these support structures and guidance provided by MKO (Tabak & Reiser, 2022).

Scaffolding can, for example, realise as method of promoting children’s participation by engaging them in documentation of and reflection on meaningful events. In this way, educators can create pedagogical practices and activities to support children’s agency, which results in interaction (Lipponen et al., 2013). Emilson and Johansson’s (2009) study reports that if the children were able to initiate practices in kindergarten, positive interactions between the teachers and children were highlighted. This kind of pedagogy reaches *intersubjective* dimensions (Emilson & Johansson, 2009; Munter, 2013).

Paavola et al. (2004) build on sociocultural theory as they discuss the knowledge creation approach to learning. They refer to Sfard’s (1998) study of two metaphors for learning: the *acquisition metaphor* that presents learning as an individually obtained knowledge, i.e., the “human mind as a container to be filled” (p. 5); and the *participation metaphor*, which emphasises the significance of the participation in the learning community, and activities that are rooted in their cultural and situated context. Sfard (1998) summarises how the acquisition metaphor’s focus on knowing emphasises having or possessing knowledge, while, on the contrary, the participation metaphor’s view of knowing is as belonging, participating, and communicating knowledge. She concludes that both metaphors entail advantages, and one approach may be more suitable than another depending on the varying circumstances of learning. The third approach, developed by Paavola et al. (2004), is the *knowledge-creation metaphor*, which focuses on “analysing the processes whereby new knowledge and new mediating objects of activity are collaboratively created” (p. 573). Learning results in a collaborative process that involves *developing*, not merely utilising, mediated material and conceptual artefacts.

The knowledge creation metaphor was formed by Paavola et al. (2004) by comparing and particularly identifying commonalities in three established models of innovative knowledge communities: Nonaka and Takeuchi’s (1995) model of knowledge-creation, Bereiter’s (2005) model of knowledge building, and Engeström’s (2015) model of expansive learning. The authors (Paavola et al., 2004) state that Nonaka and Takeuchi’s model emphasises interaction between tacit knowledge and explicit knowledge in the individual, group, and organisational levels. Bereiter focusses on developing culturally shared knowledge objects, which are conceptual artefacts rather than physical objects. Engeström’s expansive learning viewpoint separates transmitting culturally given knowledge to students (typical in formal education, e.g., curriculum) and collaborative mastering of culturally new practices and knowledge. Nevertheless, in all of these models of innovative knowledge communities,
learning and knowledge advancement are seen as cyclical, iterative, and fundamentally social processes, which are promoted by individuals’ participation in social activities (Paavola et al., 2004).

Hakkarainen and Seitämaa-Hakkarainen (2023) describe the acquisition metaphor as monological, the participation metaphor as dialogical, and the knowledge-creation metaphor as trialogical. The knowledge-creation metaphor, as presented above, forms the basis for a trialogical approach to learning (Hakkarainen, 2009; Paavola et al., 2012). This was developed during the KP-Lab project (2006–2011) to “develop theories, technology-enhanced tools, practical models, and research methods that elicit deliberate advancement and creation of knowledge as well as transformation of knowledge practices in higher education and in the workplaces” (Paavola et al., 2012, p. 1). The trialogical approach focuses on learning as an activity in which collaborative creation of knowledge objects creates new knowledge. It emphasises that objects and tools mediate activities and are also themselves objects to be created through individual actors in collaboration with each other (Paavola & Hakkarainen, 2021). Paavola et al. (2012) present mediation as a potential concept in understanding new technologically supported activities and collaborative knowledge creation practices.

2.3 Learning by Design

The literature shows that many existing approaches combine design and pedagogical aims, such as designing pedagogy, e.g., designers and teachers designing learning activities together with the students (Toikkanen et al., 2015); instructional design (Reigeluth, 1999); learning design (Gravemeijer & Cobb, 2013); learning engineering (Goodell & Kolodner, 2022); participatory design of physical learning environments (Könings & McKenney, 2017; Leinonen & Mäkelä, 2022) or educational technology (Nicholson et al., 2022); and learning by designing, e.g., teachers and students engaging in design work together, which aims to collaboratively create something new by forming a learning community (Vartiainen & Enkenberg, 2013).

According to Reigeluth (1999), instructional design offers “explicit guidance on how to better help people learn and develop” (p. 5). Instructional design theories are design-oriented, which means that, rather being descriptive and predictive (see Reeve’s model (2006), Section 3.2.1, Figure 7), they aim to understand the context of learning to solve practical problems. While learning theories describe the ways in which learning occurs, design theories focus on designs that facilitate learning (e.g., methods of instruction).

Similar to instructional design, learning design has its foundations in design research. As Gravemeijer and Cobb (2013) discuss design research from the learning design perspective, they state that the “goal of design experiments is
to develop theories about both the process of learning and the means that are designed to support that learning” (p. 75).

Learning engineering is referred to as engineering for learning in technology environments. Learning engineering combines an engineering design methodology, human-centred design tools, and data analytics (Goodell, 2022). Learning engineering is a process that starts with a challenge that is addressed by the investigation, creation, and implementation of a solution (Kessler et al., 2022), and thus shares similarities with the design learning process. As a practice, learning engineering is still emerging, and critical views also exist (Lee, 2023). According to Lee (2023), the discourse around the concept of learning engineering is diverse, unclarified, and developing in its connections to the learning sciences.

Learning by design or design learning merges perspectives from both design and learning; their practice and research is at the intersection of the disciplinary traditions of art education (Niinimäki & Kallio-Tavin, 2013; Sederholm, 2015), craft education (Hatanpää, 2016; Kangas, 2014), science education (Kolodner et al., 2003), technology education (Seitamaa-Hakkarainen et al., 2012; Tuhkala et al., 2019), and maker education (Dougherty, 2012; Dufva, 2017; Kajamaa et al., 2020). This last employs various kinds of technologies and digital fabrication methods as a broad framework for design and technology education (e.g., see, FabLearn Digital Fabrication in Education). Maker education is often referred to as STEM or STEAM learning (Carter et al., 2021; Kumpulainen et al., 2018; Ussher et al., 2023) and derives its pedagogical goals and practices from the combination of the knowledge domains of science, technology, engineering, and mathematics, addressing them in an inter- or transdisciplinary framework. The STEAM approach extends this view to the knowledge domains of art and design, which the addition of the letter A stands for.

Many learning approaches that employ design as a means for organising instruction in the interdisciplinary learning context, such as learning by collaborative designing (LCD) (Seitamaa-Hakkarainen et al., 2012), learning by Inventing (LI) (Hakkarainen & Seitamaa-Hakkarainen, 2023), and design-oriented pedagogy (DOP) (Vartiainen, 2014), have their foundations in socioculturally informed theories and practices. Next, I explain the features of these three approaches in more detail.

The pedagogies of LCD, LI, and DOP underline the processes of collaborative knowledge creation through shared objects. Mediated, situated, and object-oriented learning have their theoretical foundation in knowledge practices (Kangas & Seitamaa-Hakkarainen, 2018). The key aspects of these three pedagogies are summarised in Table 3, as they are described by their original developers in the corresponding literature.

14 The abbreviation of LI is not used by the original authors but developed for the purposes of this thesis.
### Table 3
Comparison of the Key Aspects of DOP, LCD, and LI Pedagogies

<table>
<thead>
<tr>
<th>PEDAGOGIES</th>
<th>Design-oriented pedagogy (DOP)</th>
<th>Learning by collaborative designing (LCD)</th>
<th>Invention pedagogy, Learning by inventing (LI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Vartiainen, 2014; Vartiainen &amp; Enkenberg, 2013, 2014; Vartiainen et al., 2012)</td>
<td>(Kangas, 2014; Seitamaa-Hakkarainen et al., 2010)</td>
<td>(Davies et al., 2023; Hakkarainen &amp; Seitamaa-Hakkarainen, 2023)</td>
</tr>
<tr>
<td>ORIENTATION</td>
<td>General education extended learning environments</td>
<td>Crafts technology education</td>
<td>STEAM science education, maker education</td>
</tr>
<tr>
<td>APPROACH TO LEARNING AND DESIGN</td>
<td>Participatory learning employing learning objects</td>
<td>Inquiry-based and object-oriented learning</td>
<td>Thinking through doing and learning by making</td>
</tr>
<tr>
<td></td>
<td>Knowledge creation through natural or cultural artefacts in extended learning environments</td>
<td>Knowledge creation through shared objects</td>
<td>Technology-enhanced knowledge practices in maker education</td>
</tr>
<tr>
<td></td>
<td>Design is an approach to the development of participatory learning activities.</td>
<td>Learning is a socially, culturally and materially embodied process, rather than mere play with ideas.</td>
<td>Epistemic objects and practices, artefacts in making</td>
</tr>
<tr>
<td></td>
<td>The technologies enhance learning across different contexts, and enable one to collect various empirical data when implementing inquiries in authentic environments.</td>
<td>Design can be seen as a form of object-oriented process of knowledge-creation.</td>
<td>Invention pedagogy engages teams of learners across all ages in computer-supported collaborative learning, which involves using traditional and digital fabrication technologies for ideating, designing, and making complex artifacts sparking intellectual, engineering, and aesthetic challenges.</td>
</tr>
<tr>
<td>APPROACH TO TECHNOLOGY</td>
<td>The DOP also aims to enhance the opportunity to apply diverse physical, cognitive, and social tools and technologies in collecting, developing, and sharing information.</td>
<td>Technology-enhanced learning environments provide tools and practices that elicit participation in meaningful, socially and culturally rich, and creative working with knowledge.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technologies provide the possibilities and means through which students share their ideas, thoughts, and own designs related to real-life artefacts with the extended community in the form of a learning object.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| THEORETICAL FOUNDATIONS            | Sociocultural perspectives of learning                                                     | Sociocultural perspectives of learning                                                                   | Sociocultural perspectives of learning                                                 |
|                                    | Pragmatism                                                                                  | Constructionism                                                                                           | Constructionism                                                                         |
Instead of merely focusing on individuals or subjects who are learning, the DOP, LCD, and LI models highlight collaborative design and the creation of knowledge artefacts as a *community of learners*. DOP highlights a participatory learning approach, which enables an individual to learn from others and share their own expertise. Students investigate and create various natural and cultural artefacts, referred to as learning objects, as they frame and conduct their open-ended learning task. In the DOP, the *learning task* is designed, developed, and solved in collaboration with peers as well as with the aid of teachers and professional expert communities external to the school (Vartiainen & Enkenberg, 2014). The DOP pays attention to the underutilised resources of extended learning environments, such as natural environments and museums. It provides a pedagogical method to connect these places of valuable learning opportunities, and connects theoretical, school-based learning to authentic, real-life investigation. The DOP is applied widely to investigate various phenomena in the general education context, instead of focusing on any particular school subject, such as crafts or arts (Vartiainen & Enkenberg, 2013).

The LCD model originates from the craft tradition and underlines collaboration and distributed expertise in all phases of the design learning process. The design work is externalised to a wider learning context through its authentic design context (Kangas & Seitamaa-Hakkarainen, 2018). In the LCD, the teacher sets up the design task for the students, while carefully balancing open-endedness and the design constraints. An authentic design task is situated in a meaningful context and requires the teacher to guide the students to move between thinking and doing. The students frame the design work, and develop ideas, constraints, and solutions by working with various materials, technologies, and objects (Kangas & Seitamaa-Hakkarainen, 2018). According to Seitamaa-Hakkarainen et al. (2010), the LCD “engages pupils in creating both new conceptual and material artefacts in collaboration with one another” (p. 110). They state that “technology-enhanced learning environments appear to provide tools and practices that elicit participation in meaningful, socially and culturally rich, and creative working with knowledge” (p. 110). Knowledge artefacts are both *conceptual* (e.g., questions, theories, and ideas) and *material* (e.g., drawings [analogue or digital], prototypes, or products) (Seitamaa-Hakkarainen et al., 2010).

Learning by inventing (LI) connects to computer-supported collaborative learning and maker culture as it highlights learners of all ages working with traditional and digital fabrication techniques to create complex technology artefacts to meet intellectual, engineering, and aesthetic challenges (Hakkarainen & Seitamaa-Hakkarainen, 2023). Davies et al. (2023) consider “maker practices to be an umbrella term that combines scientific, engineering, and design practices in the context of collaborative designing, making, and inventing artifacts with the help of both traditional craft and digital fabrication
technologies” (p. 3). Learning by inventing underlines learning processes, which support self-organised and non-linear invention and personal and collaborative improvisational exploration (Davies et al., 2023; Hakkarainen & Seitamaa-Hakkarainen, 2023). The pedagogical activities are open, flexible, and enable planning, testing, and iterating (Hakkarainen & Seitamaa-Hakkarainen, 2023). These kinds of learning processes require teachers to learn to facilitate instruction for nonlinear, open-ended, and inventive study processes. They need to recognise the situations in which the students need strategic guidance, e.g., step-by-step instructions for mastering a production tool (Davies et al., 2023).
It was nice to do filming myself. At first, I didn’t remember what we were supposed to film, but then Jane and Matt [educators] helped me.

(Excerpt from data, personal communication, educator’s statement, 2017)
3 METHODOLOGY

In this chapter, I describe the methodological framework, which has been formed through sub-studies. Participatory, open-ended, and data-driven approaches have guided the choice of methods from the very early stages of the research. This research approach has created a methodological space in which the choices of methods have been iteratively assessed and reflected upon in each phase of the thesis.

This qualitative research combines grounded theory and design research methods: educational design research, (i.e., design experiments), participatory design (PD), and research-based design (RBD). The thesis conducted a grounded theory (GT) process, which guided the sequence of the research activities, i.e., the design workshops, sampling, data collection, and analysis. The research process covered two design experiments, DE1 and DE2, in kindergarten over one year (2017–2018), to explore pedagogical aspects of design and digital tools in a real-life educational context. The methodological framework is presented in Figure 4.

**Figure 4**
Methodological Framework
This research is qualitative because it has its foundations in authentic real-world encounters with the research environment and research subjects. Furthermore, the methods and processes of this research, i.e., activities, observations, data collection and production, sampling, and analysis, are formed, documented, and analysed by acknowledging the subjective understanding of the researcher (Flick, 2014; Patton, 2002). This means that the interpretations that lead to the findings are formed through the researcher’s personal view of reality, i.e., ontological conceptions of the world and epistemological understanding of knowledge (Batista, 2021).

In qualitative research, the research designs do not have strict, purely objective methods of measuring (e.g., mathematical data and analysis in quantitative research) and the activities and observations are not separate from the culture and environment in which they were created. The new knowledge discovered through research activities is intertwined with the research context in complex and messy interactions between people.

According to McKenney and Reeves (2019), even though qualitative findings are situated, immediate, time-bound, and culture-specific, they can be applicable to similar contexts, practices, and situations, which can emerge in different places between different people. In this sense, these local or middle-range theories of qualitative nature can also be applied to, tested, and developed further in more general contexts, and with different demographic groups, or even applied to a different field of study. In this way, theories that are initially based on local and situated observations and findings may eventually, through many iterations of research, evolve into more high-level, general theories.

Studying complex and situated real-life phenomena calls for an epistemological understanding of collaboratively created knowledge and a fluid methodological space. To validate this kind of research approach, the key is the careful documentation of the research process and transparent reporting of the findings. In this research, the methodological choices have resulted from a long-term, open-ended, and data-driven research process conducted with a heterogeneous group of participants. The choice of methods has been made to match the research activities and the needs of the sub-studies (the selected methods are reported in the publications). Studying the phenomenon with openness has enabled the combination of various design research methods and grounded theory (see Sections 3.2 and 3.3). The interdependent connections of the research methods are presented in the form of the methodological triangle in Figure 5.

15 Mixed methods research provides a methodological means to combine qualitative and quantitative data and analysis in research design (Flick, 2014).
16 Terminology for theory formation differs between educational design research (i.e., local theory, see: McKenney & Reeves, 2019, pp. 40–41) and grounded theory (i.e., substantive theory, see grounded theory: Glaser & Strauss, 1967, p. 79).
This transdisciplinary research has been conducted under the wide umbrella of the humanities and social sciences by combining the knowledge domains of art and design education; design; and technology-enhanced learning. With these knowledge domains in question, major epistemological conflicts did not emerge—such as there could have been, for example, between the natural sciences and the social sciences.

An open-ended and transdisciplinary research process, as in this thesis, is all about identifying, clarifying, and refining fragile and emergent ideas. The process encourages hidden ideas and knowledge to be revealed. In their study on the epistemological grounds of transdisciplinary research, Regeer and Bunders (2003) discuss how, in transdisciplinary research, knowledge is collaboratively created in heterogeneous participatory processes. Accordingly, Regeer and Bunders (2003) state that the integrated view on knowledge-creation unifies the different knowledge bases to form a unity of new knowledge, which means that knowledge is equally valued whether it has been created by practitioners or researchers. Moreover, the methods used to integrate the different knowledge bases become important for validating the findings (Regeer & Bunders, 2003).

Next, I present the philosophical foundations for the methodological choices of this thesis. Then, I introduce the design research methods and
the GT method employed in this thesis. Design research methods consist of educational design research, (i.e., design experiments), participatory design (PD), and research-based design (RBD). Afterwards, I describe the flow of the entire GT process, i.e., the data collection, sampling points, and analysis process of this thesis (Figure 14 and Table 6). Here, I also present the participants and strategies for data analysis from the wider perspective of the entire research project. As the detailed research designs, data, and analysis of each sub-study are reported in the original publications, I do not repeat them here.

3.1 Pragmatism as a Philosophical Foundation

According to Flick (2014), pragmatism “focuses on ideas that the meaning of concepts can be found in their practical use, that thought guides action, and that the test for truth is the practical consequences of beliefs” (p. 541). This definition emphasises pragmatism’s connection to practical actions, (i.e., practices) as a process of gaining knowledge and understanding. As this method of inquiry is realised through action, it should also be tested in practice and will ultimately benefit practice. Connecting with and aiming for a better understanding of the world in this way is an embodied, tactile, multisensory, and potentially messy and smelly endeavour.

According to Longino (1990), even though we have some biological sensory means of making these connections, the way we interact with the world is constantly changing and contextual. This means that our knowledge about the world is always evolving. Legg and Hookway (2021) point out that pragmatists emphasise that the “focus of epistemological inquiry should not be on showing how we can possess absolute certainty, but on how we can develop self-correcting methods of inquiry that make fallible progress” (Section 4.1, para 6). This perception of knowledge eschews positivism (Longino, 1990), as the pragmatist view on research is that it cannot be conducted in isolation nor repeated with the same results regardless of the circumstances.

According to Legg and Hookway (2021), a classical pragmatist, John Dewey, “recognizes that when we face a problem, our first task is to understand it through describing its elements and identifying their relations. Identifying a concrete question that we need to answer is a sign that we are making progress” (Section 4.2, para 2). Morgan (2014) observes that Dewey’s approach to pragmatism emphasises human experience as the basis of inquiry. He states that experience is formed through our beliefs, which guide our actions. As our beliefs originate in our previous actions, they are interconnected and form a cycle. By reflecting on these actions, we re-evaluate and modify our beliefs. In this way, “experiences create meaning by bringing beliefs and actions in contact with each other” (Figure 6) (Morgan, 2014, p. 1046).
Figure 6
Dewey’s Models of Experience and Inquiry Based on Morgan (2014, p. 1046)

Pragmatist epistemology and Dewey’s model of inquiry have been proposed as a foundational model for the epistemology of design research by many researchers (Dixon, 2019, 2020; Dixon et al., 2023; Goldkuhl, 2020; Steen, 2013; Stompff et al., 2022). According to Steen (2013), science typically describes and is concerned with past or current situations in the effort to discover facts. In contrast, design explores phenomena with alternative situations to become and that might be—integrating both facts and values. In design, problems and solutions are developed in parallel in iterative cycles. Complex design problems are rarely approachable only by considering known facts or with existing pre-knowledge. In contrast, solutions require concrete practical actions in the real world.

Dixon (2020) states that, “while philosophers have traditionally celebrated the well-structured rational argument, designers operate apart from the constraints of fixed protocols and formal logic. According to the standard narrative, they deal in real-world concerns and open-ended experimentation, not in the language of abstraction” (p. 1). Goldkuhl (2020) presents the stages of the design process in relation to the world-state as follows: pre-design relates to the world-as-is; in-design relates to the world-as-might-be; and post-design (i.e., use) relates to the world-as-become and the world-to-become.
In this research, Dewey’s model of inquiry is understood as a design inquiry. It resonates with the moments of doubt and uncertainty that are present particularly in the early phases of the process (see Stompff et al., 2022). The moments of *not knowing* have been identified by being mentally open and by not forcing the direction of the design or research. These moments precede the recognition of a problem—meaning a situation that requires a confrontation of the unknown and that invites us to take steps that are not familiar or predictable.

In those times that I have avoided turning back to the familiar and proceeded to explore a problem openly, I have entered into design inquiry. By designing solutions (i.e., prototypes of learning activities), exploring them in practice, reflecting on my experiences, and refining the solutions, I have gained new knowledge, which has foundationally changed my understanding of the phenomenon.

Furthermore, by reporting the process of this inquiry in publications and in this thesis, I have reflected upon and structured the process and also made it transparent for others to evaluate. Consequently, through the process of inquiry, the earlier problematic situation has transformed into a clarified explanation of the phenomenon (see Goldkuhl, 2020). The analysis and reflection of the real-life events and the initiative of taking these experiences into dialogue with theories have produced solutions that are applicable to practice.

Moreover, I have not experienced this process alone but together with colleagues and participants in this research. We have experienced the process of inquiry together, via ongoing parallel and individual learning processes. Together, we have reflected on the meaningfulness of the process, and created a shared understanding to an unstructured problem (see Dixon, 2020).

### 3.2 Design Research Method

As presented above, the grounded theory approach guides the overall research process, i.e., data collection, sampling, and analysis. Under the overarching empirical and qualitative framework, guided by GT, this research applies design research methods on three different levels.

- *Educational design research* (EDR) and particularly *design experiments* (DE) provide a context for design interventions in kindergarten.
- *Research-based design* (RBD) methodology provides a foundation for developing and studying a technology prototype (+Andscape prototype) for early childhood learning.
- *Participatory design* (PD) is a method that facilitates interaction with the research participants.

Next, I present the three design research methods applied in this thesis.
3.2.1 Educational Design Research

This thesis applies educational design research (EDR) with design experiments in an authentic environment (Anderson & Shattuck, 2012; Cobb et al., 2003; Collins et al., 2004; Design Based Research Collective, 2003; Edelson, 2002; Giannakos, 2022; McKenney & Reeves, 2014; McKenney & Reeves, 2019; Pernaa & Akseli, 2013). According to McKenney and Reeves (2019), the design research method is not a fixed methodology but rather a “genre of inquiry” (p. 3) that entails many methodological approaches. They refer to EDR as a “family of approaches that strive toward the dual goals of developing theoretical understanding that can be of use of others while also designing and implementing intervention to address problems in practice” (p. 18). This family of approaches encompasses, for example, design-based research (DBR) (Collins et al., 2004; Design Based Research Collective, 2003), development research (Akker et al., 1999), and design experiments (Brown, 1992; Cobb et al., 2003; Collins, 1992; Collins, 2010).

McKenney and Reeves (2019) choose to use the term educational together with design research for underlining and positioning the field of study. This is to avoid misconceptions, as, for example, in addition to the field of education, DBR has also been widely used in human computer interaction research. In this thesis, I also choose to use the term educational design research to commonly refer to the abovementioned EDR approaches, which in this case entail literature discussing EDR, DBR, and design experiments.

McKenney and Reeves (2019) refer to Stokes (1997) as they present educational design research as use-inspired basic research, which combines elements from basic research and applied research. Use-inspired basic research seeks fundamental knowledge (basic research) in the context of real-world environments (applied research). McKenney and Reeves (2019) also state that educational design research can be defined as a genre of research in which the iterative development of solutions to practical and complex educational problems also provides the context for empirical investigation, which yields theoretical understanding that can inform the work of others. (p. 6)

Educational design research is theoretically oriented, interventionist, collaborative, responsively grounded, and iterative. EDR extends the theoretical orientation to utilise existing theories (and also creative inspiration and craft knowledge) to not only frame the research but also shape the design solution to a real problem (McKenney & Reeves, 2019). The interventionist aspect refers to the solutions that are designed, e.g., educational products, processes, programs, or policies. Here the “intention is – alongside the development of theoretical understanding – to make a real change on the ground” (McKenney & Reeves, 2019, p. 13).
EDR is conducted in collaboration with others. Collaboration enables both the outsider (researcher) view and insider (practitioner) view on a design problem. As EDR creates design solutions that are developed in iterative cycles through theoretical orientation, participant expertise, and field testing, both the research design and research methods evolve as the research progresses. Actively responding to these emerging complex circumstances rather than forcing the activities to fit a pre-defined structure enables a responsively grounded research process. The iterative aspect of EDR refers to the elaboration and evolution of engagement, activities, and interventions through multiple cycles of investigation, development, testing, and refinement (McKenney & Reeves, 2019).

According to Cobb et al. (2003), design experiments (DE) entail a pragmatic and theoretical orientation. The pragmatic perspective refers to design, and the theoretical refers to the creation of new conceptual knowledge, which they describe as an ecology of learning. Cobb et al. (2003) summarise the concept of the ecology of learning in the following way:

We use the metaphor of an ecology to emphasize that designed contexts are conceptualized as interacting systems rather than as either a collection of activities or a list of separate factors that influence learning. Beyond just creating designs that are effective and that can sometimes be affected by ‘tinkering to perfection’, a design theory explains why designs work and suggests how they may be adapted to new circumstances. Therefore, like other methodologies, design experiments are crucibles for the generation and testing of theory. (p. 9)

Ecologies of learning aim to present a complex, multi-level context of learning in a holistic and understandable form. Ecology refers to contexts that emerge as complex interaction systems rather than individual and separate elements in a classroom, such as tasks, problems to solve, or tools (Cobb et al., 2003).

Cobb et al. (2003) present five cross-cutting features of design experiments (DE). DEs aim for theory building of both the process of learning and the means to support it. They are interventionist design-based test beds for educational innovation. DEs are both prospective and reflective, which means that the preliminary designs are implemented as tests, which are later critically and openly reflected upon.

Cobb et al. (2003) state that a critical and open attitude embeds the notion of the continuous development of solutions. This requires iterations to gain a sufficient understanding of the context and practices. Theories that are developed through DEs must do real work, i.e., they are efficient and applicable to practical educational context.
Reeves (2006) summarises, based on Brown (1992) and Collins (1992), that the critical characteristics of design experiments are

- addressing complex problems in real contexts in collaboration with practitioners;
- integrating known and hypothetical design principles with technological advances to render plausible solutions to these complex problems; and
- conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles. (p. 58)

In his research on educational technologies, Reeves (2006) describes a basic model for design research with four phases: collaborative analysis of a design problem; development of the design solutions; iterative cycles for testing and refinement; and reflection to produce design principles or solution. The design research model differs from a traditional predictive research model in its close connection with practice (see Figure 7).

Figure 7
Basic Model of Four Phases of Predictive Research and Design Research, Based on Reeves (2006, p. 59)
Design research collaborates with practitioners from the early stages of research. Contrary to predictive research, which derives its hypotheses from existing theories, design research initiates its inquiry by analysing practical problems together with the practitioners, and proceeds to test and reflect on the solution in iterative cycles. The aim of this is to form a holistic understanding of the phenomenon to create solutions that are applicable to practice (Reeves, 2006).

In this research, I conducted two design experiments. The first design experiment (DE1) was conducted in a kindergarten in 2017. DE1 entailed the orientation phase and 15 participatory workshops. DE1 produced Dataset 1 (see appendices). Its analysis is reported in Publications I and III (Table 2). In DE1, participatory design was employed to engage teachers, children, and other stakeholders to collaboratively develop everyday pedagogical practises and learning activities. The collaborative research activities constituted of designing, implementing (i.e., testing), and reflecting on the learning activities. The emphasis was on developing pedagogical use of digital tools.

DE1 was conducted in a kindergarten as part of the Insights into Early Childhood Education project. Partners were the City of Helsinki, the University of Helsinki, and Aalto University’s School of Arts, Design and Architecture. The project was funded by the Finnish National Agency for Education.

The second design experiment (DE2) was conducted in parallel to DE1, in 2017–2018. It entailed three design workshops and four workshops of children playing with a technology prototype, +Andscape. DE2 produced Dataset 2 (see appendices). Its analysis is reported in Publication II (Table 2). DE2 originated from DE1, which identified various design resources that were external to the daily routines and common learning environments in kindergarten. These resources, such as Aalto Fablab and Design Museum Helsinki, provided the inspiration to expand the inquiry towards more playful, adventurous, and explorative means of investigation, i.e., building a technology prototype for early childhood learning. This discovery, and a point of theoretical sampling (see Figure 14 and Table 6), led us to initiate the parallel design experiment, DE2, in which a research-based design (RBD) methodology was employed to design, build, and test an augmented reality sandbox, +Andscape—as we named the prototype. This enabled us to explore the pedagogical opportunities of augmented reality. Originally, the AR sandbox was developed at UC Davis (Woods et al., 2016) and was designed to allow its users to create topographic models by shaping sand. With the +Andscape prototype, we were able to design and build special features, particularly for early childhood learning.

DE2 was conducted as a participatory design process, in which kindergarten teachers and pedagogical staff from Design Museum Helsinki and the local library, together with pedagogical specialists from the City of Helsinki, engaged in designing the pedagogical content of the features of +Andscape. The prototype was produced in cooperation with the City of Helsinki: Insights
into Early Childhood Education project; and Aalto University, School of Arts, Design and Architecture; and Aalto Fablab17.

Table 4 presents the design experiments, corresponding publications, and +Andscape prototype. In Section 3.4, Table 7 summarises the research activities, data, participants, and analysis strategies in DE1 and DE2. Also, the appendices provide a complete list of all research activities, participants, and collected data for both DEs.

Table 4
Design Experiments, Corresponding Publications, and the +Andscape Prototype

<table>
<thead>
<tr>
<th>DESIGN EXPERIMENT 1 (DE1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WORKSHOPS</td>
</tr>
<tr>
<td><strong>Publication I</strong></td>
</tr>
<tr>
<td><strong>Publication II</strong></td>
</tr>
</tbody>
</table>

| **Publication III**  |

<table>
<thead>
<tr>
<th>DESIGN EXPERIMENT 2 (DE2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prototype</strong></td>
</tr>
<tr>
<td><strong>Publication II</strong></td>
</tr>
</tbody>
</table>

17 The technical execution of the prototype was realised by Niklas Pöllönen and Jason Selvarajan from Aalto University (see Section 1.3).
Figure 8 presents the ways in which the design experiments of this thesis connect to the design research model by Reeves (2006).

The entire research process, including phases, design experiments, sampling, GT analysis, and publications, is presented in Figure 14. In addition, detailed information on the design workshops is presented in the appendices.

**Note.** In Figure 8, DE is an abbreviation for design experiment.
3.2.2 Research-Based Design

This thesis applies research-based design (RBD)\(^\text{18}\) as a methodology to guide the process of designing, implementing, and testing a technology prototype, +Andscape (Leinonen et al., 2021). RBD was developed by Leinonen and his colleagues in Aalto Media Lab’s Learning Environments Research Group (LeGroup). RBD is a methodological orientation for building artefacts, tools, and prototypes for learning (Leinonen, 2010; Leinonen et al., 2008).

According to Leinonen (2010), as with design, the RBD process does not follow a strict linear progression, but is negotiated in dialogue with the developers and community of users. RBD is influenced by and connected to the tradition of Scandinavian participatory research tradition in which design challenges and solutions alike respond to the human context of practitioners and end users. Leinonen et al. (2008) state that the goal of RBD is to involve end users in the design of learning tools and services. The RBD process can be described through four intertwined phases, which are concurrent, parallel, and iterative (see Figure 9). These phases are contextual inquiry, participatory design, product design, and software (here, prototype) as hypothesis (Leinonen, 2010; Leinonen et al., 2008). The ways in which these phases are applied in the development of the +Andscape prototype are reported in Publication II.

Figure 9
Research-Based Design Process: Contextual Inquiry, Participatory Design, Product Design, and Production of Prototype as Hypothesis, Based on Leinonen et al. (2008, p. 67)

---

\(^{18}\) Research-based design (RBD) should not be confused with design-based research (DBR), which refers to design interventions as a research method in educational design research (Leinonen, 2010).
3.2.3 Participatory Design

This thesis applies participatory design (PD) as a method of interaction with research participants. PD as a research method shares the action researcher’s position in the field. As in participatory design, action research enables a researcher to engage in collaboration with research participants in order to enhance participants’ everyday lives. The solutions evolve as the collaborative design and research advance. The researcher does not predetermine the direction of the research; “instead it emerges from consultation with those who will be affected by it” (Willig, 2014, p. 15). Participatory design constitutes a research method (Spinuzzi, 2005).

In this thesis, the motive behind employing PD in education is to engage various stakeholders in pedagogy development, aiming at innovative novel pedagogical solutions and utilising technology to facilitate everyday participation and deeper and more effective learning. The design and research activities are interconnected and interdependent, as the design process provides the framework for the research and the practical means for data collection (see Figure 14).

I started the design process with the Edukata model19, which is a participatory design model for developing learning activities that employ digital technologies in learning (Toikkanen & Keune, 2014; Toikkanen et al., 2015). The Edukata model includes several iterative workshops with stakeholders in design and reflection sessions (Figure 10). The PD sessions in Edukata involve participants in the discussion of the design context, challenges, and opportunities, and guide participants in designing everyday learning activities.

In this research, Edukata provided a fully developed and tested model with a systematic yet flexible orientation to initiate the design process and data collection. Due to the children’s young age, the approach to children’s participation in the design process was designed accordingly. One of the design goals was to find novel practices for child-initiated pedagogy and map innovative ways to engage children in co-designing the daycare activities. The premise of the participation in the design process was that children contributed by the means of expression that were most natural to them (e.g., creative practices and play). Publications I and III report the results of the Edukata process.

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19 Edukata – Rethinking Learning
Edukata was developed as part of the Innovative Technologies for an Engaging Classroom project, iTEC, 2010–2014, in which European Schoolnet worked with education ministries, technology providers, and research organisations to transform the way that technology is used in schools. The project was co-funded by the European Commission.
In our design process, design work, implementation (i.e., testing of the activities), and reflection alternated. I was responsible for organising and documenting each workshop and concluding the discussion in a short summary afterwards. This functioned as an initial analysis as I reviewed the collected data for the key topics and started to identify emergent concepts. This phase also contributed to memo writing, which is highlighted in the GT approach. These memos commonly served as visual means of identifying emergent key concepts and their relationships. A visual memo from the early stages of the process presented in Figure 11, and the concepts it entails, formed the foundations for the entire design and research process.

The people participating in the workshops varied due to the content and objectives of the workshop. The core group participating in all the activities included myself and the kindergarten teacher (presented in this thesis as Matt). Also, other daycare personnel, such as assistants and a pre-service teacher, regularly participated in the workshops; in addition, pedagogical specialists from the City of Helsinki participated in the workshops and provided their expertise for the design work. Children participated in 10 workshops. The participants, content, and data of each workshop are summarised in Section 3.4 and reported in detail in the appendices.
3 METHODOLOGY

**Figure 11**
*Example of Visual Structuring of Concepts as a Visual Memo in the Initial Phase of Analysis*

![Diagram](image)

- **Intrinsic value of childhood**
  - Learning by doing and playing, learning about the world
  - Observation and ideation of play and by playing, discussing about play, documenting play

- **PARTICIPATION**
  - Artistic expression and activity
    - Photographing/video, drawing, construction, film, drama, dance, music, word art, audio
  - Observation and dokumentation of art-play
  - Reflecting on the outcomes, documentation of activities, observation of environment

- **COMMUNITY**
  - Observation and dokumentation of art-play
  - Listening and presence, asking and telling

- **CHILD-CENTREDNESS**
  - Agency

*Note.* This figure demonstrates a visual structuring of concepts, and has been formulated after Workshop 1.

**Figure 12**
*Edukata Workshop in Kindergarten*

![Image of workshop](image)

*Note.* This figure is a documentation of Workshop 4, in which we were mapping design resources.
3.2.4 Design Principles in Design Research

The main contribution of this thesis is to develop design principles for open design pedagogy. For this purpose, I developed a principle-focused elaboration process to identify and refine design principles from the reported sub-studies. I describe this process in Chapter 4 in detail and reveal the findings. Therefore, I introduce here the background of design principles as one of the tools and methods of design research (Akker et al., 1999).

According to Akker et al. (1999), in design and development research, designing and implementing educational interventions should aim at both a practical and scientific contribution. A practical contribution refers to ideas that aim to improve the intervention, and a scientific contribution refers to the formulation of design principles (DP). The authors continue to state that “these principles can be of a ‘substantive’ nature, referring to characteristics of the intervention (what it should look like), or of a ‘procedural’ nature (how it should be developed)” (p. 5). Thus, the orientation of DPs should be towards generalised knowledge (Akker et al., 1999).

Fu et al. (2015) present a literature review and a critical analysis to define the methodological foundations for design principles, and their relation to close concepts such as guidelines and heuristics. They propose formal definitions for principles, guidelines, and heuristics, which are presented in Table 5.

Table 5
Formal Definitions for Principles, Guidelines, and Heuristics by Fu et al. (2015)

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principle</td>
<td>“A fundamental rule or law, derived inductively from extensive experience and/or empirical evidence, which provides design process guidance to increase the chance of reaching a successful solution.” (Fu et al., 2015, p. 2)</td>
</tr>
<tr>
<td>Guideline</td>
<td>“A context-dependent directive, based on extensive experience and/or empirical evidence, which provides design process direction to increase the chance of reaching a successful solution.” (Fu et al., 2015, p. 3)</td>
</tr>
<tr>
<td>Heuristic</td>
<td>“A context-dependent directive, based on intuition, tacit knowledge, or experiential understanding, which provides design process direction to increase the chance of reaching a satisfactory but not necessarily optimal solution.” (Fu et al., 2015, p. 4)</td>
</tr>
</tbody>
</table>
The definitions reveal that all of these concepts emphasise experiential and/or empirical foundations, but the principles extend from the context-dependent directive to more general applications. Fu et al. (2015) summarise design principles as follows:

- [Design principles] are not universally applicable, effective, or true, but instead are generally applicable, effective, and true in a given context.
- Principles are typically based on experiences, examples, or empirical evidence.
- The application of principles may be context and/or problem dependent but should be more generalisable than a few isolated instances.
- Principles are used as foundations for understanding and for the development of supporting methods, techniques, and tools. (p. 2)

According to Herrington and Reeves (2011), in EDR, design principles are elementary to render theoretical educational research more applicable to the educational practices. The aim is not to create universally applicable principles, but to employ them to develop contextual solutions, which can be applied by educators in other parallel contexts.

Similar to the grounded theory (GT) approach, Fu et al. (2015) highlight inductive orientation, and present a process “where inductive research is based upon a process in which data is collected first, patterns are extracted, and a theory is developed to explain those patterns” (p. 1). Although they argue that a data-driven and evidence-based approach is necessary to ground principles in practice, their literature review revealed studies that engaged with both inductive (descriptive) and deductive (prescriptive) methods to develop design principles (yet they did not report studies referring to abductive reasoning in their formation of DPs).

According to Fu et al. (2015), for validation of the principles, a set of dimensions of principles should be addressed: the level of supporting evidence, the level of specificity, the level of formalisation, and the position on the spectrum of prescriptive–descriptive. Also, the principles should be reviewed, if relevant, in relation to the state-of-the-art, technological, social, and economic trends, and in relation to the context of use, the intended users, and the required qualifications to apply these principles successfully. In this thesis, I address these dimensions to the extent that is applicable to this research. Also, Chapter 1 provides an introductory context to the developed DPs.
3.3 Grounded Theory Method

3.3.1 Background of Grounded Theory

This research applied a *grounded theory* (GT) approach (Bryant & Charmaz, 2007, 2019; Corbin & Strauss, 2015; Flick, 2014; Glaser & Strauss, 1967/1999; Thornberg & Charmaz, 2014), which is widely used and an established method in qualitative research. GT guided the design and process of sampling, data collection, and analysis. GT is a qualitative research method, which was originally developed by two social scientists, Barney G. Glaser and Anselm L. Strauss, in the 1960s for the purposes of studying the care of dying patients (Glaser & Strauss, 1965). Accordingly, in their seminal book, *The Discovery of Grounded Theory* (Glaser & Strauss, 1967/1999), they discuss the importance of a data-driven, inductive inquiry, and the limitations of a theory-oriented, deductive approach. Glaser and Strauss (1967/1999) underline that the findings of GT research are *discovered* through engagement with the data. Discovering means that the data are interpreted through the researcher’s open attitude and the findings are developed through a data-driven, systematic yet flexible analysis strategy (Bryant & Charmaz, 2007; Charmaz, 2014).

As Glaser and Strauss (1967/1999) studied the awareness of dying in terminally ill patients, they needed to engage deeply with the people involved, and let the research subjects’ input (emerging through the data) guide the research process. This kind of delicate research context required an *approach of openness* and truly listening to research subjects and their thoughts, feelings, and desires. In such a situation, studying the awareness of dying, they could not rely on general existing theories or design a fixed data collection process in advance. Moreover, they could not anticipate the possible directions that the study would eventually take. As social scientists (not trained as medical personnel), they naturally did not have a prior understanding of what is involved in caretaking for terminally ill patients. Thus, an open-ended and gradually developed research design was a necessity.

To reach their goal of data-driven inquiry, Glaser and Strauss (1967/1999) also developed an analysis process in which data collection and analysis operated in parallel. Here, the analysis starts immediately after acquiring the first set of data. The concepts, which emerge in the first steps of the analysis, guide the subsequent steps of the research. This kind of sampling process in which concepts, instead of other parameters such as demographics (e.g., age, ethnicity, occupation, or place of residence), guide the sampling decisions is central to GT. It is called *theoretical sampling*, and leads to a cycle, as the data collection is followed by immediate analysis, which results in concepts, which generate questions that guide the proceeding research activities, which, in turn, lead to the collection of new data. This cycle is repeated until similar concepts begin to emerge as new data are analysed, and no new relevant
information emerge, i.e., all main categories are fully developed. This point of completion is called theoretical saturation. It means that the categories are identified for their properties and dimensions (Corbin & Strauss, 2015).

In their seminal work, Glaser and Strauss (1967/1999) underline the inductive and data-oriented approach. They state that the data should be approached as objectively as possible. Since their early work in the 1960s, they have continued working separately and developed GT practices in different directions. A Glaserian approach to GT underlines a strictly inductive approach to data analysis with emphasis of ultimate objectivity (Thornberg & Charmaz, 2014). The Straussian line of GT differs from this and leans towards abductive reasoning in data analysis (Charmaz, 2014).

Since its early years, GT has gained popularity amongst qualitative researchers, and the approach has been developed further, with many variations (Bryant & Charmaz, 2019; Charmaz, 2016; Morse et al., 2016). Nevertheless, a researcher always need to reflect on and design the data collection and analysis according to their research design and research context (Bryant & Charmaz, 2007; Charmaz, 2014).

3.3.2 Basic Principles of Grounded Theory

The goal of a GT process is to form a theory. Most commonly, the literature discusses the formation of a substantive theory, “a theoretical interpretation or explanation of a delimited problem in a particular area, such as family relationships, formal organisations, or education” (Bryant & Charmaz, 2007, p. 610). A substantive theory goes beyond the mere description of a phenomenon, focusing on theoretically conceptualising the key components. In this research, design principles are understood as such theoretical conceptualisation, explaining in a concise form the ways in which the principles should guide the pedagogical design.

The basis for discovering a substantive theory is a data-driven analysis and theoretical sampling. Constructing a substantive theory means that the inquiry holds a firm basis in reality through data-driven inquiry. A strong link to authentic, real-life situations grounds the substantive theories in data, from which the name grounded theory originates.

Data analysis in GT involves coding of the data, which requires the analyst to define a certain coding strategy. In most cases, the coding process in GT starts with open coding, in which an analyst identifies various incidents and emergent concepts in the data. In this phase, hundreds of codes can be generated, depending on the data. Next, these codes are organised under categories. The categories are compared for their properties and dimensions. This phase is called axial coding. In the next selective coding phase, core categories are identified for the basis of the formation of a substantive theory.
To apply this kind of coding, a pre-defined theoretical framework cannot provide guidelines for the analysis. The concepts that emerge from the data may lead to a different theoretical direction than a researcher could have determined beforehand. For this reason, an open mind is the key to data-driven analysis. Nevertheless, existing theories are used to inform the analysis. They are employed to provide understanding of the emergent concepts that are discovered through the analysis, i.e., in the axial and selective coding phases. From this point of view, the data collection, analysis, and review of theory form an iterative and cyclical process, as presented in Figure 13.

While conducting the coding of the data, a constant comparative method is crucial. This method refers to the iterative analysis and going back and forth with more developed categories and raw data. Here, an analyst compares the properties and dimensions of distinct level categories and raw data to ensure that the interpretations of the researcher align with the authentic data.

3.3.3 Research Process, Theoretical Sampling, and Analysis Strategies

Below, I address the abovementioned basic principles that are central to GT and show how I have applied these principles in this thesis. The entire research process and sampling points are presented in Figure 14. Moreover, Figure 13 and Table 4 demonstrate the relationships between the two design experiments, datasets, publications, and the synthesis of this thesis. Figure 13 also presents the iterations of the analysis. A detailed description of the entire research process (Figure 14) starts from the orientation phase and progresses through the (non-linear) research activities of two design experiments. Through eight points of theoretical sampling, the process leads to the development of synthesis. In this thesis, the synthesis is presented as grounded principles for open design pedagogy in Chapter 4.

Next, I describe the conducted research process, sampling decisions, and analysis strategies through the following basic principles of GT.

- In this research, the researcher’s subjective position and open attitude towards the research environment and data were central.
- Data collection and analysis were conducted as parallel and cyclical processes, and informed each other.
- Iterative engagement with the data analysis and review of theory alternated with and informed each other.
- Sampling was designed based on the concepts that emerged from the data, i.e., theoretical sampling.
- Coding strategies followed a method of open coding, axial coding, and selective coding.
A constant comparison method cross-checked iteratively different levels of conceptualisations against each other and the raw data.

A substantive theory and design principles were formed through abductive analysis, conceptualisations, and review of theory.

In this research, as I was a researcher conducting a GT process, I approached the research environment as openly as possible, without any pre-defined assumptions, hypotheses, or detailed research questions in mind. This required me to acknowledge my prior knowledge as an artist, art educator, designer, and researcher. I had already worked with theories concerning art and design education with small children during my teacher training, and had several years of work experience as an artist/designer and art educator amongst children. I also had knowledge of design practice and research from my education and previous profession as a ceramic designer. I was also aware of the expectations of the academic research community I had recently joined as a doctoral researcher.

Approaching the research design and research environment with this prior knowledge and experience required me to reflect on my preconceptions of the phenomena of using digital tools in ECEC and to recognise my biases towards everyday life in a kindergarten. Thus, it was important for me to start the research process with an orientation to the research environment. At this phase, I reflected on my position (first of all) as a researcher, but with the background of an art educator and a designer. This orientation phase served the goal of getting to know the structure of the daily routines in the kindergarten and orientate myself to the user needs.

Intentionally, I did not have any detailed research questions. Nevertheless, for the purposes of communicating the research and aligning it with the objectives of the research environment (i.e., the objectives and values of the curriculum and practices in the kindergarten), I formed two initial and deliberately open questions to guide the collaboration with the research participants. These early stage RQs were 1) What are the characteristics of participatory design in pedagogy development in ECEC? and 2) How can audiovisual equipment and methods (and what kind) be utilised to enhance the participation of children in ECEC? These initial RQs guided the first steps of the research process; their purpose was implicit and thus they were not explicitly addressed. Furthermore, as the research process advanced, these initial and general questions were further developed into more specific research questions, which were investigated in the sub-studies and reported in the publications of this thesis (see Section 1.2).

I started the data collection with the first design workshop. By following GT principles, I started to analyse the data immediately with the first collected dataset. I wrote a research diary. For structuring the many concepts emerging in the initial analysis of the multifaceted data, I also used visual methods, which
meant structuring the initial insights into mind maps (see Figure 11). These served as visual memos, which facilitated my thinking and concept creation. These visualisations also served as a communication tool with research participants, and were commonly presented at the beginning of each design workshop to summarise previous discussions. This also provided participants with an opportunity to comment and reflect on earlier discussions and state their different opinions or reach a consensus.

The initial analysis also introduced a set of emergent concepts, such as an adult’s perception of children’s learning, and the community that supports new approaches and experimentation (Brinck et al., 2020, p. 7). These emergent concepts guided the review of theory and theoretical sampling process (see Figure 14). The sampling points are described in Table 6 in order of their appearance.

Figure 14 shows the ways in which Design experiment 1 (DE1) produced Dataset 1. Its analysis was reported in Publications I and III. The first iteration of the analysis of Dataset 1 resulted in a substantive theory of the zones of participation (ZoP) and was reported in Publication I. ZoP identifies the importance of the fluid roles that adults and children play during the design workshops and learning activities. As participants take on different roles during the activities and move between them, fluid roles indicate agency and the quality of interaction.

After the first round of analysis (Figure 14, Analysis 1), it was evident that the rich set of data entailed a wider perspective than was covered in Publication I and the ZoP conceptualisation. Subsequently, by applying theoretical sampling, another view was taken towards the data (see Figure 14, Theoretical sampling 7, and Analysis 3). Here, firstly, activities that make use of digital technology were identified from the data, and secondly, educators’ pedagogical approaches behind these activities were analysed. This second iteration of the analysis of Dataset 1 revealed the concept of open design pedagogy reported in Publication III.

Figure 14 also presents the ways in which Design experiment 2 (DE2) was initiated through theoretical sampling (see Figure 14, theoretical sampling 2, and Table 6) and produced Dataset 2. In DE1, in our design workshops, we were identifying design challenges, resources, and opportunities. In our discussions, we were pondering children’s physical interaction with the material world and exploring their immediate environment through play. These discussions are indicated in the initial analysis as, e.g., emerging concepts of getting to know the world through enquiry, learning activities that are initiated by children’s play, and excepting speed and loudness (see more of emerging concepts, Publication I, p. 7., Brinck et al., 2020). Playing with sand was one of the examples of such constructive play. From these discussions, the idea of building a technology prototype, an augmented reality sandbox (named +Andscape) to support constructive play with digitally augmented material emerged.

The design of the prototype was participatory and engaged children and educators (as reported in Publication II) to provide insights into the design of
the features of +Andscape. Two developers were involved with implementing the technical side of the prototype (see Section 1.3).

DE2 resulted in Dataset 2. Contrary to the open coding, this dataset was analysed in the framework of a progressive inquiry learning model (Hakkarainen et al., 2004) (see detailed description: Leinonen et al., 2021). Nevertheless, during the analysis, we (the authors of Publication II) remained open to the data and modified the coding frame to fit the data (instead of forcing the data to fit the coding frame). Actually, as DE2 was initiated through theoretical sampling after Phase 1/DE1, its initial analysis provided us with concepts, insight, and confidence to apply the progressive inquiry model to review the data in Analysis 2 (Figure 14).

Even though we were approaching the analysis of Dataset 2 with a pre-defined coding frame, it did not mean that we were straying from a data-driven approach. The decision to use a progressive inquiry model as a coding frame provided us an opportunity to test the concepts arising from DE1.

As a result of the GT process, I formulated a substantive theory of zones of participation (Publication I); in addition, DE1 and DE2 contributed to the final iteration of the analysis, i.e., the synthesis of this thesis, to develop grounded principles for open design pedagogy (see Figure 13).

**Figure 13**

*Iterative Development of the Data Analysis*
Grounded Principles for Open Design Pedagogy

Figure 14
Entire Research Process: Design Experiments, Sampling, GT Analysis, and Publications

DESIGN EXPERIMENT 1 (DE1)

PHASE 0/DE1: Orientation

PHASE 1/DE1: Design workshops 1–4

PHASE 2/DE1: Design workshops 5–11

PHASE 3/DE1: Design workshops 12–15

ANALYSIS 1

DATA COLLECTION AND INITIAL ANALYSIS

OPEN CODING

REVIEW OF THEORY

FIRST CODING FRAME

THEORETICAL SAMPLING 1

OPEN AND AXIAL CODING

REVIEW OF THEORY

THEORETICAL SAMPLING 2

AXIAL AND SELECTIVE CODING

SELECTING CORE CATEGORIES

INTERPRETING OF THE FINDINGS, MAIN ANALYSIS

SUBSTANTIVE THEORY OF THE ZONES OF PARTICIPATION (ZoP)

THEORETICAL SAMPLING 3

CONSTANT COMPARATIVE METHOD

THEORETICAL SAMPLING 7

THEORETICAL SAMPLING 8

ANALYSIS 3

IDENTIFYING DIFFERENT TYPES OF ACTIVITIES FROM THE DATA

CONCEPTUALISING

TWO CORE CATEGORIES OF THE ACTIVITIES WERE FORMED

TWO CORE CATEGORIES WERE ANALYSED FOR EDUCATORS’ PEDAGOGICAL APPROACHES

IDENTIFICATION OF THE IMPORTANT CONCEPTS TO DESCRIBE THE PEDAGOGICAL APPROACH

EXTRACTING EXCERPTS AND VISUAL MATERIAL FROM THE RAW DATA

SYNTHESIS: THE KEY CONCEPT OF OPEN DESIGN PEDAGOGY

Publication

Publication III

Grounded principles for
DESIGN EXPERIMENT 2 (DE2)

PHASE 0/DE2: Idea

PHASE 1/DE2: Design workshops 1–2 (children)

PHASE 2/DE2: Design workshop 3 (educators and developers)

PHASE 3/DE2: Design workshops 4–7 (children)

ANALYSIS 2

INITIAL REFLECTIONS ON DATA

REVIEW OF THEORY

THEORETICAL SAMPLING 4

THEORETICAL SAMPLING 5

IDENTIFYING EPISODES FROM THE DATA

REFLECTING ON THE INITIAL CODING FRAME

DEVELOPED CODING FRAME

+Andscape prototype

THEORETICAL SAMPLING 6

THEORETICAL SAMPLING 6

REVIEW OF THEORY

INITIAL CODING FRAME

Identification of episodes from the data

Reflecting on the initial coding frame

Developed coding frame

Publication II

Note. Theoretical sampling points 1–8 (TS, marked here in red) are clarified in Table 6.
As we were initiating the Design experiment 1 and the Design workshops 1–4 (phase 1/DE1), the main goal was to design learning activities.

<table>
<thead>
<tr>
<th>Theoretical sampling Points (TS)</th>
<th>Description of the TS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design experiment 1 (DE1)</strong></td>
<td><strong>Design experiment 2 (DE2)</strong></td>
</tr>
<tr>
<td>TS1</td>
<td>The first point of TS was to proceed from designing the learning activities to implementing them (Phase 2/DE1).</td>
</tr>
<tr>
<td>TS2</td>
<td>The second point of TS entailed a decision to expand the study to proceed with a parallel design experiment (DE2) for building a technology prototype to study early childhood learning with digital technologies. To initiate the building of the prototype, we organised two design workshops with children.</td>
</tr>
<tr>
<td>TS3</td>
<td>The third point of TS was to proceed from implementing the learning activities to develop a design tool (Design Puzzle) for the participatory design of learning activities (Phase 3/DE1).</td>
</tr>
<tr>
<td>TS4</td>
<td>The fourth point of TS engaged educators and developers to design the prototype.</td>
</tr>
<tr>
<td>TS5</td>
<td>The fifth point of TS entered into final design of the prototype based on the previous workshops and initiated the implementation.</td>
</tr>
<tr>
<td>TS6</td>
<td>The sixth point of TS organised children’s play with the prototype, data collection, and analysis.</td>
</tr>
<tr>
<td>TS7</td>
<td>The seventh point of TS recognised that another view on Dataset 1 (collected in DE1) could provide more information on activities, and thus initiated Analysis 3.</td>
</tr>
<tr>
<td>TS8</td>
<td>The eighth and final point of TS (i.e., this thesis) combined the findings of DE1 and DE2 to conduct a principle-focused elaboration process in order to form the grounded principles for open design pedagogy (see Chapter 4).</td>
</tr>
</tbody>
</table>
To begin to familiarise myself with the data in Design experiment 1 (DE1), I used open coding. As I was collecting the data myself and engaging in producing it, I had a profound understanding and knowledge of the overall content. However, only by engaging deeply with the analysis was it possible to gain solid insight and a new perspective to explain the phenomenon.

Although Glaser and Strauss (1967/1999) underline an inductive and data-driven approach, I share the view of Morgan (2020) that a purely inductive approach is unachievable in practice. This is due to the fact that we all, when engaging in academic research, have some prior knowledge of theories and an understanding of the research environment as we engage with it, and also obtain favourable means to approach it. We are not able to fully prevent these preconceptions from affecting the content of the research design, data collection, and analysis. Thus, my approach was to maintain as open a mind as possible and genuinely let the data reveal themselves.

The analysis was an iterative, nonlinear process. It included several rounds of listening, looking, and reading to form a first impression of the data. Therefore, I started the analysis with an inductive approach. As initial concepts arose through open coding, I reviewed the corresponding literature to gain a theoretical understanding of the emerging concepts. In this process, I clearly engaged in an abductive approach.

Retrospectively, I would describe the overall research process as abductive. In Figure 15, I present analysis strategies for the entire process. As Morgan (2020) discusses pragmatism and its application to GT, he identifies abduction as enabling the identification of emergent issues in the analysis through a combination of prior beliefs and being informed by the literature. From this perspective, research insights rely on the researcher’s interpretation and require a reflexive attitude towards one’s own preconceptions and beliefs.

The sub-studies in DE1 followed the coding sequence of GT, i.e., open coding, axial coding, and selective coding, and conducted a full cycle of analysis. The conclusion of each cycle involved several iterations of examining the data. In the open coding phase, I divided the data into small parts, which means that I identified individual incidents and gave them a descriptive code: e.g., critical reflection on one’s own role as an educator; ways to bring forward children’s ideas; routines and structures in the kindergarten; and documentation, its purpose, and meaningfulness. In the axial coding phase, I grouped open codes under more generalised categories, identified the properties and dimensions of the categories and applied a constant comparison method, i.e., compared these mid-level categories to each other and against the raw data. Categories in the axial coding phase included, e.g., educator, child, play, learning, and participation. As I grew in confidence that the core categories were discovered, through many iterations of analysis, I entered into the selective coding phase. In this phase, the core categories were elaborated to indicate a substantive theory emerging and the core categories being crystallised into content that
could be described as an entity of concepts, e.g., here describing the roles identified through the analysis: adult: audience; adult: whisperer; adult: actor; adult: director; child: audience; child: whisperer; child: actor; and child: director.

Contrary to the coding strategy applied in DE1, the data analysis in DE2 followed a qualitative content analysis (Flick, 2014), which here means that the data were approached through a theory-driven coding frame of progressive inquiry learning.

**Figure 15**
*Analysis Strategies*
3.4 Participants and Data

Below, in Table 7, I summarise the data, participants, and analysis strategy of each publication.

Table 7
Publications, Design Experiments, Participants, Data, and Analysis

<table>
<thead>
<tr>
<th>Publication</th>
<th>Design experiment</th>
<th>Aim</th>
<th>Participants</th>
<th>Data</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
<td>Investigating design roles in an intergenerational participatory design process</td>
<td>Kindergarten teachers (N = 2), Childcare assistants (N = 3), Pre-service teacher (N = 1), Children (N = 20), Pedagogical specialists (N = 4)</td>
<td>Photographs, Video, Audio, Text</td>
<td>Data-driven, reflecting theory Coding frame derived from the data</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>+Andscape, exploring and observing children’s play with an augmented reality sandbox</td>
<td>Children (N = 16, 5–6 years old)</td>
<td>Video</td>
<td>Theory-driven approach to data analysis Initial coding frame inspired by the DE1, then derived from theory, and modified based on the data</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>Identifying characteristics of the pedagogical activities and educators’ pedagogical approaches in an intergenerational participatory design process</td>
<td>Kindergarten teacher (N = 1), Pre-service teacher (N = 1), Pedagogical specialists (N = 4), Childcare assistants (N = 3), Children (N = 12, 4–5 years old)</td>
<td>Photographs, Video, Audio, Text</td>
<td>Data-driven, reflecting theory Coding frame derived from the data</td>
</tr>
</tbody>
</table>
About movement and dance—so last year we started to do parkour. It was clearly about what they want to play and learn, it was about physical skills. And then the ways it is playful, as it is about using children’s imagination. It’s about how to take different surfaces and move and that’s how it was. Then when it’s free, and you’re doing it according to your own skills, then it’s as meaningful as the children themselves produce it.

(Excerpt from data, personal communication, educator’s statement, 2017)
4 RESEARCH CONTRIBUTION: Developing Grounded Principles for Open Design Pedagogy

In this chapter I answer the three main research questions: RQ1 What are the design principles for designing pedagogical practices that apply digital technologies to early childhood design education? RQ2 How can these be further developed into grounded principles for open design pedagogy? RQ3 What are the grounded principles for open design pedagogy?

To investigate RQ2, and for the purpose of refining the design principles, I develop an analysis method that I call a principle-focused elaboration process. This process starts with identifying the initial pedagogical design principles (DPs) as their emergent phase from the original publications, continues with reviewing theory (framed by the initial DPs) and finalises the process by revisiting the raw data for validation. I conclude the process by presenting a synthesis: a refined version of grounded principles for open design pedagogy. These principles provide important insights into methods through which digital tools should be incorporated in early childhood pedagogy. They can also be more widely utilised by educational researchers as a starting point for further study, or by practitioners to design pedagogical activities in many levels of schooling or other educational contexts.

The initial motivation to formulate design principles arises from design-based research (Collins et al., 2004; Shattuck & Anderson, 2013) and from a personal aspiration to provide practical, research-based solutions for practitioners, with a parallel contribution to the discipline in the form of theoretical knowledge. Combining participants’ and researchers’ perspectives to develop the design principles (Shattuck & Anderson, 2013) enables a clarification of a messy and complex real-life educational context (Collins et al., 2004). As it is based on both practice and research, the aim of the DPs is to provide ways to work around challenges (Herrington & Reeves, 2011) when integrating digital tools in education—in this case, particularly in ECEC, but also other educational contexts.

To form grounded design principles for open design pedagogy requires conducting a new iteration of the analysis in Publications I, II, and III.

The analysis starts with a review of the research process from a holistic viewpoint to form a synthesis. The analysis advances in three phases: 1) a meta-analysis of the theory, findings, discussion, and conclusions sections of the articles; 2) a review of the theory for the concepts that emerge from
the meta-analysis; and 3) examining these against the raw data for validation. For this analysis cycle, I developed a process of principle-focused elaboration (Figure 16). It is one form of a triangulation method, as it combines different perspectives to the synthesis and thus strengthens the quality of the research (Flick, 2014).

**Figure 16**

*Principle-Focused Elaboration Process*

The principle-focused elaboration method is applied to the three publications (I, II, and III) of this thesis, particularly focusing on the theory, findings, and discussion/conclusion sections. These sections are chosen for analysis because they have the most prominent link to both theory and empirical investigation. Thus, conducting a meta-analysis for the abstract, introduction, and methodology sections of the articles is not relevant at this point (with one exception: Publication II integrates the introduction and theory into one section, so it is included in the analysis).

### 4.1 Description of Principle-Focused Elaboration Process

This section answers RQ2, How can these [i.e., the initial design principles] be further developed into grounded principles for open design pedagogy? The process as a whole entails three phases: 1) a meta-analysis of the original publications; 2) a review of the theory behind the concepts that emerge from the meta-analysis; and 3) an examination of these against the raw data for validation.
4.1.1 Phase 1: Meta-Analysis of Publications

The first phase of the principle-focused elaboration process contributed to answering RQ1 (What are the design principles for designing pedagogical practices that apply digital technologies in early childhood design education?). This question is addressed by conducting a meta-analysis of the original publications and identifying key concepts and core categories. This phase involves inputting the selected sections of the three publications into Atlas.ti (analysis software) and investigating them with regards to their theoretical frame and empirical findings. I identified the initial design principles through reflection, interpretation, and coding the empirical studies. This process started with reviewing the sections systematically, paragraph by paragraph, without a pre-defined coding frame. The coding of the articles was repeated several times and the codes were re-evaluated to ensure that my interpretations and choices as an analyst were correct.

I acknowledge that, because I was deeply involved in the field work, data analysis, and writing of the publications, my approach to the coding was entangled with my existing knowledge about both the research process and the outcomes. Nevertheless, as the aim here is to formulate a holistic synthesis, there are benefits to this position. Understanding the context along with the details of the raw data provided an optimal starting point for interpretation and forming conclusions—even considering that they may be informed and affected by the researcher’s (author’s) subjective understanding.

This coding phase generated 29 codes, which are linked to a quotation in 509 occasions. In Table 8, the number of codes is shown with their groundedness (Gr)\(^{20}\), and the code distribution between the publications (see also Figure 17). The open coding phase indicates a relatively even overall code distribution between the publications (N = 152–194). However, differences also occur, resulting from the different foci of the publications. For example, Publications I and III discuss *listening to a child* and *agency*, which are not prominent topics in Publication II. On the other hand, Publication II has more mentions of *artefact, tool, material, embodiment, or object* and *inquiry learning*. When interpreting the findings, it is important to remain mindful that groundedness alone does not indicate the importance of the code or concept. Sometimes it is meaningful to acknowledge the topics that are absent from the data. In this way, a qualitative analysis can also reveal the *silent points*, those unspoken topics that the analyst identifies (e.g., based on the literature) to be important, e.g., taboos that cannot be shared or discussed openly. Nevertheless, in this case, the coding shows both significant similarities and differences in the distribution of the codes between the publications. This confirms that the three studies are linked—investigating the same phenomenon but from different perspectives.

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\(^{20}\) Groundedness (Gr) presents the number of times a code has been added to a quotation.
Table 8
*Codes, Their Groundedness (Gr), and Distribution between the Publications after the Open Coding Phase*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Everyday learning) activities <em>Gr = 24</em></td>
<td>10</td>
<td>3</td>
<td>11</td>
<td>24</td>
</tr>
<tr>
<td>Agency <em>Gr = 18</em></td>
<td>8</td>
<td>3</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>Artefact, tool, material, embodiment, or object <em>Gr = 54</em></td>
<td>3</td>
<td>37</td>
<td>14</td>
<td>54</td>
</tr>
<tr>
<td>Children’s voices, ideas, and experiences <em>Gr = 46</em></td>
<td>14</td>
<td>19</td>
<td>13</td>
<td>46</td>
</tr>
<tr>
<td>Collaborative exploration <em>Gr = 6</em></td>
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<td>5</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Digital technologies <em>Gr = 55</em></td>
<td>3</td>
<td>35</td>
<td>17</td>
<td>55</td>
</tr>
<tr>
<td>ECEC <em>Gr = 14</em></td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Inquiry learning <em>Gr = 7</em></td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Learning environment <em>Gr = 10</em></td>
<td>2</td>
<td>1</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Listening to a child <em>Gr = 8</em></td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Open design pedagogy <em>Gr = 6</em></td>
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<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Participation <em>Gr = 31</em></td>
<td>23</td>
<td>2</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>Participatory design—theory <em>Gr = 3</em></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Participatory design and children—theory <em>Gr = 5</em></td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Participatory design—process <em>Gr = 13</em></td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Pedagogical practices and approaches <em>Gr = 19</em></td>
<td>7</td>
<td>2</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>Pedagogical presence <em>Gr = 6</em></td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Playful interaction with technology <em>Gr = 41</em></td>
<td>2</td>
<td>32</td>
<td>7</td>
<td>41</td>
</tr>
<tr>
<td>Prototype <em>Gr = 8</em></td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Real-life investigation <em>Gr = 12</em></td>
<td>2</td>
<td>10</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Reflection <em>Gr = 29</em></td>
<td>7</td>
<td>1</td>
<td>21</td>
<td>29</td>
</tr>
<tr>
<td>Receptivity to new ideas and change, tolerance of uncertainty <em>Gr = 21</em></td>
<td>4</td>
<td>0</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>Roles <em>Gr = 22</em></td>
<td>20</td>
<td>0</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td>Sociocultural context and environment <em>Gr = 10</em></td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Storytelling <em>Gr = 17</em></td>
<td>0</td>
<td>17</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Twenty-first century skills <em>Gr = 2</em></td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Visual documentation <em>Gr = 10</em></td>
<td>1</td>
<td>0</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>World <em>Gr = 3</em></td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Zones of participation <em>Gr = 9</em></td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Totals</td>
<td>152</td>
<td>194</td>
<td>163</td>
<td>509</td>
</tr>
</tbody>
</table>
Next, I continued by organising the individual codes into categories by dividing them into code groups (in Atlas.ti). This axial coding phase generated nine upper-level categories. I did not force the codes to fall under any specific category. The term *sociocultural context and environment*, for example, is conceptually so broad that it frames and informs all the other categories rather than falls into any one category. For this reason, it is identified as an up-level frame for all the categories. Thus, it is selected as an overarching theoretical frame on which all the other categories reflect.

Taken together, these upper-level categories form the initial pedagogical design principles, which are directly derived from the original publications, and thus answer the RQ1. These initial DPs are deeply rooted in the empirical data and the published findings of three sub-studies. Subsequently, they are grounded on their own and have stand-alone merit. The initial DPs are a starting point for developing the synthesis of this thesis: the refined design principles for open design pedagogy.

The nine initial DPs are (in alphabetical order):

- Following children’s ideas
- Pedagogical presence
- Playful interaction with technology
- Promoting active participation
- Reflection
- Understanding fluid roles in pedagogical activities
- Versatile use of tangible artefacts
- Visual documentation
- Working openly in conditions of uncertainty

The distribution of the categories (i.e., initial DPs) by the publications is illustrated in Figure 17.
Figure 17

Distribution of the Initial DPs in Publications I, II, and III
Next, I conducted a selective coding phase to discover higher-level core categories. Elaboration of these core categories is based on the groundedness of the codes and the categories, as well as my experience and interpretation as a qualitative researcher, resulting from the sensitivity gained towards the process and the data. I have prior knowledge and a deep understanding from being active as a designer and researcher while conducting the fieldwork, collecting, producing, and analysing empirical data, reviewing the literature, and writing the publications. Based on this subjective perspective, these categories are justified because they make sense in this specific context.

Through selective coding, the initial DPs that were derived from the empirical studies are further conceptualised as the core categories of the learning environment, learning task, learning community, and learning activity (Table 9). Thus, I have chosen them as focal points for the theoretical investigation.
### Table 9
**Coding Process of Meta-Analysis**

<table>
<thead>
<tr>
<th>Open coding: concepts</th>
<th>Axial coding: categories</th>
<th>Selective coding: core categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Everyday learning) activities $Gr = 24$</td>
<td>Following children’s ideas</td>
<td>Learning environment</td>
</tr>
<tr>
<td>Agency $Gr = 18$</td>
<td>Pedagogical presence</td>
<td>Learning task</td>
</tr>
<tr>
<td>Artefact, tool, material, embodiment, or object $Gr = 54$</td>
<td>Playful interaction with technology</td>
<td>Learning community</td>
</tr>
<tr>
<td>Children’s voice, ideas, and experiences $Gr = 46$</td>
<td>Promoting active participation</td>
<td>Learning activity</td>
</tr>
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<td>Collaborative exploration $Gr = 6$</td>
<td>Reflection</td>
<td></td>
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<tr>
<td>Digital technologies $Gr = 55$</td>
<td>Understanding fluid roles in pedagogical activities</td>
<td></td>
</tr>
<tr>
<td>ECEC $Gr = 14$</td>
<td>Versatile use of tangible artefacts</td>
<td></td>
</tr>
<tr>
<td>Inquiry learning $Gr = 7$</td>
<td>Visual documentation</td>
<td></td>
</tr>
<tr>
<td>Learning environment $Gr = 10$</td>
<td>Working openly in conditions of uncertainty</td>
<td></td>
</tr>
<tr>
<td>Listening to a child $Gr = 8$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open design pedagogy $Gr = 6$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation $Gr = 31$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participatory design—theory $Gr = 3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participatory design and children—theory $Gr = 5$</td>
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<tr>
<td>Participatory design—process $Gr = 13$</td>
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<tr>
<td>Pedagogical practices and approaches $Gr = 19$</td>
<td></td>
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<tr>
<td>Pedagogical presence $Gr = 6$</td>
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<td></td>
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<tr>
<td>Playful interaction with technology $Gr = 41$</td>
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<td></td>
</tr>
<tr>
<td>Prototype $Gr = 8$</td>
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<tr>
<td>Real-life investigation $Gr = 12$</td>
<td></td>
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<tr>
<td>Reflection $Gr = 29$</td>
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<tr>
<td>Receptivity to new ideas and change, tolerance of uncertainty $Gr = 21$</td>
<td></td>
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<tr>
<td>Roles $Gr = 22$</td>
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<tr>
<td>Storytelling $Gr = 17$</td>
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<tr>
<td>Visual documentation $Gr = 10$</td>
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<tr>
<td>World $Gr = 3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zones of participation $Gr = 9$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.1.2 Phase 2: Review of Theory

Engeström (2018) states that any theories of learning must address the questions of who, why, what, and how: who addresses subjects of learning; why queries the reason for learning, i.e., the fuel to make the effort for learning; what implies to the learning contents and outcomes; and how refers to the “key actions of processes of learning” (p. 46). Although I acknowledge here that I do not form any general learning theory, my aim is to form principles for a pedagogical design, which apply to a local context. Thus, I choose to apply this frame of questioning to my review of theory as part of the principle-focused elaboration process. I start by examining these basic questions based on theory (Phase 2), and continue to investigate them against the empirical data (Phase 3).

In relation to the basic mediated action triangle created by Vygotsky (Figure 3), I position the questions that Engeström proposes in the following way: who refers to the subject and learning community; what refers to the object and learning task; how refers to the mediational means and learning environment; and, finally, why is positioned in the middle to address the process of learning and learning activity (see Figure 23).

4.1.2.1 Who Are the Subjects of Learning?

According to Illeris (2017), the subject of learning is traditionally understood as an individual—a person who learns something new. He states that, since the late 1980s the concepts of social learning and situated learning have emphasised that learning happens between people in a social and cultural context. These theories of the social nature of learning have their foundations in Vygotsky’s (1978) theories, as he extended the view from simple stimulus–response actions to culturally mediated actions in which the learning subject is an active agent. Following Vygotsky, Wertsch (1993) points out that human mental functioning emerges in the interaction between the environment and individual agent and cannot be analysed in isolation. Nevertheless, learning in social interaction happens in an individual mind and therefore, learning has both an individual and social side (Illeris, 2018).

In his expansive learning model, Engeström (2018) extends the concept of zone of proximal development to apply a context of organisational learning. He describes the learning cycle of an activity system, or many parallel activity systems, in which the learning subject is (instead of an individual) a working team or an entire organisation. Furthermore, the situated learning theory by Lave and Wenger (1991) suggests that communities of deep collaboration, such
as communities of practice (Lave, 1991), can be considered collaborative subjects of learning. Lave and Wenger (1991) also argue that participation should be regarded as a way of learning and that learners (or newcomers, as they refer to them) are “absorbing and being absorbed in – the ‘culture of practice’” (p. 95). Adding to this, Vartiainen and Enkenberg (2014) encourage educators to build communities of learning in which students, fellow educators, and professional experts outside the school collaborate. This expanded learning environment and the social networks it entails ground the learning processes in authentic environments, with heterogeneous participants sharing their individual and communal expertise. Learning as a community requires learners to share their expertise and also receive others’ contributions to the task. This kind of distributed expertise is essential in collaborative learning.

In our case, the educators and children were learning together as an intergenerational learning community. The educators’ statements in Excerpts 2 and 3 describe the way in which learning as a community was recognised as a new mode of thinking. These experts are also presented in Publication I.

**Excerpt 2**

*Discussion between Educators 1, 4, and 5 in Workshop 4*

- Educator 1: I think that, at this moment, our design goals and our discussions are focusing on the ‘child as a learner’. What is special in early childhood education is that the ‘adult is a learner’ as well. So, if we wish to change something, the change needs to happen in the adult and in their thinking. In this way, children get opportunities to move beyond what has been previously defined by the adults. Could this [design] process lead to a method for adults to learn new [participatory] ways for designing activities and instruction?

(Personal communication, educator’s statement in Workshop 4, 2017) (Brinck et al., 2020, p. 9).

**Excerpt 3**

*Discussion between Educators 1, 4, and 5 in Workshop 1*

- Educator 2: Do we give opportunities to children to learn from each other in different ways? Do we act as educators or just as ‘one of those adults’ who define how the group [of children] is formed and what the activity is and what they do?
- Educator 1: In the group activity, does it really matter who are the adults and who are the children, if there is a common goal to work towards? What if we don’t position ourselves as adults and children . . . [but as a group of designers]?

(Personal communication, educator’s statement in Workshop 1, 2017) (Brinck et al., 2020, p. 9).
In summary, the learning subject can be understood both as an individual participating in cultural activities and as a group of subjects, such as a team, organisation, or community (Engeström, 2018; Lave, 1991, 2009; Lave & Wenger, 1991). In this research, a learning community is understood as a heterogeneous and collaborative entity of individuals who share their individual and communal expertise. The learning community supports a participant to act in their various roles, which prevents a strict hierarchy.

4.1.2.2 Why Do Subjects Learn?
Illeris (2017) points out that humans are created to learn and at the same time doomed to learn because they cannot avoid learning. Also, humans are, in contemporary societies, enforced to learn to gain abilities to function in their daily lives, which makes learning problematic as we cannot choose the learning content based on our ambitions and desires.

Sociocultural theories identify social and cultural actions as central to learning (Vygotsky, 1978). Reflecting on this approach, the question of why subjects learn is parallel to the question of why subjects act. This, again, leads to the concept and context of the learning activity itself. According to Lave (2009), a person’s actions “cannot be analyzed in isolation from the socially material world of that activity” (p. 201). She continues to discuss the context, meaning the relationships between people acting and interacting with the social world. She notes that situated activity results in changes in both knowledge and activity, which is the inherent basis of learning. She describes this process as “changing participation in the culturally designed settings of everyday life” (p. 201). This is contradictory to traditional cognitive theory, which sets up a division between the learning mind and the social, lived-in world. Situated activity, i.e., the situated nature of learning, makes heterogeneous, multi-voiced participation the heart of all learning activities (Lave, 2009).

By promoting children’s participation by engaging them in documentation of and reflection on meaningful events, educators can create pedagogical practices and activities that support children’s agency (Lipponen et al., 2013). Munter (2013) refers to Emilson’s and Johansson’s (2009) study on the values that are communicated in teacher and child interactions. She states that, in those cases in which the children initiated practices in kindergarten, the interactions between the teachers and children were characterised by playfulness, laughing, joking, and joy. This kind of pedagogy reaches intersubjective dimensions, in which an adult recognises a child as a discussion partner (Munter, 2013).

Excerpts 4 and 5 indicate that participating in an activity (doing things together) with people supports the community of learners.
Excerpt 4

*Discussion between Educators 1, 4, and 5 in Workshop 3*

- Educator 4: Yeah, we did these new friends’ play days last year.
- Educator 1: Here, it could be linked to doing things together to make new friends, with whom one can play with cameras and take photos, or something. It can be such a big opportunity when you get to do things with someone else that you don’t usually do. In this way, no one pose any old roles on you or even drift into them themselves.
- Educator 4: Well, we actually did this here, as there was a group doing things together that would not necessarily naturally get involved like that with each other.

(Personal communication, educators’ discussion in design workshop 3, 2017).

Excerpt 5

*Discussion between Educators 1, 4, and 5 in Workshop 4*

- Educator 4: How would you say it... understanding and tolerating the fact that playing produces certain kinds of things—it is noisy, and it can include some elements of chaos and mess, or at least it seems so...

(Personal communication, educator’s statement in design workshop 4, 2017).

These excerpts reveal the ways in which the educators were reflecting on the activities that supported child-initiated actions, children’s participation, and a learning community. Figures 18 and 19 show two occasions of spontaneous play as part of the design activities. Figure 18 presents a situation in which the children were taking photographs of their favourite places in the kindergarten (Workshop 2) and at the end of the session took us (the educators) to the gym and engaged in collaborative climbing and jumping play.

Furthermore, Figure 19 shows a scene from the same workshop, and particularly a situation in which the children spontaneously, as a group, changed the way in which they moved around. By acting this way, the children engaged in self-initiated collaborative play, which appeared to be joyful and enjoyable to the children. In these cases, the educators needed to let go of strict control over the events and allow the collaborative activity to emerge and actualise as spontaneous play.
Figure 18
Child-Initiated Play in Workshop 2

Figure 19
Children’s Spontaneous Change in the Way They Moved Around—An Example of Child-Initiated Play
In summary, full participation and collaboration with others in meaningful sociocultural practices engages a person in a process of learning (Lave & Wenger, 1991). In this research, a learning activity is understood as the interconnected actions of actor(s) participating in an activity, targeted towards the object of the activity, utilising mediational means (i.e., tools and artefacts) for acting on the object (see Section 2.2).

4.1.2.3 What Are Subjects Learning?

The contents and outcomes of a learning process are here understood as objects of learning (Figure 23). Clearly, what is valued as a substance-knowledge and also the desired skill requirements vary from one discipline to another. Subsequently, the processes that define the learning content and the ways in which the outcomes are assessed become significant. The participatory and situated learning context, as described by Lave and Wenger (1991), acknowledges and values learners’ participation and active agency as key elements in a successful learning process. This approach departs from the top-down approach in which the learning content is determined and provided by teachers to students or by policymakers to teachers in a form of a strict curriculum (Vartiainen & Enkenberg, 2013). Here, it is important to reflect on the processes of designing and assessing the learning content and the desired learning outcomes that the culturally situated learning context supports (Vartiainen & Enkenberg, 2013).

Learning to understand complex phenomena and solve ill-defined problems requires open-endedness from a learning assignment. As there is no one solution to the task, it is possible to explore multiple viewpoints and potential solutions. This means that the learning content cannot be one-sided, pre-defined, or static.

In our design process, our aim was to enhance children’s participation in their everyday lives, and thus provide them with agentic opportunities to make decisions and voice their opinions. As an example, I present a design tool from the final stages of our design process. We (educators working with children) developed a Design Puzzle22, a method for participatory designing everyday activities in ECEC. The method is based on question cards and picture cards, which are used as a design tool, discussion aid, and reflection method. With the Design Puzzle, a group of children and educators can create a visualised and simplified structure of a complex activity. Each step of an activity is broken into smaller parts and presented as a visual narrative. The method supports collaborative decision making, e.g., on how the activity is documented, with whom it is shared and by what means. The visual narratives that the Design Puzzle creates can also be reflected on afterwards and used as a communication aid to discuss daily activities with guardians.

22 The Design Puzzle material is published in Finnish (Suunnittelupalat). Contact the author for access to the material. In this research, the Design Puzzle is mentioned as an outcome in Publication I, but it has not been particularly described as a design product, nor studied as a method. The Design Puzzle method should be tested and validated in further studies.
Question cards
The ready-made question cards are based on the educator’s idea blocks (page 15) and can also be printed from the appendix. In general, questions are the central part of any planning process. For example, the idea block for documentation is presented as a question card: How do I document the activity? There are also blank card templates that you can use to formulate your own questions. You can use, for example, Post-it notes. The questions can be specific: What do I wish to explore more, or where do I wish to visit? Or more general, discussion-provoking questions: What do I dream about, or how do I use my imagination?

Picture cards
The picture cards provide solutions for the question cards, and act as discussion aids. Picture cards offer options for tackling the question cards. For example, to the question How do I document the activity?, the picture cards can offer a solution that proposes, e.g., drawing and writing, video-recording, or photographing. Picture cards cover the following subject areas: places, digital devices, crafts and art, music, movement, emotions, and senses. There are also blank cards that you can use to draw or write on, or photograph different tools, moods or other aspects of the activity.

How do I document the activity? [orange card]
How do I recognise and show a skill? [blue card]
With whom do I share? In what way do I share? [red card]
How do I explore and play? [green card]
Write your own question here. [yellow card]
In summary, if the learning subject is understood as a collaborative group of individuals, a learning community, then the learning object should also be collaboratively defined, reflected on, and developed. In this research, a learning task refers to the means and actions used to reach the object of learning (i.e., the target or outcome of the action) (see Figure 23).

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24 Translation of Figure 21 by the author.
The Design Puzzle pattern was on display throughout the activity. The children returned to watch the Design Puzzle from time to time and presented it to their guardians as well.
“Today we did a parkour trip! Today we watched photos together! Today we made skill-cards!”
This sparked interesting discussions about the activity and about the objectives of the activity, also among adults.
4.1.2.4 How Do Subjects Learn?

As he reflects on the tradition of art education, Atkinson (2019) discusses the immanence of learning, which emphasises pedagogical spaces that manifest how something matters for a learner. This kind of pedagogical approach requires openness and risk-taking from the educator, as no pre-defined agendas are sufficient here because since the learning goals are negotiated collectively in practice together with the learner and the educator (Atkinson, 2019). On this point, Wertsch (1993) refers to Vygotsky (1978) when he points out that, instead of focusing merely on an individual’s cognitive abilities, learning should always be analysed by taking into account the social dimensions of mental functioning, particularly the ways in which people reflect on and create sociocultural settings. According to Illeris (2017), the word reflection has fluid meanings. In its common sense, one engages in afterthought, i.e., reflects on some event or experience. On the other hand, the word reflexivity is used in cases in which the afterthought is mirrored against personal biography as a self-reflection (Illeris, 2017). He states that the “new impulses arising from interaction with the environment do not occur directly – the words afterthought and reflection contain this element of time lag” (p. 62).

The process of reflection arises from interaction with the environment but requires time to mature into afterthought (Illeris, 2017). Accordingly, Smith et al. (2015) emphasise reflective and retrospective thinking, as they are discussing design thinking for digital fabrication with children. They propose that, to initiate reflective thinking in their students, an educator can pose a question such as “how can this product be considered successful?” (p. 24), to guide critical assessment of one’s own work and also to compare solutions with others in order to learn from their peers.

Subjects do not act directly in the world; their actions are mediated by signs (i.e., psychological) and tools (i.e., physiological). The process of mediation enables them to cross the divide between the external world (material tools) and the internal world (symbolic signs) (Silvonen, 2003). This process of mediation requires mediational means, e.g., tools and artefacts, which play a key role in sociocultural theory. The concept of tools and artefacts has been further developed by a growing number of scholars that follow Vygotsky’s thinking (Cole, 1996; Engeström, 2007; Wertsch, 2007; Wertsch & Rupert, 1993). Wertsch and Rupert (1993) discuss mediated agency as they connect culturally and socially constructed mediation to agency, i.e., “who it is that carries out action” (p. 230). They summarise the meaning of mediated agency as follows:

It [mediated agency] does mean, however, that human action is fundamentally shaped and constrained by the mediational means it employs. It is difficult, if not impossible, to have certain thoughts or memories, to formulate (let alone to solve) certain problems,
and so forth if appropriate mediational means are not available. For example, the history of science provides a constant reminder that, without the appropriate cultural tools, certain problems are very unlikely to be recognized, let alone resolved. (p. 230)

The use and creation of a variety of tools and artefacts is culturally, historically, and institutionally situated, which connects the development of new ideas and practices to existing and socioculturally situated, mediational means (Wertsch & Rupert, 1993).

In our case, various forms of play had a significant role in our design and research activities. It provided multiple opportunities for intersubjective encounters, and employed mediational means; play was developed by children in interaction with—and was enabled by—their learning environments. To explore the pedagogical opportunities of play in a digital environment, we designed and developed +Andscape—an interactive AR sandbox with magic sand, motion sensing camera, a sound system and projection (see Publication II).

Children’s play sessions with +Andscape were observed and analysed to record their actions in terms of observations, discoveries, and exploration. In addition, the analysis revealed the kind of play and stories they invented with the AR.

As stated by Leinonen et al. (2021), play with +Andscape initiated a spirit of inquiry that connected the social, material, and virtual worlds through collaborative play and storytelling. As the children were constructing imaginative stories together, they were physically and mentally engaged in developing the shared purpose of the activity. The play promoted children’s sense of agency and feeling of production-oriented participation in the digital world (Leinonen et al., 2021).
In summary, the key actions included in the processes of learning involve various mediational means to engage with and participate in sociocultural practices. This process requires time to reflect on what has happened and on one’s agency as a learner. In this research, a learning environment is understood to include the learner, other people, and the physical environment in which the learning situation occurs (Nathan & Sawyer, 2022). Student-centred learning environments acknowledge that, instead of knowledge being transmitted (by teachers or technologies), it is actually constructed by learners (Land & Jonassen, 2012).
4.1.3 Phase 3: Revisiting Empirical Data

Below, I continue to rationalise the ways in which the basic questions of who, why, what, and how formed by Engeström (2018) emerge in this thesis, and connect these questions to the early stages of the empirical data. To provide a broad view of actual situations, I select sections of the empirical data that have not yet been presented as excerpts in the publications.

Investigation of the empirical data leads to an interesting interpretation in that, in the model of open design pedagogy, the subject, object, and mediated means function as a set of interconnected processes rather than as linear or static incidents. With the term process, I refer here to the definition in the Cambridge English Dictionary (2018): “a series of actions that you take in order to achieve a result.” In this study, these series of actions can be identified in both the initial DPs and also the refined grounded design principles of open design pedagogy. In this analysis, the core categories of a learning community, a learning environment, a learning task, and a learning activity (see Table 9) are identified as frames for these processes.

Figure 23 indicates that the subject of learning (who) refers to a participatory learning community with fluid roles, the object (what) refers to an open-ended, collaboratively defined and reflected learning task, and the mediational means (how) refers to a flexible learning environment with various tools and the creation of artefacts. The learning activity (why) combines the other three frames and actualises them in time and practice. In Figure 23, the learning activity is placed in the middle to highlight the educator’s pedagogical approaches of presence and openness to ignite and support the overall learning processes.

25 The methodology of the empirical work is presented in Section 3 and in each original publication in their methodology sections. Also, the particulars of the research activities and the data are presented in appendices. Consequently, I do not repeat the details here.
Next, I show the ways in which the initial design principles relate to these frames of processes by providing examples from authentic research situations. Here, I underline that the initial DPs do not have any fixed relation to a certain frame, but interconnect and overlap. In Figure 24, for the purposes of rationalisation, I position the initial DPs around the frames of processes instead of strictly organising them in a table. Nevertheless, I show the most prominent connections between the initial DPs and the frames of processes through excerpts from authentic research situations and the original research notes.
Figure 24
*Initial Design Principles Positioned in Relation to the Learning Community, Learning Task, Learning Environment, and Learning Activity*

To identify descriptive excerpts, I revisit the data that were produced in the very early stages of the design process, in Workshops 1 and 2. I also review the research notes from that time. Going back to the very beginning of the design process to revisit the raw data enables me to reassess and validate my previous analysis and interpretations as a qualitative researcher. By looking back, I am engaging with the emergent ideas of the design process.

Next, I provide four examples and show excerpts from the original research notes to show evidence of how these situations connect to the nine initial pedagogical design principles and the upper-level conceptualisations of the *learning community, learning environment, learning task, and learning activity*. 

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Setting the general scene for extracts 1–4

The four extracts, with excerpts from data and from the research diary, originate from the first two design workshops. The first workshop was organised between the educators (N = 5). The content of the workshop entailed an introduction to the Edukata model and participatory design; mapping out our visions and values for the future ECEC; and brainstorming how to engage children in the design process. Our discussions also aimed to contribute to the collaborative formation of the overall objectives of our design process. These discussions highlighted the objective of enhancing children’s agency and participation, and engaging with other educators for the benefit of children and developing pedagogy. In the first workshop, we focused our discussions around two early-stage questions: (1) Which pedagogical methods (with or without digital technology) should we utilise to achieve the objective of enhancing children’s participation? and (2) What should future early childhood education look like? The data from this workshop include documentation of the ideation and discussion (photographs of the design walls, i.e., sticky notes with written thoughts), and video recordings of these discussions (40 minutes), two written reflections, and research notes.

The second workshop was organised together with the educators (N = 3) and the children (N = 5, 4–years old). In this workshop we engaged in the design work together with children for the first time. We asked them to take photographs (with tablet computers) of pleasurable places in the kindergarten. We (the educators) facilitated the photography session and discussed the choices with the children. This activity was followed by two reflective discussions: one with the children and another between the educators.

Our objective in this workshop was to observe children’s actions and discuss their ideas to find practices for enhancing child-initiated pedagogy. We (the educators) also wanted to test our initial ideas, discussed in Workshop 1, to develop means to engage children in the design process on their own terms. The data produced in Workshop 2 included visual documentation (photographs taken by both children and adults), a video recording of the reflective discussion with the children, an audio recording from the reflective discussion amongst the educators, two written reflections by the participants, and research notes.

Below, I present four extracts from the abovementioned workshops. Each extract provides, through several excerpts, an authentic view of these very early stages of the design process and reveals the emerging foundations for the four high-level conceptualisations of the learning community, learning task, learning environment, and learning activity.

Extract 1

*Learning Community*

This extract describes the emerging state of the two initial DPs: understanding fluid roles in pedagogical activities and promoting active participation.
Our design process emphasised promoting children’s agency and active participation, particularly investigating and developing the pedagogical use of digital tools. The aim was to develop and employ methods that would advance from merely observing children’s actions to actually promoting genuine participation (Brinck et al., 2020, 2023). In discussions between educators, the premise for the collaboration was that adults and children would form an *intergenerational unit of learners* who learn from each other together. Our aim was to advance from the traditional the *adult leads and children follow approach*. This view was conceptualised in Publication I as zones of participation (ZoP), which highlight the fluid roles of participants during the design process (Brinck et al., 2020). ZoP describes the ways in which both adults and children were able to take on various roles: as directors, whisperers, actors, and audience during our activities. The findings also show that, instead of playing only one particular role, the participants were able to switch between roles (Brinck et al., 2020).

The next three excerpts give initial thoughts about the meaningfulness of the intergenerational collaboration between adults and children to promote active participation. The emergent idea of a participatory community of learners with fluid roles was brought up by the participants for the first time.

**Extract 1, Excerpt 6**

*Educator 1’s statement in Workshop 1*

> If we could make it so that adults are not lined up to observe what happens, but are part of a conversation about what’s going on. Not in a way that the adult says how it goes, but maybe an adult can throw something in—‘tell me what you’re drawing’ or ‘tell me what you’re building’. In this way, it is like all of us are playing together.

(Personal communication, educator’s statement in Workshop 1, 2017)

**Extract 1, Excerpt 7**

*Children’s reflections on Workshop 2*

- Child 1: It was nice to do the filming myself. At first, I didn’t remember what we were supposed to film, but then Jane and Matt [educators] helped me.
- Child 2: There we were, [listing the names of the children] and Matt [educator], then there was Jane and Julia [educators]. We were filming and then we were looking at those pictures. It was fun when I knew how to do it. I didn’t remember what we were supposed to be shooting at first.
- Child 3: It was fun filming. Yeah, I almost didn’t dare.

(Personal communication, children’s reflections on Workshop 2, 2017)
Extract 1, Excerpt 8
Reflection by Educator 3 on Workshop 2

- Educator 3: What stuck in my mind was, like, that this doing together was fun for them, and they knew how to take the others into account and asked, ‘do you want to take the picture as you haven’t taken any yet?’ That’s a pretty advanced interaction because we didn’t guide them into it in any way, but it came from the children at that point.

(Personal communication, educator’s reflection in on Workshop 2, 2017)

Extract 1, Excerpt 9
A reflection by Educator 3 on Workshop 2

- Educator 3: And I guess that learning happens when you have that kind of security. You’re about to try out a little bit of what you can’t do yet, but you want to learn.

(Personal communication, educator’s reflection on Workshop 2, 2017)

The excerpts reveal the ways in which a learning subject can be understood both as an individual participating in cultural activities, and as a group of subjects, such as a team, organisation, or community (Engeström, 2018; Lave, 1991, 2009; Lave & Wenger, 1991). This highlights the importance of working together and building trust for creating a safe space for learning. To have trust in your peers and group means that you get help and encouragement when you are uncertain or timid in new situations. Through encouragement and trust, participation in common activities is possible even for those who would not dare to act otherwise.

Extract 2
Learning Task

This extract describes the emerging state of the two initial DPs: following children’s ideas and reflection. Our objectives concerning the design of the learning tasks were framed by the curriculum (FNAE, 2017). In its learning goals, ECEC underlines learning by experimentation, playing, doing, and inquiry. Based on our previous understanding of participation, we (the educators) determined that, rather than having a fixed learning goal, participation in the learning activities could be enhanced through a collaboratively formed and open-ended learning task. We agreed in our discussion that the activity might be initiated by adults, but reformed and adapted by the children as they go. Subsequently, instead of focusing on pre-defined learning goals, the means of defining the learning objectives together and reflecting on them became
significant. With small children, the challenge is to get to know children’s ideas, as the means of children-to-adult communication and expression of ideas is different from adult-to-adult conversation. Below, I present an excerpt from Workshop 1 in which we discuss the objectives and execution of an upcoming learning task.

**Extract 2, Excerpt 10**

*Discussion between Educators 1, 4, and 5 in Workshop 1*

- Educator 1: But is it something like this, but at the children’s level… Could it be the kindergarten of your dreams or a future daycare centre or something like that?
- Educator 4: Yeah, because we need to have some kind of a start.
- Educator 1: Yes, a start that is pretty easy to grasp. If you could just think about building a daycare centre, what would it be like?
- Educator 5: Could we do it with all kinds of things? Drawing, photography, and filming?
- Educator 4: And then to be open to what it becomes.

(Personal communication, educators’ discussion in Workshop 1, 2017)

**Extract 2, Excerpt 11**

*Statement by Educator 2 in Workshop 1*

- Educator 2: About movement and dance—so last year we started to do parkour. It was clearly about what they want to play and learn, it was about physical skills. And then it is playful, as it is about using children’s imagination. It’s about how to take different surfaces and move and that’s how it was. Then when it’s free, and you’re doing it according to your own skills, then it’s as meaningful as the children themselves make it.

(Personal communication, educator’s statement in Workshop 1, 2017)

In this extract, the educators are discussing opportunities that emerge with young children to design learning tasks together as a learning community. This pedagogical approach requires *openness* from educators, as they should not pre-define the process or the outcomes of it in any detail. Accordingly, to be *open* towards the directions that collaboratively defined learning task might lead in terms of learning, is enabled through *trust* towards both the process and each other. Whether the learning goals are meaningful to the learners, and if they have been met in the process of activity, is negotiated together through collaborative reflection.
Extract 3

Learning Environment

This extract describes the emerging state of the three initial DPs: versatile use of tangible artefacts, playful interaction with technology, and visual documentation. In our discussions, we understood that the concept of a learning environment entails social, material, and cultural aspects that manifest in both the physical and virtual realms. Here, in Workshops 1 and 2, the discussions addressed physical learning environments that extended from the immediate premises of the kindergarten to a nearby seashore and forest, and the tools and artefacts employed in the activities.

Extract 3, Excerpt 12

Discussion Between Educators 2 and 3 in Workshop 1

- Educator 2: The purpose of these digital technologies is to contribute to progress in learning. There is this one thing [documentation] and then we get back to it and repeat it.
- Educator 3: That’s really good, it relates to reflecting. And learning by repetition is also mentioned in Vasu [the ECEC curriculum] as being natural for a child.
- Educator 2: When we were filming yesterday by the rapids, I then showed the film to the kids and asked, ‘what is this place?’ ‘Hmm,’ they said as they looked at it for a while and then replied, ‘at the rapids!’ So, the child genuinely went back to that moment and thought, ‘hey, we were at the rapids for a trip’.

(Personal communication, educators’ discussion in Workshop 1, 2017)

Extract 3, Excerpt 13

Reflection by Educator 4 on Workshop 2

- Educator 4: Yes, they were like, let’s go play, and then the thought came from that. But yeah, a little bit like that, I was thinking about how it’s going to go, can they [children] sort of remember the task, and I thought that probably when we go to those spaces, it will bring it up.

(Personal communication, educator’s reflection on Workshop 2, 2017)

Extract 3, Excerpt 14

Excerpt from the Research Notes (28.4.2017) after Workshop 2

About the use of the camera: The tools themselves interested the children. Filming with a tablet, big camera and tripod, video projector. ‘How does the picture get on the wall?’ Technology and the device guide children’s activities; the device itself and filming can become that thing—camera play—in which
case, the given task to photograph an object or place in the kindergarten that brings you joy, goes on in parallel, but both the device and the task gain importance in the child's activity. These take turns.

**Extract 3, Excerpt 15**

*Excerpt from the Research Notes (28.4.2017) after Workshop 2*

From the participation point of view, the pictures in which a child is playing, moving, an active actor, can be more inclusive and powerful than an image in which the child has filmed their interests. Then, also, the interaction between children is highlighted. Children take pictures of each other, and adults document children's play and exercise—especially children's own activities—with joy.

Here, the equipment has two meanings:

1) a plaything, which makes the technology itself something to explore: What can you do with this? How can you play with this? How can a camera be part of a play?
2) a storytelling (sharing and documentation) tool: the camera documents and saves. It was a way to return to the moment together as well as to reflect on what has happened and share things. Could a camera or other audiovisual equipment act as a stimulus around which play is emerging or created?

In this extract, it is brought up that children were able to go back in time and reflect on the events through visual documentation, in which digital tools were employed. Children's playfulness and embodied exploration of the material world were highlighted. Documenting the activities visually served both goals of the investigation and observation of the environment. Later on, the visual documentation facilitated discussion and served as a reflection aid.

**Extract 4**

*Learning Activity*

This extract describes the emerging state of the three initial DPs: *working openly in conditions of uncertainty and pedagogical presence*. The learning activity combines the processes involving the learning environment, the learning community, and the learning task. The activity can be described as *energy for learning*, which is needed to inspire learners to engage fully with the task at hand. In our process, the design of the learning activities highlighted open-endedness (versus pre-defined) for two reasons: The learning situations with the small children were rapidly changing, fluid, and complex; and as our aim was to promote children's own inquiry and creation and enable them to follow through on their ideas, the educators needed to be pedagogically present and aware, and also to tolerate uncertainty. Accepting feelings of uncertainty as an educator was also a requirement for a successful design process.
Extract 4, Excerpt 16
Statement by Educator 3 in Workshop 1

- Educator 3: Yeah, and here, in particular, how can we as adults see what are the things that children want. What kind of methods can we use to do this? I write down here being present [in a moment]. It should be like that, it came to my mind. It's really important that we are even noticing [children's initiatives].

(Personal communication, educator’s statement in Workshop 1, 2017)

Extract 4, Excerpt 17
Statement by Educator 4 in Workshop 2

- Educator 4: But nice, this is a nice thing. But even thinking of oneself, it's like that, even though we've talked about throwing oneself into something new, and to see where it's [the design process] going. It's always a little bit exciting and you don't know what's going on here.

(Personal communication, educator’s statement in Workshop 2, 2017)

Extract 4, Excerpt 18
Excerpt from the Research Notes (21.4.2017) after Workshop 1

We discussed the ‘state of not-knowing’, which is required for the open process of collaborative designing. A certain vagueness and uncertainty are present at the beginning. As the process progresses, things become structured. It is good to start by looking for ideas more widely, dreaming and thinking big. Shared expertise and the personal perspectives that are brought to the process through the life and work experience of each of us add richness to the design work. This combination of perspectives can create something that is multi-voiced and new—giving fresh insights.

This extract shows that ambiguous design process and ill-defined design challenges required tolerance of uncertainty from the educators. The educators acknowledged the need for pedagogical presence to identify children's initiatives and ideas that were often vaguely communicated. Nevertheless, as the educators articulated this uncertainty, it provided them with a communal space for embracing new experiences together with their colleagues and the children. This approach required trust both in the design process and in each other. This state of trust is not static but actualises in time-bound processes of an activity through experiences, interactions, and reflections between people.
4.2 Grounded Principles for Open Design Pedagogy

This section answers RQ3: What are the grounded principles for open design pedagogy? As presented in the previous paragraphs, learning activities and pedagogical practices do not take place in an abstract or theoretical sphere, but in embodied interactions of acting together. These actions are facilitated (i.e., carried out) via cultural tools and artefacts, which can be used and/or created in a time-bound process of an activity. Collaborative investigation for learning something new requires tolerance for risk taking and embracing uncertainty as an opportunity, and thus trust in each other, which also ties in with the open-endedness and early ambiguity of the design learning process.

Next, I summarise these findings as refined design principles, which I present in the form of the 4Ts of open design pedagogy: togetherness, tools, trust, and time (Figure 25).

**Figure 25**  
The 4Ts of Open Design Pedagogy
Open design pedagogy should foster learning contexts that are designed around the following four principles.

**Promote TOGETHERNESS in your learning community.**

In the context of open design pedagogy, educators and students together form a learning community in which the roles of leading, acting, supporting, and receiving alternate. In this way, the educator's openness towards fluid roles in pedagogical activities fosters participation, agency, and learning together and from each other.

**Employ digital and tangible TOOLS as a means of investigation, documentation, and collaborative creation of artefacts.**

When designing activities in the context of open design pedagogy, the open-minded exploration of the opportunities and resources in the immediate and extended learning environments becomes important. The integration of digital tools as an integral part of the activities to facilitate collaborative investigation, documentation, and artistic creation enhances learning.

**TRUST the design learning process and enable the learner's agentic opportunities.**

In the design of open design pedagogical activities, building trust is important for creating a safe space for learning. The learning task is designed together as a learning community, and the learning process or the outcomes are not pre-defined in detail in advance. This kind of open-ended and inquiry-oriented learning requires trust in both the process and the community of learners.

**Allocate TIME for exploration, inquiry, reflection, and iteration.**

Allocating time for exploration, inquiry, reflection, and iteration is the key to a fruitful open design learning process. Learning occurs as a change in a person's thinking, attitude, and behaviour over time, and new knowledge is created and internalised through reflection. In a participatory process, the meaningfulness of the activity should be reflected on both individually and together as a learning community.
4.3 Summary of Contribution

Chapter 4 answers the main research questions of this thesis. The main RQs and the ways in which they are answered in this thesis are summarised in Table 10.

Table 10

<table>
<thead>
<tr>
<th>Main research questions</th>
<th>Summarised answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1: What are the design principles for designing pedagogical practices that apply digital technologies in early childhood design education?</td>
<td>By conducting a meta-analysis of the publications of this thesis, the principle-focused analysis process revealed <em>nine initial design principles</em> (DPs): Following children's ideas; Pedagogical presence; Playful interaction with technology; Promoting active participation; Reflection; Understanding fluid roles in pedagogical activities; Versatile use of tangible artefacts; Visual documentation; and Working openly in conditions of uncertainty. With this investigation, Chapter 4 answers RQ1.</td>
</tr>
<tr>
<td>RQ2: How can they be further developed into grounded principles for open design pedagogy?</td>
<td>This thesis developed, described, and implemented the principle-focused elaboration method, and thus answers how the DPs can be further developed into grounded principles for open design pedagogy. The process entails three phases. These phases are 1) the meta-analysis of the original publications; 2) a review of the theory behind the concepts that emerge from the meta-analysis and 3) an examination of these concepts against the raw data for validation. With this method, Chapter 4 answers RQ2.</td>
</tr>
<tr>
<td>RQ3: What are the grounded principles for open design pedagogy?</td>
<td>Finally, the grounded principles for open design pedagogy (i.e., 4Ts) are refined through the principle-focused elaboration method. The 4Ts are togetherness, tools, trust, and time. They are introduced in Chapter 4, Section 4.2. With these principles, Chapter 4 answers RQ3.</td>
</tr>
</tbody>
</table>

This thesis explores the ways in which pedagogical practices should be designed to apply digital technologies in early childhood design education. Thus, the open design pedagogy and the 4Ts that this thesis develops provide new perspectives on designing pedagogical activities in the ECEC context by early childhood educators.
I think that, at this moment, our design goals and our discussions are focusing on the ‘child as a learner.’ What is special in early childhood education is that the ‘adult is a learner’ as well. So, if we wish to change something, the change needs to happen in the adult and in their thinking. In this way children get opportunities to move beyond what has previously been defined by the adults. Could this [design] process lead to a method for adults to learn new [participatory] ways for designing activities and instruction?

(Excerpt from data, personal communication, educator’s statement, 2017)
5 DISCUSSION

Social theory is not true or false. It is not a ‘proposition’ or a statement of truth, as in the natural sciences. It is validated through its usefulness for telling meaningful stories about the human condition. It guides inquiries by focusing on certain aspects of this condition, suggesting questions to pursue and ways of framing the answers.

(A statement by Wenger-Tryner in Farnsworth et al., 2016, p. 141)

In Chapter 4, I presented the process of the development of grounded principles for open design pedagogy, the 4Ts: togetherness, tools, trust, and time. In this chapter, I discuss the 4Ts in relation to the academic literature and highlight the novel aspects of the thesis. At the end of this chapter, I also state the limitations of the research.

As mentioned in earlier chapters, the 4Ts should not be regarded as separate or individual, but as intertwined and interdependent, and should be considered from a holistic point of view as a set of principles for open design pedagogy rather than as four separate ones (see Figure 25). Nevertheless, for the sake of clarity, I discuss these principles under four headlines that each reflect one dimension of the 4Ts of open design pedagogy. The topics are educating for an uncertain future (referring to togetherness); learning to utilise and create new tools (referring to tools); learning not only to cope with change but to thrive (referring to trust); and unlearning chaos and relearning to focus and slow down (referring to time). I also connect these principles to the concept of openness, as it is understood in the context of open design pedagogy.

5.1 Educating for an Uncertain Future (Togetherness)

As discussed in the academic literature, learning is realised in social interaction and actualised in an individual mind (Illeris, 2017). Educational objectives are culturally (in)formed and have local and global dimensions (Claxton, 2002; Cole, 1996). The objectives are defined according to policymakers’ and/or educators’ best knowledge of the future ahead in the form of curricula and classroom practices. These educational objectives are transformed into pedagogical interventions and implemented, in many cases, top-down from an educator’s (adult’s) point of view—i.e., from a position of power and placed
upon the learner (child). This system of learning institutions, curricula, testing, and timetables might make education more predictable, but also reduces the openness of the educational system and limits the agency and reflexivity of teachers (Biesta, 2023).

The context of institutionalised learning (in this case ECEC) envisions children as novices or newcomers, as they experience and learn about the world for the first time, and adults as experts or old-timers who already have deep knowledge of the world and are passing on this knowledge to the next generation. However, we should think more openly about whom we refer to as newcomers or old-timers in an ever-changing digital society and in the participatory cultures that it generates (Jenkins, 2009), and the various communities of practice it creates and supports (Lave & Wenger, 1991). Lave and Wenger (1991) discuss the idea of newcomers and old-timers when they address the participants in the communities of practice (see also Farnsworth et al., 2016; Wenger, 1999).

As introduced in Chapter 2, communities of practice explore learning as a pervasive social phenomenon enabled by participation, in which the level of participation changes according to the positions that the participants take. The identification of newcomers and old-timers is not based on age or status, nor on any other external definition imposed upon a person (such as gender, ethnicity, or ability). The level of participation is self-regulated and non-static.

In the current digital media environment, and reflecting on the speed with which it evolves, it is evident that adults are as much, or even more, newcomers in this ever-changing digital society, and sometimes children are the old-timers. For this reason, a learning together perspective is essential, as Lave (2009) states: “People in activity are skillful at, and are more often than not engaged in, helping each other to participate in changing ways in a changing world” (p. 201).

For adults, openness is an imperative, as to be confronted with new (digital) environments and experiences, we need to reflect on our preconceptions, readjust our orientation based on what we have already mastered and direct it towards a newcomer’s curiosity to embrace opportunities for learning something new. To this end, in some pedagogical situations, the roles of the teacher and student may be reversed, such that the student becomes the expert. These roles can change according to the requirements of the task (Brinck et al., 2020). Accordingly, Wenger (2009) writes about the community of learners: “a way of talking about the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence” (p. 211).

To sum up, if participation is regarded not only as a result of collaboration but as a competence that we should pursue to thrive in a changing society, then togetherness should be at the heart of any pedagogical design. In this research, openness towards the fluid and changing roles during learning activities
enhanced participation and collaborative exploration as a learning community (Brinck et al., 2020, 2023). Nevertheless, the adult is ultimately responsible for promoting (and requiring) ethical conduct, quality of interaction, and beneficial activities. Thus, the reflexivity and agency of a teacher play a significant role in a learning together approach.

5.2 Learning to Utilise and Create New Tools (Tools)

Wells and Claxton (2002) state that the ‘higher mental functions’ do not develop simply as a result of individual learning or intellectual maturation. Rather, they depend upon mastering the use of culturally created semiotic tools such as language, artistic representation and scientific procedures, which principally occur ‘interpsychologically’ (i.e. interactively) in activities undertaken with other members of the culture. (p. 5)

The concept of a tool is here understood as the mediational means (Wertsch, 1993; Wertsch & Rupert, 1993) that diverse learning environments entail; and the multiple opportunities they provide for creating them (Paavola & Hakkarainen, 2021) and through which the tools enable participation in cultural activities (Lave, 1991; Lave & Wenger, 1991; Paavola & Hakkarainen, 2021). Tools can be either physical (material) or mental (i.e., ideas, plans, descriptions), and their collaborative creation and development is a target of an activity, not only an object that mediates activity (Paavola & Hakkarainen, 2021).

Moreover, the virtual (digital and online) environment has its own dimension of materiality (Leinonen et al., 2021) and becomes more and more a part of our sociocultural environment throughout our whole lives, impacting, on many levels, on the ways in which we conduct our lives and learn. Recent development of mixed media environments that employ augmented and virtual realities to deliver learning content, and the utilisation of artificial intelligence, such as ChatGPT, are examples of the pervasive impact that technology will increasingly have on education and our daily lives.

As the recent Covid-19 pandemic has forced us to confront, access and skills to act in digital environments and participate in media culture are critical for citizens of the 21st century. To have equal opportunities in education and society is a fundamental basic right of children (UNICEF, 1989) and, thus, a requirement for achieving their full potential in life. According to Heeks (2022), there has been a recent shift in understanding the ways in which inclusion (and not only exclusion from) in digital environments is causing inequality. This is due to the fact that digital systems of some kind are in reach for most groups and individuals and more generally distributed in the world. Subsequently, the focus has shifted from haves and have nots to social inequalities (gender, race, disability, income, etc.). The ability to benefit the
value chain that digitalisation creates, individual user skills, and knowledge about the digital environment play important part in the ways people are able to participate in society, also beyond digital sphere.

In this research, openness towards engagement with the learning environment and tools identified as a resource in the multiform material environment provided invaluable opportunities for learning. The identification of multiple resources for extended learning environments and the collaborative production of tangible and visual artefacts with digital technologies—and the documentation that they enabled—played a key role in investigation and exploration, and provided opportunities for taking initiative and agency for both adults and children.

5.3 Learning Not Only to Cope with Change but to Thrive (Trust)

Change is a paradoxical concept in relation to learning. According to Illeris (2018), change that is not only biological in origin (maturing and aging) but leads to change in our permanent capacity, is learning. Nevertheless, change can sometimes be chaotic if it is forced upon us and originates from structures and systems that are external and alien to us. This kind of change demands our attention, requiring us to react to it and cope with it. To resist these kinds of external demands takes a lot of effort and focus. Rather, if we reflect on these expectations and their origins and objectives, we are in a better situation to adapt to external changes/demands and make informed decisions about the ways in which we respond to them and can benefit from them, or modify them and protest against them, in those cases where they are against our values and ethics. In this way, we are able to reflect what is meaningful to us as individuals and as a community. Stocchetti (2020) summarises the situation effectively:

In a critical perspective, technological development is not a natural but a social process: not autonomous from but very much dependent upon the inter-play of forces and institutions in society. But if technological development is indeed a powerful force of social change, the role of education is to create the conditions for the selective endorsement (or rejection) of this power. In democratic societies, the role of education should thus be discussed keeping in mind the problem of the democratic control of technological innovation: its potential for subversive social change. (p. 3)

This statement leads to two questions: on what grounds do we identify moments of decision when we choose endorsement or rejection, particularly as we embark on something new; and how do we assess the value—the meaning—of a new incident or phenomenon?
Wenger (2009) refers to meaning as “a way of talking about our (changing) ability – individually and collectively – to experience our life and the world as meaningful” (p. 211). Thus, meaning is not a given, or defined in isolation, but negotiated through participation in communities. As he discusses communities of practice, Wenger-Tryner states, “for human beings, a central drive for the negotiation of meaning is the process of becoming a certain person in a social context – or more usually a multiplicity of social contexts” (Farnsworth et al., 2016, p. 145).

In this research, openness towards change was identified as an important dimension of open design pedagogy, which indicated trust in the design learning process and its open-endedness. Trust was not only highlighted in discussions between educators, but also through their actions as they engaged with emerging opportunities in encounters with others and various learning environments. They identified and openly utilised the social, material, and technological resources presented to them as an opportunity (Brinck et al., 2023).

### 5.4 Unlearning Chaos and Relearning to Focus and Slow Down (Time)

As mentioned regarding the formulation of educational objectives, they are often defined top-down and imposed upon students. Moreover, the rhetoric around 21st-century learning emphasises the importance of the skills and competencies that a learner needs to obtain in order to be a productive member of society and a good citizen (Griffin et al., 2012). In some cases, the curriculum and its learning objectives are cluttered with abundant information, and leisure time also overwhelms both children and adults with multiple stimuli in the form of digital, commercially motivated products and equipment. These demands and their constant changing can overburden us and create feelings of inadequacy, haste, and lack of time to satisfactorily finalise any content we are working with.

Biesta (2022) states that education should be regarded as a verb, as for him “education’ refers to an activity, that is, to something that educators do” (p. 4). According to him, this entails that an educator is willing and able to recognise situations where inaction is the best way forward. Biesta states, “This includes, as I have emphasised, the category of ‘intentional non-action,’ which is about the situations where we decide, for good educational reasons, not to act, not to interfere, not to speak, not to ‘rub it in,’ and so on” (Biesta, 2022, p. 58). These situations in which an educator decides not to act or exercise strict control over action, leaves room for a student to ponder, question, think, and reflect. These moments require time and openness from an educator, enabling events to proceed in an undefined direction and the social content to be reflected on and negotiated inter- and intrasubjectively in participation with others.
Biesta (2022) writes that learning itself should never be the stated objective of teaching; rather, what is important is what a student does with what they have learned at the time that it is meaningful. Accordingly, Wenger (2009) discusses identity as “a way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities” (p. 211). To educate students to become subjects of their own learning focuses on “encouraging children and young people to become knowledgeable and skilful in their own right” (Biesta, 2022, p. 8). This kind of encouragement stems from the educator’s ability to respect students’ freedom in their learning (Biesta, 2022). Wondering in a pedagogical situation, demands intentional non-action (Biesta, 2022), which requires time to proceed in an open direction and evolve into the “personal histories of becoming in the context of our communities” (Wenger, 2009, p. 211).

In this research, such moments have been witnessed in situations in which an educator has stepped back, provided space and let go of strict control as they resisted acting in a pre-defined way while letting the situation develop in its own direction (Brinck et al., 2020). Commonly, this has resulted in play, investigation of the environment, and exploration of the tools at hand (Brinck et al., 2023). This kind of pedagogical act—call it, for example, wondering—requires time and openness, which equates to presence, and is realised through reflection.

### 5.5 Implications for Research and Practice

This thesis’s implications for research and practice involve both the research findings and the method of acquiring them. The findings, i.e., the grounded principles for open design pedagogy (togetherness, tools, trust, and time), are aligned with current educational research. However, these concepts appear as separate in the current research and are addressed individually. This thesis, for the first time, brings together these principles as an interdependent set of principles and investigates them in the context of designing pedagogy with digital technologies in ECEC.

In terms of methodological novelty, this thesis introduces a method to identify and refine design principles. The development of a principle-focused elaboration method combines empirical and theoretical knowledge and employs triangulation in educational design research for developing design principles.

ECEC is a learning environment that eschews pre-designed, step-by-step pedagogical models in favour of designs that exhibit flexibility. Accordingly, the 4Ts empower teachers to embrace the openness of the messy and complex learning processes, rely on collaboration and sharing, and engage their students by fostering their agency and participation.
With this thesis, I encourage ECEC educators to make these principles a focus in their pedagogical designs and include them as a basis for discussions with colleagues, students, and local ECEC communities.

Moreover, this thesis confirms that the participatory design of learning activities in ECEC is a successful method to engage with practitioners and children to together design everyday learning activities involving digital technologies. Based on the findings from this research process, participatory design with children should be considered an area of study in pre-service ECEC teacher education. The pedagogically meaningful application of digital technologies in learning in ECEC could be enhanced by participatory design.

5.6 Limitations of the Research

The findings of this thesis are the result of an analysis, which is based on my subjective interpretations and thus has limitations. Nevertheless, the measures of assessing the accuracy of the interpretations during the analysis constituted a constant comparative method, which refers to the iterative analysis and the process of going back and forth between more developed categories and the raw data. With this method, I compared the properties and dimensions of distinct level categories with the raw data to ensure that my interpretations aligned with the authentic data. However, Publication II was an exception: three researchers conducted the analysis (see p. vii, Publication II).

This thesis obtained and analysed two rich datasets produced over one year (2017–2018). The data consisted of video data from design workshops, activities, and reflective discussions totalling over seven hours, audio recordings of design workshops and reflections totalling over seven hours, more than 400 photographs, and written reflections and fieldnotes. Both children and adults contributed to producing this data.

Since 2017, I have returned to the data many times, working so intensively and with such focus that I can say I know the content mostly by heart. However, I have not relied on my memory in my interpretations but, instead, each time, returned to the raw data. I must confess that during this process of iterative analysis, I have—whether it is pathetic or not—fallen in love with the analysis software that has accompanied me on this journey (Atlas.ti). It enabled a fluent and well-documented analysis. It provided room for creative thinking and enabled a flexible process that I could navigate with ease while combining different data sources, i.e., video, text, audio, and photographs. Moreover, Atlas.ti facilitated emergent thought processes and allowed my interpretations of the formulated research findings to mature, and enabled me to communicate significant points of discovery to others, i.e., co-authors, colleagues, participants, and stakeholders. Thus, I have been able to maintain
and enhance the transparency of my research, which is the guiding principle I aimed to abide by.

Furthermore, the research environment of ECEC had an impact on the study. One might think that ECEC, as a research context, provides findings that are not generalisable to other contexts. But, on the contrary, ECEC is an environment that is based on intergenerational encounters and complex and non-verbal (and thus challenging) interactions with a necessity for pervasive pedagogical and ethical conduct in every moment. ECEC is also an environment in which the organisation of daily activities is based on systematic planning ahead and, at the same time, openness to change in the direction of an activity. With young children there are no other means of creating meaningful learning situations than having an open mind and being prepared for sudden changes.

Leinonen and Mäkelä (2022) state that, as we design environments that are functional and interesting for children, we are actually designing functional environments for everyone. This research shares that point of view and extends it to designing pedagogy and learning.

Many things that we value in learning are present in ECEC practices. In ECEC, learning, participation, care, play, curiosity, creativity, and movement flourish, thanks to the children, but only if these are allowed by adults (Leinonen & Mäkelä, 2022). Resnick (2017) proposes kindergarten as the greatest invention of the previous thousand years. According to him, the invention of kindergarten fundamentally changed the approach to schooling. He states that we all should become lifelong kindergarteners and approach learning throughout our lives with playfulness, passion, and creativity. We just need to see beyond our biases and preconceptions towards learning in ECEC.
I guess that learning happens when you have that kind of security. You’re about to try out a little bit of what you can’t do yet, but you want to learn?

(Excerpt from data, personal communication, educator’s statement, 2017)
In this chapter, I conclude this thesis by summarising the contribution and providing perspectives for further research.

This study conducted a grounded theory process that resulted in a set of principles for open design pedagogy: togetherness, tools, trust, and time. However, these principles are not applicable as a pedagogical model for organising instruction step-by-step, but rather they should be considered as foundational principles on which the pedagogical model, instruction, and activities are designed. Their successful application requires critical reflection from a practitioner, and they should be approached according to the needs of each situation to meet their particular pedagogical objectives.

The education field encompasses a great number of principles and guidelines, which may or may not have any foundation in theory. For example, design methods have sometimes been applied into the learning context without any theoretical justification via light, trendy, and oversimplified step-by-step guidelines. These kinds of design learning models may appear easy to apply and attractive, but should be tempered by learning theories, and critically reflected upon. With this thesis, my attempt has been to provide this kind of discussion and reflection—a research-based investigation of which principles should guide design pedagogies. Moreover, this thesis provides an evidence-based perspective on design learning with digital technologies in the ECEC context. The design principles, i.e., the 4Ts, align with current educational research but also add a new perspective to the discussion.

The thesis is based on sufficient fieldwork and a large enough dataset to provide insight into the phenomenon. However, the research was conducted in one kindergarten in one city so, in further stages, the design principles of open design pedagogy should be tested, reflected on, and put into use not only in ECEC but also in other contexts that require people to learn together.

Based on empirical evidence, testing, and evaluation, an in-depth theoretical investigation of the concepts of togetherness, tools, trust, and time should be conducted, particularly in the context of educational psychology, art and design education, design, and technology-enhanced learning. At this point, the 4Ts of open design pedagogy should be considered as early-stage research with initial findings, and a proposal for principles for developing the field of design pedagogy with digital technologies in an interdisciplinary and intergenerational learning context.
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Appendix 1

Design Experiment 1 and Dataset 1: Research Activities, Participants, Content, Outcomes, and Data

Orientation to the design process in ECEC
27.2.–3.3.2017

Before the actual design process, I spent time in the kindergarten to familiarise myself with everyday practices by participating in a field trip to the nearby forest and by conducting an art education project with four-year-olds. We drew, painted, took photographs, and filmed a time-lapse animation of the painting process. Later on, the kindergarten staff built a forest-themed art exhibition. No data collection.

The FIRST PHASE of the process, design workshops 1–5:
Designing learning activities

<table>
<thead>
<tr>
<th>Research Activity</th>
<th>Participants</th>
<th>Content</th>
<th>Outcomes</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>WORKSHOP 1 20.4.2017 9.30–11.15</td>
<td>Kindergarten teacher (N = 1) Childcare assistant (N = 1) Pedagogical specialists (N = 3)</td>
<td>Introduction to Edukata model and participatory design. Mapping out our vision and values for future ECEC. Brainstorming how we can engage children in the design process.</td>
<td>Design landscape for a scenario. Ideas for how to co-design activities with children.</td>
<td>Photographs of the design wall layouts (2) Video recordings (2) Video 1: 00:33:09 Video 2: 00:06:06 Reflections by the participants, text (2) Field notes (in Atlas.ti as memo)</td>
</tr>
<tr>
<td>WORKSHOP 2 27.4.2017 8.45–9.45 Photography workshop</td>
<td>Kindergarten teacher (N = 1) Children (N = 5, 3 girls and 2 boys born in 2012—4 years old) Pedagogical specialists (N = 2)</td>
<td>The children took photographs of pleasurable places in the kindergarten. We aimed to visualise and discuss what children valued in kindergarten.</td>
<td>Observations to find novel practices for child-initiated pedagogy and to test ideas for how to engage children in the design process. Visual documentation (conducted both by children and adults) in the form of photographs and video. A scenario was designed after these two workshops.</td>
<td>Photographs taken by the children (21) Photographs taken by the adults (8) Video recording (1): Discussing the photographs with the children, video: 00:17:14 Audio recordings (1): Summarizing the workshop amongst adults, audio: 00:13:47 Reflections by the participants, text (2) Field notes (in Atlas.ti as memo)</td>
</tr>
<tr>
<td>WORKSHOP 3 4.5.2017 12.40–13.40</td>
<td>Kindergarten teacher (N = 1) Childcare assistant (N = 2) Pedagogical specialists (N = 2)</td>
<td>Mapping out design challenges and opportunities.</td>
<td>Design challenges and opportunities</td>
<td>Photographs of the design wall layouts (1) Audio recording, design workshop (1) 01:08:10 Reflections by the participants, text (1) Field notes (in Atlas.ti as memo)</td>
</tr>
</tbody>
</table>
## The FIRST PHASE of the process, design workshops 1–5: Designing learning activities

<table>
<thead>
<tr>
<th>Research Activity</th>
<th>Participants</th>
<th>Content</th>
<th>Outcomes</th>
<th>Data</th>
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<tbody>
<tr>
<td><strong>WORKSHOP 4</strong></td>
<td></td>
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</tr>
<tr>
<td>10.5.2017</td>
<td>Kindergarten teacher (N = 1)</td>
<td>Mapping out design resources.</td>
<td>Design resources</td>
<td>Photographs of design wall layouts (1) Audio recording, design workshop (1) 00:57:33 Reflections by the participants, text (1) Field notes (in Atlas.ti as memo)</td>
</tr>
<tr>
<td>9.30–11.15</td>
<td>Childcare assistant (N = 1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pedagogical specialists (N = 3)</td>
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<tr>
<td><strong>WORKSHOP 5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6.2017</td>
<td>Kindergarten teacher (N = 1)</td>
<td>Parkour trip to a nearby beach. Children took turns leading the way and we documented the trip by taking photographs. At the end of the workshop, we collaboratively reflected on the documentation.</td>
<td></td>
<td>Documentation of the workshop with the children: Photographs taken by the adults (43) Video recordings (3): Reflecting on the trip by discussing the photographs with the children, video: 00:19:05 Stop motion animation (playground) 00:00:27 Collage animation 00:00:08 Audio recordings (1): Summarising the workshop amongst adults, audio: 00:15:24</td>
</tr>
<tr>
<td>9.30–11.15</td>
<td>Children (N = 4, 2 girls and 2 boys born in 2012—4 years old)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pedagogical specialists (N = 2)</td>
<td></td>
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<td></td>
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</tbody>
</table>
### The SECOND PHASE of the process, design workshops 6–11: Implementing and evaluating learning activities

<table>
<thead>
<tr>
<th>Research Activity</th>
<th>Participants</th>
<th>Content</th>
<th>Outcomes</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>WORKSHOP 6 11.9.2017 9.30–10.30</td>
<td>Kindergarten teacher (N = 1) Pre-service kindergarten teacher (N = 1) Children (N = 9, 4 girls and 5 boys born in 2012—4–5 years old) Pedagogical specialists (N = 1)</td>
<td>Planning and preparation for Aalto Fablab trip. Introducing an 'explorer' idea to the children. Learning how to operate cameras. Taking photographs of each other. The images aim at a puzzle, fabricated in Aalto Fablab.</td>
<td>Children participated in planning the trip, exploring and documenting the trip by taking photographs and videotaping, compiling a visual travelogue collage.</td>
<td>Documentation of the workshop: Photographs taken by the children (20) Photographs taken by the adults (2)</td>
</tr>
<tr>
<td>WORKSHOP 7 12.9.2017 8.30–14</td>
<td>Kindergarten teacher (N = 1) Childcare assistant (N = 1) Children (N = 9, 3 girls and 6 boys born in 2012—4–5 years old) Pedagogical specialists (N = 1)</td>
<td>A field trip to Aalto Fablab. Children participated in planning the trip, exploring and documenting the trip by taking photographs and videotaping. Laser cutting children's images on plywood puzzle pieces. Playing the puzzle. Inventing variations for the game.</td>
<td>Documentation of the workshop: Photographs taken by the children (The trip = 65) (Fablab = 41) Photographs taken by the adults (The trip = 11) (Fablab = 28) Video recordings (13): 00:04:00 Children documenting (9) -The trip (6) 00:02:60 -Fablab (3) 00:01:40 Adults documenting (4) -Fablab (4) 00:02:33</td>
<td></td>
</tr>
</tbody>
</table>
The SECOND PHASE of the process, design workshops 6–11: Implementing and evaluating learning activities

<table>
<thead>
<tr>
<th>Research Activity</th>
<th>Participants</th>
<th>Content</th>
<th>Outcomes</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>WORKSHOP 8 13.9.2017 8.30–14</td>
<td>Kindergarten teacher (N = 1) Pre-service kindergarten teacher (N = 1) Childcare assistant (N = 1) Children (N = 11, 4 girls and 7 boys born in 2012—4–5 years old) Pedagogical specialists (N = 2)</td>
<td>A field trip to Aalto Fablab. Children document by photographing and videotaping. Compiling a visual travelogue collage. Laser cutting the previous day’s photographs onto plywood to increase the number and variety of puzzle pieces.</td>
<td>Documentation of the workshop: Photographs taken by the children (The trip = 5) (Fablab = 88) Photographs taken by the adults (The trip = 18) (Fablab = 36) Video recordings (13) Children documenting -Fablab (7) 00:02:00 Adults documenting (6) 00:11:53 Reflections (both trips 7. and 8.9.) by the participants, text (1)</td>
<td></td>
</tr>
<tr>
<td>WORKSHOP 9 15.9.2017 10–11.30</td>
<td>Kindergarten teacher (N = 1) Pre-service kindergarten teacher (N = 1) Children (N = 6, 2 girls and 4 boys born in 2012—5 years old) Pedagogical specialists (N = 1)</td>
<td>Playing with the laser-cut puzzle pieces at the kindergarten. Inventing different ways to play with them.</td>
<td>Insight into how children interacted with the puzzle in a situation in which no rules for playing were introduced. The play started, developed, and varied, but differently to how adults anticipated.</td>
<td>Photographs (30) Video recordings (13) 00:39:78</td>
</tr>
</tbody>
</table>

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The SECOND PHASE of the process, design workshops 6–11:
Implementing and evaluating learning activities

<table>
<thead>
<tr>
<th>Research Activity</th>
<th>Participants</th>
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<th>Outcomes</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>WORKSHOP 11 28.9.2017</td>
<td>Kindergarten teacher (N = 1) Pre-service kindergarten teacher (N = 1) Children (N = 11, 4 girls and 7 boys born in 2012—5 years old) Guardians (N = 14) Pedagogical specialists (N = 1)</td>
<td>An exhibition at the kindergarten presenting our field trips to Aalto Fablab. The target groups are kindergarten staff, children, and families.</td>
<td>Feedback from parents, children and colleagues</td>
<td>Photographs (5)</td>
</tr>
</tbody>
</table>
## The THIRD PHASE of the process, design workshop 12–15: (Re)designing the learning activities and design of the Design Puzzle

<table>
<thead>
<tr>
<th>Research Activity</th>
<th>Participants</th>
<th>Content</th>
<th>Outcomes</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WORKSHOP 12</strong></td>
<td>Pedagogical specialists (N = 4)</td>
<td>Commenting on three different initial participatory design tools.</td>
<td>Ideas and comments on prototypes for a participatory design tool.</td>
<td>Audio recording, design workshop (1) 00:14:56</td>
</tr>
<tr>
<td>10.10.2017</td>
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<td></td>
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<tr>
<td><strong>WORKSHOP 13</strong></td>
<td>Kindergarten teacher (N = 2) Pre-service kindergarten teacher (N = 1) Pedagogical specialists (N = 5)</td>
<td>Commenting on and giving guidelines to redesign and develop the design tool further.</td>
<td>Two examples on how to plan and construct learning activities with the design tool. Comments on the activities and early prototype.</td>
<td>Audio recording, design workshop (1) 01:49:37</td>
</tr>
<tr>
<td>24.10.2017</td>
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<tr>
<td><strong>WORKSHOP 14</strong></td>
<td>Kindergarten teacher (N = 1) Children (N = 8, 6 girls and 2 boys born in 2011—6 years old) Pedagogical specialists (N = 2)</td>
<td>Designing learning activities, testing with children and commenting on the prototype of the design tool. Designing a learning activity together with children.</td>
<td>Comments on and observations of the early prototype testing session. Learning activity design: How to measure wind? (Learning math in the woods).</td>
<td>Video recording, design workshop (3) 00:53:59 Photograph (1)</td>
</tr>
<tr>
<td>31.10.2017</td>
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<tr>
<td><strong>WORKSHOP 15</strong></td>
<td>Kindergarten teacher (N = 1) Children (N = 5, all girls born in 2011—6 years old) Pedagogical specialists (N = 1)</td>
<td>Iteration 2 The design tool prototype testing and commenting.</td>
<td>Comments on and observations of the early prototype testing session. Design Puzzle participatory design method for designing learning activities together with children.</td>
<td>Video recording, design workshop (3) 00:54:25 Photograph (1) Comments on the Design tool: text/email (1)</td>
</tr>
<tr>
<td>5.12.2017</td>
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### Appendix 2

**Design experiment 2 and Dataset 2: Research Activities, Participants, Content, and Data**

<table>
<thead>
<tr>
<th>Research Activity</th>
<th>Participants</th>
<th>Content</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design workshop</td>
<td></td>
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<tr>
<td>22.8.2017</td>
<td>Kindergarten</td>
<td>Children playing with the magic sand. Interaction with the material, stories emerged, emotions.</td>
<td>Video recordings (2) Video (2): 00:40:00 Fieldnotes Children’s comments on play</td>
</tr>
<tr>
<td>Design workshop</td>
<td>Kindergarten teacher (N = 1) Children (N = 8, 4 girls and 4 boys born in 2012—4–5 years old) Pedagogical specialists: (N = 1)</td>
<td>Reflecting on the documentation of the previous workshop: the sand play.</td>
<td>Video recordings (2) Video (2): 00:32:65 Fieldnotes</td>
</tr>
<tr>
<td>Edulab Helsinki</td>
<td>Kindergarten teacher (N = 1) Librarian (N = 1), Museum staff (N = 1) Pedagogical specialists: (N = 5)</td>
<td>A participatory design workshop was facilitated to design features of the +Andscape.</td>
<td>Audio recordings (1) 1:14:47</td>
</tr>
<tr>
<td>Playing with the +Andscape</td>
<td>Group 1: Children (N = 4, 1 girl and 3 boys born in 2012—5 years old)</td>
<td>Children playing with +Andscape.</td>
<td>Video (1): 00:25:47</td>
</tr>
<tr>
<td>14.12.2017 Design Museum</td>
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<tr>
<td>Playing with the +Andscape</td>
<td>Group 2: Children (N = 4, 1 girl and 3 boys born in 2012—5 years old)</td>
<td>Children playing with +Andscape.</td>
<td>Video (1): 00:24:23</td>
</tr>
<tr>
<td>14.12.2017 Design Museum</td>
<td></td>
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<td></td>
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<tr>
<td>11.1.2018 Design Museum</td>
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<tr>
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In the past few decades, design has been introduced as a method to implement and develop teaching and learning practices that are more active, evidence-based, and interdisciplinary, as well as to confront real-life situations and problems. Moreover, in the current world, skills and competencies to utilise and benefit from various digital technologies are increasingly important for an individual to fully participate in society. Socialisation into digital media culture starts from an exceedingly early age, and digital environments are an integral part of children’s everyday sociocultural environment. Thus, digital tools should be integrated in early years pedagogy.

This research explores the ways in which pedagogical practices should be designed to apply digital technologies in early childhood design education. The pedagogical dimensions of design practice are investigated in real-life educational context by conducting two design experiments.

As an overall contribution, this thesis developed grounded principles for open design pedagogy, a set of principles which is called the 4Ts of open design pedagogy. The main finding of this thesis is that open design pedagogy should foster learning contexts that are designed around the principles of togetherness, tools, trust, and time.