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# INTEGRATING DESIGN THINKING IN K–9 DESIGN AND MAKER EDUCATION

Teachers' Evolving Roles and Design Empathy

Noora Bosch

DOCTORAL DISSERTATION

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# Abstract

Societal, technological, and educational changes increasingly require learners to cultivate transversal design-related competencies, such as creativity, empathy, and collaboration. Consequently, teachers need pedagogical approaches that enable meaningful student participation in design processes. While design thinking is well established in higher education, its application in formal K–9 contexts remains underexplored, particularly from the perspective of teachers' design work and facilitation practices.

This dissertation addresses these needs by examining the integration of a design thinking approach in formal K–9 design and maker education. Particular attention is given to teachers' roles and practices in this process, as well as to the manifestation of design empathy (i.e., empathy in design processes) in students' design processes.

The research draws on an in-depth qualitative case study conducted in a Finnish lower-secondary craft classroom. Students participated in a 12-session participatory design project in which preschoolers were involved in the design process as future users of the final products. The data consisted of video recordings, pedagogical materials, photographs, field notes, a reflective diary, audio reflections, interviews, and questionnaires. The data were analyzed using narrative, thematic, and qualitative content analysis to examine how teaching, learning, and design processes unfolded during the project.

The findings suggest that design thinking can be integrated into formal education. This is supported by a structured design process, human-centered and participatory methods, and a mindset that embraces uncertainty, experimentation, and mistakes as part of learning. Empathy is central to both students' design processes and teachers' pedagogical practices and should therefore be emphasized when integrating design thinking into education.

This dissertation highlights the evolving roles of teachers as designers and facilitators of creative and open-ended learning processes. Teaching design thinking is conceptualized as a design activity that requires a design thinking mindset, improvisation, and continuous reflection. Based on the findings, the dissertation proposes an initial conceptual framework to support teachers in designing and implementing empathy-oriented design- and maker-based learning experiences in K–9 education.

In conclusion, the dissertation provides empirical, conceptual, and pedagogical insights into how design thinking can support and enrich formal K–9 design and maker education. Design thinking offers a promising approach to fostering creativity, empathy, and collaborative design practices in schools, and teachers' design competencies are essential for embedding these practices in everyday classroom contexts.

Keywords: Design Thinking, Empathy, Design and Maker Education, Teacher Roles, K–9 Education, Participatory Design, Teacher Education

# Tiivistelmä

Yhteiskunnalliset, teknologiset ja koulutukselliset muutokset edellyttävät yhä enemmän laaja-alaisten kompetenssien, kuten luovuuden, empatian ja yhteistyötaitojen kehittämistä. Opettajat tarvitsevat siten uusia pedagogisia lähestymistapoja oppilaiden osallistamiseksi suunnitteluprosesseihin. Vaikka muotoiluajattelu on vakiintunut lähestymistapa korkeakoulu-opetuksessa, sen soveltamista perusopetukseen, erityisesti opettajien suunnittelutyön ja fasilitointikäytäntöjen näkökulmasta, on tutkittu vähän.

Tämä väitöskirja vastaa näihin tarpeisiin tarkastelemalla muotoiluajattelun integroimista perusopetuksen (K–9) muotoilu- ja maker-opetukseen. Erityistä huomiota kiinnitetään opettajien rooleihin ja käytäntöihin tässä prosessissa sekä muotoiluempatian (eli empatian suunnitteluprosesseissa) ilmenemiseen oppilaiden suunnitteluprosesseissa.

Väitöskirja perustuu syvälliseen laadulliseen tapaustutkimukseen, joka toteutettiin yläkoulun käsityönopetuksessa. Oppilaat osallistuivat 12 opetuskerran muotoiluprojektiin, jossa esikoululaiset osallistettiin suunnitteluprosessiin lopputuotteiden tulevina käyttäjinä. Aineisto koostui videoista, pedagogisista materiaaleista, valokuvista, kenttämuistiin-panoista, reflektiivisestä päiväkirjasta, audioreflektioista, haastatteluista ja kyselyistä. Aineistoa analysoitiin narratiivisen, temaattisen ja laadullisen sisällönanalyysin avulla. Näin voitiin tarkastella, miten opetus-, oppimis- ja suunnitteluprosessit etenivät projektin aikana.

Tulokset ehdottavat, että muotoiluajattelu voidaan integroida osaksi perusopetusta. Tätä tukevat jäsennelty muotoiluprosessi, ihmiskeskeiset ja osallistavat menetelmät sekä ajattelutapa, joka hyväksyy epävarmuuden, kokeilemisen ja virheet osaksi oppimista. Empatia on keskeistä sekä oppilaiden suunnitteluprosesseissa että opettajien pedagogisissa ratkaisuissa. Sen tulisi siis korostua, kun muotoiluajattelua yhdistetään osaksi opetusta.

Tutkimus korostaa opettajien muuntuvia rooleja luovien ja avoimien oppimisprosessien suunnittelijoina ja fasilitaattoreina. Muotoiluajattelun opettaminen näyttäytyy suunnittelutyönä, joka edellyttää muotoiluajattelun ajattelutapaa, improvisointia ja jatkuvaa reflektointia. Havaintoihin perustuen väitöskirja ehdottaa alustavaa konseptuaalista mallia, joka tukee opettajia empatiaa korostavien muotoilu- ja maker-oppimiskokonaisuuksien suunnittelussa ja toteuttamisessa perusopetuksessa.

Yhteenvetona väitöskirja tuottaa empiiristä, käsitteellistä ja pedagogista tietoa siitä, miten muotoiluajattelu voi tukea ja rikastaa perusopetuksen muotoilu- ja maker-opetusta. Muotoiluajattelu tarjoaa lupaavan lähestymistavan luovuuden, empatian ja yhteisöllisen suunnittelun vahvistamiseen perusopetuksessa, ja opettajien monipuolinen suunnittelu-osaaminen on keskeistä näiden käytäntöjen juurtumisessa osaksi koulun arkea.

Avainsanat: Muotoiluajattelu, empatia, muotoilu- ja maker-opetus, opettajan rooli, perusopetus (K–9), osallistava suunnittelu, opettajankoulutus

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# List of Original Publications

This dissertation is based on the following publications:

I Bosch, N., Lavonen, J., & Kangas, K. (2022). Learning to create: Creating to learn. In T. Korhonen, K. Kangas & L. Salo (Eds.), *Invention pedagogy – The Finnish approach to maker education* (1st ed., pp. 56–69). Routledge. https://doi.org/10.4324/9781003287360-6

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III Bosch, N., Härkki, T., & Seitamaa-Hakkarainen, P. (2022). Design empathy in students' participatory design processes. *Design and Technology Education: An International Journal, 27*(1), 29–48. https://doi.org/10.24377/DTEIJ.article1150

The publications are referred to in the text by their roman numerals.

# 1 Introduction

Design is deeply embedded in contemporary life through the artifacts, services, and media that surround us. It shapes cultural, social, and environmental systems and influences how individuals interact with the world (Nelson & Stolterman, 2012). As a practical and social activity, design brings together tools, materials, people, and agencies, making it both a collective practice and a fundamental human endeavor (Koskinen, 2023). Because all goods and services are designed, the quality of design directly affects everyday life (Cross, 2007). Consequently, there is a growing need to develop a range of design competencies and design literacy—a broad cultural and educational capacity to interpret, critique, and create design in everyday contexts (Baynes & Baynes, 2010; Iversen et al., 2018; Lutnæs, 2019).

Contemporary design approaches increasingly emphasize participatory, empathic, and context-driven practices in which users are engaged as partners rather than as passive recipients (Bonsignore et al., 2017; Kouprie & Sleeswijk Visser, 2009; Sanders & Stappers, 2008). Whereas earlier design traditions focused largely on technical expertise and product development, current approaches foreground transversal competencies that support engagement with people and communities, address complex and ill-defined problems, and enable the creation of meaningful—often technology-mediated—solutions (Mattelmäki et al., 2014; Noel & Liub, 2017; Téllez-Bohórquez & Gonzalez-Tobon, 2019). These competencies integrate knowledge, skills, and attitudes across subjects and domains (Binkley et al., 2012; UNESCO, 2020; United Nations, 2015). Design competencies such as empathy, creativity, collaboration, courage, flexibility, and agility in thinking, and the capacity to navigate uncertainty constitute an essential part of this broader set of competencies, preparing learners to engage with an increasingly complex world (Wrigley & Mosely, 2023).

Design is thus understood as both a practical and social endeavor that shapes how people live, learn, and participate in the world. Participatory approaches to learning similarly highlight the value of engaging students in authentic cultural activities and collaborative efforts to frame and solve meaningful problems (Hakkarainen et al., 2013). Within this context, Participatory Design (PD) and design thinking (DT) offer complementary but distinct orientations for fostering design literacy and design-related competencies in formal education.

PD brings a commitment to democratic participation, empowerment, and socio-ethical considerations, foregrounding people as active partners whose perspectives, needs, and experiences guide the design process (Bødker et al., 2022; Simonsen & Robertson, 2013). In PD, design is understood as emerging through social, material, and dialogic interactions (Björgvinsson et al., 2012), and participation with children is conceptualized as meaningful, contextual, and political, with mutual learning as a central principle (Kinnula & Iivari, 2021). Building on these commitments, PD contributes a value-based orientation that emphasizes direct user involvement, co-design, and mutual learning (Smith et al., 2025).

In contrast, DT complements this orientation by offering a structured, teachable approach to engaging end users with open-ended problems and supporting productive engagement with uncertainty (Carroll, 2014; Henriksen et al., 2020). As an approach to creative and collaborative problem-solving, DT promotes a mindset that integrates empathy, curiosity, and resilience with systematic processes for idea development and material exploration (Goldman & Kabayadondo, 2016). In this context, DT provides a pedagogical structure for organizing creative inquiry in classroom settings, through which participatory values and broader design-related competencies can be enacted in practice.

Together, PD's values-driven rationale—the *why* of participation and mutual learning—and DT's methodological orientation—the *how* of designing and making in classroom contexts—provide a foundation for students to develop as reflective, empathic, and collaborative designers. These orientations also connect with broader educational aims that emphasize inclusivity, democratic engagement, and 21st-century competencies, reflecting a wider interest in design and participatory approaches in education (Cumbo & Selwyn, 2022; DiSalvo & DiSalvo, 2014).

Despite growing interest in design-oriented approaches and the widespread recognition of the importance of creativity and innovation in contemporary society, research and pedagogical approaches that intentionally foster these design-related competencies in K–9 settings remain underdeveloped (Cremin & Chappell, 2021). Many aspects central to design—such as constructing technology for specific users, conducting design inquiry, and developing empathy—are still seldom addressed in earlier school curricula (Bush et al., 2024; Dindler et al., 2020; Klapwijk & Van Doorn, 2015). Panke's (2019) systematic review shows that only a small proportion of DT case studies provide detailed accounts of implementation, particularly in school contexts. Moreover, the teacher's role in facilitating DT processes remains under-examined, even though teachers' pedagogical decisions fundamentally shape both the quality of design learning and student outcomes (Cortés Loyola et al., 2020; Hennessey & Mueller, 2020; Retna, 2016).

The aim of this dissertation is to address these gaps by examining the integration of a DT approach in formal K–9 design and maker education, with particular attention to the roles and practices of teachers in this process and to the

manifestation of design empathy in students' design activities. To address this aim, the dissertation was guided by the following research questions: RQ1: How were the dimensions of the design thinking approach implemented in facilitating and structuring the creative design process in formal K–9 design and maker education? RQ2: What roles and practices do teachers enact when integrating the design thinking approach in formal K–9 design and maker education? RQ3: How is design empathy manifested in students' design processes in formal K–9 design and maker education?

In this dissertation, DT serves as the primary pedagogical and analytical framework through which design processes are examined and integrated into formal K–9 design and maker education, while PD functions as a value-based orientation that informs the participatory, reflective, and democratic character of the learning design.

# 2 Theoretical Background

This chapter presents the theoretical background for the dissertation. It begins by outlining the design thinking (DT) approach and its key dimensions, then examines DT in formal education, with particular attention to its relationship with craft, design, and maker education. The chapter continues by explaining learning through DT and concludes by focusing on teachers' roles in creative learning environments within formal education.

## 2.1 Design Thinking Approach

This section first outlines the definition and methodological foundations of DT. It then examines the role of empathy as an integral component of DT. Finally, it presents the dimensions of DT used in this dissertation.

### 2.1.1 Definition and Methodology of Design Thinking

The research focus on design emerged alongside efforts to define professional design as a distinct discipline (Cross, 2011). Simon (1969) offered an early definition of design as a cognitive activity aimed at "changing existing situations into preferred ones," framing it as a systematic and future-oriented practice. He described design as a science of the artificial, that is, the study of things intentionally created by humans to serve purposes.

Archer (1979) advanced this view by proposing design as a third culture alongside science and the humanities, emphasizing its unique ways of thinking, knowing, and acting. Building on this foundation, Cross (1992, 2001, 2011) articulated a *designerly way of knowing*, emphasizing abductive reasoning, non-verbal modeling, intuition, and reflection as central to navigating ambiguity and generating novel solutions to ill-defined problems. Drawing on Gardner's (1983) theory of multiple intelligences, Cross (1992) situated design ability as a multifaceted cognitive skill involving visual–spatial, bodily–kinesthetic, and interpersonal intelligences. Designers continuously reframe ill-defined problems, generating solutions as well as new ways of understanding them. Dorst's concept of frame creation (2011) extends this idea by describing designers' capacity to reinterpret and redefine problems through iterative synthesis and reflection.

Current perspectives on design are strongly influenced by Schön's (1983) constructionist theory of design as a reflective practice. Whereas the sciences rely primarily on systematic methods and the arts on intuition, design lies between them; it represents an approach to acquiring knowledge, skills, and attitudes that respond to the interdisciplinary complexity of life (Cross, 2023).

Razzouk and Shute (2012) define design as "an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign" (p. 330). According to Meyer and Norman (2020), DT includes four critical components: (1) focusing on the needs and capabilities of the people who will use the result, (2) solving the correct problem rather than its symptoms, (3) applying a systems approach that recognizes interdependencies, and (4) iterating through repeated cycles of prototyping, testing, and refinement. These components can occur in different orders and through many techniques. Goldman and Kabayadondo (2016) describe DT as a human-centered, empathy-driven approach to generating novel solutions by drawing on insights into people's needs, refined through prototyping and stakeholder testing. Teams adapt and refine their processes through cycles of ideation, prototyping, and testing (Rauth et al., 2010). Hands-on exploration with materials plays a central role, linking thinking, feeling, and making (Groth, 2016).

DT is often represented through structured models such as IDEO's human-centered design process (2010), the Stanford d.school model (2010), or the Design Council's Double Diamond (2005). Although these models are often depicted as linear, in practice, DT is non-linear and cyclical, with problem framing and solution development occurring in parallel. It integrates both cognitive and affective processes, requiring experimentation and iteration while drawing on participants' prior knowledge and experiences (Razzouk & Shute, 2012). Across models, empathy remains central, guiding designers to engage deeply with users' experiences (Sun, 2017).

Uncertainty is central to this process. As Buchanan (1992) and Cross (2011) note, design engages with wicked problems—ill-structured situations that can be understood only through speculative attempts to solve them. Schön (1983) describes this as the epistemology of practice that defines human-centered professions: a reflective engagement with "uncertainty, instability, uniqueness, and value conflict" (p. 49). Such situations demand creativity, flexibility, and tolerance for ambiguity. Designers' personal attitudes about uncertainty, including how they think, feel, and act under ambiguous conditions, strongly influence their processes and outcomes (Tracey & Hutchinson, 2016).

Since the mid-2000s, DT has evolved into a broader, transferable approach to human-centered creative problem-solving that extends beyond professional design domains into business, management, education, and social innovation (Brown, 2009; Cross, 2023; Johansson-Sköldberg et al., 2013; Kimbell, 2011). Despite its

broad appeal, DT has also been subject to critical scrutiny. Scholars have noted that it is often ambiguously defined and sometimes reduced to toolkits detached from authentic design practice. Cross (2023) and Laursen (2019) distinguish *designerly thinking,* which concerns epistemological structures, from US-based managerial DT, which focuses on methods and techniques. Others caution that decontextualized versions may overlook ethical, social, and power-related dimensions of design (Johansson-Sköldberg et al., 2013; Laursen & Haase, 2019; Yorgancıoğlu et al., 2025).

Kolko (2018) proposed that the design way of thinking rests on three foundational pillars: *empathy*, rooted in participatory design practice and the involvement of users as co-designers; *problem exploration*, blending divergent and convergent thinking; and *making*, understood as the practical transformation of abstract ideas into tangible forms through modeling and testing.

These characteristics are further elaborated in this dissertation through the four interrelated dimensions of DT introduced in Section 2.1.3.

### 2.1.2 Empathy in Design

In the 1980s, Cross (1982) identified human-centeredness—essentially empathy—as a defining characteristic of design, with designers learning from users' experiences to create meaningful solutions. Since then, empathy has been one of the values that distinguishes the field of design from the sciences and the humanities, and its role in design has grown considerably (Heylighen & Dong, 2019; Stephan, 2023). Empathic design refers to the creation of solutions that address both the functional and emotional needs of users. When designers focus only on functional requirements and overlook emotional, cultural, or social aspects, the resulting solutions may be less meaningful from the user's perspective (Woodcock et al., 2018).

Design researchers have increasingly emphasized the emotional and experiential dimensions of design, establishing the basis for empathic, often qualitative methods to uncover users' needs, desires, and challenges (Koskinen et al., 2003; Kouprie & Sleeswijk Visser, 2009). Initially, the aim was to understand human experience to inspire and inform design. Over time, users became more actively involved through co-design and participatory practices, and more recently through speculative and future-oriented design (Téllez-Bohórquez & Gonzalez-Tobon, 2019).

From a social psychological perspective, empathy integrates both affective experiences and cognitive processes (Cotton, 2001; Smeenk et al., 2019a). Although these dimensions are often separated in theory, in design practice they are closely intertwined; both are necessary for effective engagement with users, and empathy is therefore understood as a relational and situated practice.

Empathy in design requires balancing users' perspectives and experiences with designers' own insights and interpretations (Kouprie & Sleeswijk Visser, 2009). Empathy includes intertwined self- and other-oriented perspectives (Batson, 2009; Hess & Fila, 2016). While the self-oriented perspective is based on "how one would think and feel in another's situation," the other-oriented perspective is based on "imagining how another thinks or feels" (Batson, 2009; Efilti & Gelmez, 2024; Hess & Fila, 2016). In this dissertation, empathy in design is approached as a broad conceptual orientation. Building on this perspective, the concept of *design empathy* is used to more specifically capture how empathy is manifested and enacted within students' design activities. The degree of empathic engagement is shaped by situational factors such as emotional state, responsibility, and the timing of interaction, with designers inevitably interpreting user data through their own experiences (Smeenk et al., 2016; Smeenk et al., 2019a).

Although empathy varies between individuals, it can be strengthened through training, motivation, and direct user engagement (Kouprie & Sleeswijk Visser, 2009). Research indicates that designers who feel personally connected to a user group or interact directly with users tend to be more motivated and produce more relevant outcomes (Mattelmäki et al., 2014; van Rijn et al., 2011). Recent studies also suggest a positive relationship between empathy and creativity. For example, Li, Chen, and Fu (2024) found that empathy predicts creativity, while Demetriou and Nicholl (2022) demonstrated that empathy instruction can enhance both emotional and cognitive creativity in learners.

Despite its recognized importance, theories of empathy in design remain underdeveloped, particularly regarding how empathy functions in practice and how it can be intentionally supported in educational contexts (Hess & Fila, 2016; Smeenk et al., 2019a; Surma-aho & Hölttä-Otto, 2022). In higher-level design education, students are often encouraged to establish empathy with users to understand their realities, inspire design practice, and develop artifacts that respond to human needs (Téllez-Bohórquez & Gonzalez-Tobon, 2019). Emerging evidence suggests that empathy can also be cultivated in lower levels of design education (Montero, 2023). As design education increasingly adopts human-centered approaches, fostering empathy through intentional methods, direct user engagement, and reflective practice provides a pathway toward more meaningful and socially responsive design outcomes.

In educational contexts, empathy can also be understood as a pedagogical stance that shapes how teachers interpret learners' experiences, needs, and perspectives. Within design-oriented pedagogy, teachers' empathic orientation influences how learning activities are framed, how participation is scaffolded, and how students are supported in engaging with users and communities. Empathy, therefore, operates not only as a competence to be developed by students but also as a guiding principle

for the design and facilitation of learning experiences (Carlson & Dobson, 2020; Cook & Bush, 2018).

In this dissertation, empathy is conceptualized at two interrelated levels. First, it is examined empirically as design empathy manifested in students' design activities, which forms the primary analytical focus of Study III. Second, empathy functions as a pedagogical principle informing teachers' learning design and facilitation practices, shaping the conditions under which students engage with human-centered design processes. While the empirical analysis focuses primarily on students' design empathy, teachers' empathic orientation toward learners and users forms an important contextual condition that supports these processes.

Several scholars have noted that empathy remains conceptually diffuse and is defined in multiple ways across disciplines (Hess & Fila, 2016; Kouprie & Sleeswijk Visser, 2009; Smeenk et al., 2019a). Given the broad and sometimes inconsistent use of the concept across fields, providing a comprehensive theoretical definition of empathy lies beyond the scope of this dissertation. Instead, this dissertation draws on established conceptualizations of design empathy that emphasize perspective-taking, engagement with users' experiences, and the relational nature of design processes.

### 2.1.3 Dimensions of Design Thinking

In this dissertation, which was designed and implemented in the context of comprehensive education, DT is conceptualized as an interconnected framework comprising four dimensions—process, methods, mindset, and empathy (Bathla et al., 2025; Brenner et al., 2016; Carlgren et al., 2016b). This framing (Figure 1) positions DT as a framework for learning and participation rather than expertise reserved for professionals.

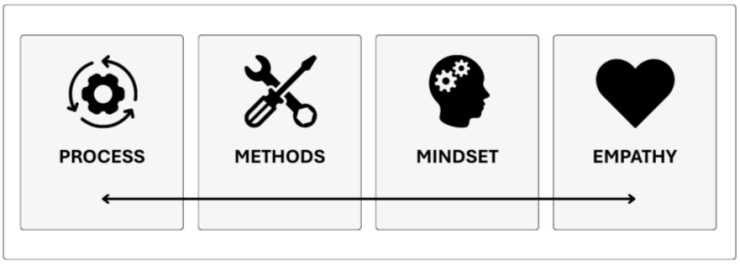



**Figure 1** The four dimensions of design thinking

It can be approached as a teaching and learning process, as a set of tools and methods that guide design activity, and as a mindset cultivated throughout the design journey. Empathy plays a particularly significant role, as it underpins

human-centered approaches to design (Carroll & McBain, 2021). In this sense, DT is seen as a universal human capacity that everyone can participate in (Brown, 2009; Pacione, 2017).

**Design Thinking as a Process**

The DT process is iterative and non-linear and encompasses empathizing, defining, ideating, prototyping, and testing. Each stage can be revisited as new insights emerge, allowing ideas to evolve in response to feedback. This adaptability supports both divergent and convergent thinking (Cross, 2011). Structured models such as the Double Diamond illustrate how designers move between problem exploration and solution generation through reflection and iteration (Design Council, 2005). The Double Diamond model features two main stages: problem definition and solution creation. Each stage involves both divergent (expansive) and convergent (focused) thinking, supported by iterative feedback loops and overlapping steps to refine ideas and solutions (Design Council, 2005).

**Design Thinking as Methods and Tools**

DT employs a wide range of tools and techniques to support its process. Micheli et al. (2019) identified 37 commonly used methods, including ethnographic research, personas, journey maps, brainstorming, mind mapping, prototyping, and field experiments. These methods correspond to different stages of the process: interviews and observations are applied during the research and definition phases to uncover user needs and insights; brainstorming and mind mapping expand the range of ideas in the ideation stage; and rapid prototyping and visualization facilitate collaboration and concept testing. By combining and adapting such methods, practitioners ensure that the iterative process addresses complex challenges while fostering creativity and innovation.

**Design Thinking as Mindset**

DT also represents a mindset that values curiosity, empathy, optimism, and resilience in the face of uncertainty (Howard et al., 2015). This mindset enables learners to experiment without fear of failure, collaborate across disciplines, and approach ambiguity as a source of creativity. Schweitzer et al. (2016) identify eleven key attitudes associated with the DT mindset, including embracing collaboration and diversity, valuing experiential intelligence, tolerating uncertainty, and fostering critical questioning. Vignoli et al. (2023) add risk-taking, learning orientation, and a focus on impact as key attributes of this mindset. These attitudes encourage individuals to challenge conventional practices, trust their intuition, and remain open to new perspectives. When nurtured in collaborative communities, these dispositions foster creative confidence—the belief in one's ability to generate and test ideas through action (Kelley & Kelley, 2013).

**Design Thinking as Empathy**

Empathy links the cognitive, affective, and social aspects of design. It enables designers to connect with users, interpret experiences, and create inclusive, human-centered solutions (Téllez-Bohórquez & Gonzalez-Tobon, 2019). Kouprie and Sleeswijk Visser (2009) emphasize the importance of a balanced approach to empathy, integrating user insights with designers' reflections and experiences. Empathy enhances the design process and contributes to designers' personal growth by strengthening interpersonal skills and fostering the capacity to develop more relevant and impactful solutions. Through empathic engagement, designers are better equipped to craft sustainable, human-centered innovations that address real-world challenges.

Together, these four dimensions suggest framing DT as a pedagogy that integrates designing, making, reflection, and collaboration. In educational contexts, they support learners in navigating complex, real-world problems while fostering creativity, empathy, and agency.

## 2.2 Design Thinking in Formal Education

This section examines the role of DT in formal education, with particular attention to its frequent association with K–9 design and maker education (DME) and their compatibility. It concludes by outlining the rationale for integrating DT into Finnish lower-secondary craft education, which provides the context for this dissertation.

### 2.2.1 From Higher Education to Comprehensive Schools

In the twenty-first century, DT became visible across educational levels, from higher education in design, engineering, and business to school-based classrooms (Calavia et al., 2023; Scheer et al., 2012; Smith et al., 2015; Wrigley & Straker, 2017). The spread of DT from professional and industry contexts into education marked a turning point in its development. Its integration into Stanford University's curriculum in the early 2000s established a model later adopted by leading universities, including Harvard, UC Berkeley, and MIT (Yorgancıoğlu et al., 2025). In higher education, DT is viewed as a catalyst for reform—encouraging interdisciplinary collaboration, creativity, and innovation. Programs in management, medicine, and the humanities increasingly use DT to support students in addressing complex, real-world challenges (Beligatamulla et al., 2019; Wrigley & Mosely, 2023). Research on DT interventions in higher education shows positive effects on creativity, teamwork, and problem-solving, as well as other 21st-century skills (Guaman-Quintanilla et al., 2023; Koh et al., 2015; Yu et al., 2024).

Although higher education has played a key role in legitimizing DT, its translation to primary and secondary schooling is more recent. For example, the Central Board of Secondary Education in India introduced its *Design Thinking and Innovation* course for Grades 6–12 in 2022 (Bathla et al., 2025). Reviews indicate growing interest in DT in lower-level school settings while noting that research remains emergent (Li & Zhan, 2022; Lin et al., 2025; Saseendran & Thomas, 2025). Studies show that DT can operate as a teaching method, a learning objective, and a framework for curriculum design (Lor, 2017; Panke, 2019). Across models, common elements include empathy and user-centeredness, creativity and innovation, rapid prototyping, experimentation, and multidisciplinary collaboration (Lor, 2017).

Yet a persistent gap remains between DT's conceptual value and its classroom implementation. DT has been critiqued for its ambiguity and commodification (Johansson-Sköldberg et al., 2013; Kimbell, 2011), which complicates its operationalization in curricula. Reviews also highlight the absence of consensus about the purpose of DT in education (Davis & Littlejohn, 2016; Mosely et al., 2018). Research tends to emphasize positive outcomes while neglecting challenges (Panke, 2019). Notably, scholars highlight the lack of sufficient guidance on how to teach DT to non-designers, including teachers and children (Henriksen et al., 2020; Mosely et al., 2018; Starostka et al., 2021).

### 2.2.2 Design Thinking into Design and Maker Education

Making has always been central to human experience—from childhood play to everyday repair and craft (Klapwijk & de Vries, 2023). Industrialization and digitalization have distanced people from these practices, prompting renewed interest in hands-on, creative learning. Maker education reintroduces this engagement through opportunities for tinkering, iteration, and tangible production (Honey & Kanter, 2013; Papert & Harel, 1991). Integrating traditional crafts with digital tools such as e-textiles, coding, and electronics broadens the space for creativity and digital literacy (Peppler et al., 2020). This blend of digital innovation and craft traditions strengthens students' problem-solving and design competencies (Klapwijk & de Vries, 2023) and is increasingly recognized by policymakers seeking to integrate design, engineering, and making into curricula that support creativity and innovation (Danish Ministry of Education, n.d.; OECD, 2019; Vuorikari et al., 2019).

At the same time, critics have noted that maker education—and related STEM initiatives—often devote insufficient attention to the societal and ethical implications of technology (Bush et al., 2024; McCurdy et al., 2020; Smith et al., 2020). Research demonstrates that making and tinkering can foster meaningful STEM learning, agency, and equity when activities intentionally value community,

culture, and identity (Bevan, 2017; Vossoughi et al., 2016). Such approaches position learners as technology creators rather than passive consumers (Buchholz et al., 2014; Kafai et al., 2014), and framing making as a contribution to one's community has been shown to particularly motivate girls (Holbert, 2016). Incorporating fiber arts and other traditionally gendered crafts likewise challenges stereotypes around who can participate in making (Buchholz et al., 2014; Dougherty, 2013; Wingard et al., 2022). Situating making within social and cultural contexts therefore supports inclusive and transformative education (Vossoughi et al., 2016). In response, scholars advocate integrating design practices into maker education to help students reflect critically on how technologies shape communities and power relations (Dindler et al., 2020; Iivari et al., 2023; Smith et al., 2015). Because social structures such as gender, class, and race influence learners' identities and opportunities in STEM (Peppler et al., 2020), designing and making have been described as pathways to computational empowerment (Dindler et al., 2020), digital citizenship and Bildung (Katterfeldt et al., 2015; Schelhowe, 2013), and emancipation (Martinez & Stager, 2013). Smith et al. (2015) describe DT as cultivating "reflective dialogues on the complex connections between analogue materials, digital technologies, and people." The convergence between DT practices and maker approaches emphasizes participation, agency, and design for social good. This perspective aligns with a broader educational shift that positions learners as reflective and creative actors capable of shaping their environments, rather than merely as technology users (Blikstein & Worsley, 2016; Iversen et al., 2017; Schaper et al., 2023).

DME integrates designing, digital fabrication, and hands-on making to cultivate competencies such as creativity, empathy, collaboration, and resilience (Van Mechelen et al., 2021; Veldhuis et al., 2021). DME engages students in constructing knowledge through creative and collaborative activity, emphasizing experiential, learner-driven, and interdisciplinary practices that connect doing, thinking, and reflecting (Clapp, 2016; Seitamaa-Hakkarainen & Hakkarainen, 2017).

As DME expands globally, tensions emerge between the open-ended nature of design processes and the structures of standardized curricula (Godhe et al., 2019; Rouse & Rouse, 2022). Teachers must develop new knowledge and mindsets to design and facilitate creative, technology-rich learning environments (Andersen & Pitkänen, 2019; Calavia et al., 2023; Smith et al., 2016). Barriers include limited teacher preparation, insufficient time for open-ended work, limited resources, cross-disciplinary coordination, and challenges in assessing process-oriented outcomes (Li & Zhan, 2022; Parker et al., 2021). The complexity of multi-material and digital fabrication approaches, combined with curriculum demands, further complicates implementation (Porko-Hudd et al., 2018; Walan & Gericke, 2023).

Researchers have proposed DT as a structured process that can help teachers implement inquiry-based, construction-oriented learning in everyday classroom

practice. DT enables learning through interaction with the world, as the act of designing involves a continuous dialogue between ideas and their material realization (Retna, 2016; Rusmann & Ejsing-Duun, 2022; Scheer et al., 2012).

**Finnish Craft Education Context**

Finland provides a distinctive context for DME. Although schooling historically prioritized literacy and mathematics, educators such as Pestalozzi, Fröbel, Cygnaeus, and Montessori emphasized the importance of materiality and embodied learning (Klapwijk & de Vries, 2023). Finnish craft education (sloyd), introduced in 1866 by Uno Cygnaeus, evolved into a Nordic model emphasizing practical skills, creativity, and agency (Klapwijk & de Vries, 2023; Marjanen & Metsärinne, 2019). The English name of the school subject Crafts (craft and design) (EDUFI, n.d.) is also translated as craft, design, and technology education in global contexts (Porko-Hudd et al., 2018).

According to the most recent National Core Curriculum for Basic Education, craft education ('Crafts') is a mandatory subject for all students in Grades 1–7 (ages 7–13), with about two hours of instruction per week. In Grades 8–9 (ages 14–15), craft education becomes optional, alongside art and other skills-based subjects (EDUFI, 2014). The curriculum emphasizes a holistic design process that fosters students' cognitive, emotional, and social development (Pöllänen, 2020). Craft education in Finland combines technical and textile work to support students' creativity, critical thinking, and problem-solving through experimentation with materials, technologies, and techniques (EDUFI, 2014). Craft education teachers are qualified specialists who hold a university master's degree integrating pedagogical studies and subject-specific expertise in craftsmanship (Porko-Hudd et al., 2018).

Craft education is traditionally taught in two dedicated learning spaces—technical craft and textile craft workshops—which are standard facilities in Finnish comprehensive schools. However, current developments in Finnish craft education increasingly emphasize integrated learning environments that support holistic processes, multi-materiality, and interdisciplinary design work (EDUFI, 2014; Marjanen & Metsärinne, 2019; Pöllänen, 2020). In these emerging unified, multi-material learning spaces—conceptualized as makerspaces (Jaatinen & Lindfors, 2019)—textile and technical craft are understood as complementary rather than separate domains. This material-rich and increasingly integrated infrastructure provides a strong foundation for incorporating DT and maker practices that combine traditional craftsmanship with digital fabrication and computational tools (Jaatinen & Lindfors, 2019). Recent work by Hartvik and Porko-Hudd (2024) highlights how craft education fosters multifaceted learning and Bildung, while Grönman et al. (2025) further emphasize the potential of incorporating DT

principles to enhance creativity, reflection, and collaborative problem-solving in craft education.

In Finland, researchers have conducted extensive work on integrating design and maker practices into basic education (Hakkarainen & Seitamaa-Hakkarainen, 2022; Korhonen et al., 2022). Situated within frameworks such as invention pedagogy, these studies involve close collaboration between researchers and teachers to co-develop, pilot test, and refine practical models for classroom use. Together, they have developed approaches that help teachers adopt design-based and maker-centered pedagogies and cultivate classroom cultures that value creativity, experimentation, knowledge creation, and shared problem-solving. This body of research has also examined non-linear design and making processes, documenting how students and teachers navigate open-ended, iterative, and collaborative project work (Korhonen et al., 2022).

### 2.2.3 Learning Through Design Thinking

Learning through design closely aligns with constructionism, a learning theory that posits learning occurs best when individuals actively create artifacts with personal and social meaning (Papert & Harel, 1991). Learners are builders of their own knowledge (Kafai & Resnick, 1996), and learning is understood as both the development of knowledge and the cultivation of ways of thinking and acting. From a sociocultural perspective, learning is collaborative and occurs within groups, communities, and networks (Hakkarainen et al., 2013), highlighting the role of interaction, language, and culture in cognitive development (Vygotsky, 1978).

To participate in design activity, learners need diverse forms of knowledge, skills, and dispositions (Goldman & Kabayadondo, 2016; Sawyer, 2018). Authentic, human-centered challenges cultivate critical and creative thinking, collaboration, empathy, and the ability to interpret and shape social and experiential dimensions (Davis, 1998).

A growing body of empirical work shows how DT supports interconnected cognitive, social, and affective learning outcomes (Cook & Bush, 2018; Xu et al., 2024) and that design competencies are holistic and multidimensional (Fass et al., 2018; Luka, 2019). In higher education, Tsai (2021) found that DT fostered higher-order thinking (e.g., defining problems, ideation, synthesis), collaboration (e.g., communication, coordination), socio-emotional characteristics (e.g., empathy, self-confidence), and learning strategies (e.g., participation, time management).

International frameworks help situate design competencies within broader educational aims, including creativity, collaboration, communication, and critical thinking (Partnership for 21st Century Skills, 2019), as well as the taxonomy of ten key competencies proposed by Binkley et al. (2012). The OECD Learning Compass 2030 (2019) distinguishes between cognitive and metacognitive, social and

emotional, and practical competencies, emphasizing empathy, respect, and agency as essential for thriving in interconnected societies. These frameworks converge in positioning design competencies and the ability to cope with uncertainty as essential for navigating complexity and shaping sustainable futures (Wrigley & Mosely, 2023).

DME provides fertile contexts for cultivating design competencies through material experimentation and authentic problem-solving. Students transform ideas into tangible artifacts, share and critique them, and iteratively refine their thinking (Mehto et al., 2020). Through these practices, learners collaborate, empathize, and communicate ideas in verbal, visual, and material forms (Clapp, 2017), exploring diverse perspectives and generating alternative solutions (Kangas et al., 2013).

While other inquiry-oriented pedagogies emphasize authentic problems, iteration, and collaboration, DT explicitly foregrounds empathy as its core dimension (Kijima & Sun, 2020; Torrisi-Steele, 2020) and highlights perspective-taking and emotional attunement as drivers of the design process (Klapwijk & Van Doorn, 2015). These practices help learners understand diverse users, consider inequities, and imagine alternative futures (Clapp & Jimenez, 2016; Goldman & Kabayadondo, 2016; Noel & Liub, 2017), ultimately fostering empathy for others (Montero, 2023).

DT offers hands-on, collaborative pathways for practicing creativity, agency, empathy, and critical thinking as students engage with real-world, often ill-defined problems (Noel & Liub, 2017; Retna, 2016; Rusmann & Ejsing-Duun, 2022). It has also been proposed to strengthen students' creative confidence (Kijima et al., 2021), including the ability to generate ideas, take risks, and persist despite uncertainty or failure (Carroll et al., 2010; Goldman & Kabayadondo, 2016; Kelley & Kelley, 2013; Rauth et al., 2010). Social interaction further opens pathways for empathy as learners discuss, plan, reason, and act collaboratively with peers and community stakeholders (Carlson & Dobson, 2020). Research links such practices—particularly those grounded in empathy, iteration, and reflection—to enhanced creativity, self-efficacy, and social-emotional learning (Voigt et al., 2019).

Taken together, learning through DT can develop a wide range of design competencies, including the ability to imagine and frame problems, empathize and collaborate with others, experiment through prototyping, and critically reflect on outcomes. Empathy, understood as perceiving and responding to others' needs and perspectives, plays a central role in this process (Carroll et al., 2010; Voigt et al., 2019).

## 2.3 Teachers' Multiple Roles in the Creative Classroom

This section focuses on teachers' multiple roles in creative, design- and maker-oriented classrooms. A creative classroom is a pedagogical environment that fosters imagination, creativity, and problem-solving through open-ended, student-centered activities that encourage exploration, risk-taking, and diverse perspectives (Craft et al., 2014; Richardson & Mishra, 2018; Sawyer, 2011). Such environments support the generation of novel and meaningful ideas within collaborative, flexible settings that connect multiple disciplines and authentic contexts (Cremin & Chappell, 2021; Davies et al., 2013). Creativity is embedded in the psychological and pedagogical dimensions of learning as well as in the social and material infrastructures of classrooms (Henriksen et al., 2023). Within DME, teachers are central in orchestrating these creative conditions.

### 2.3.1 Teacher as a Reflective Learning Experience Designer

Teaching increasingly resembles design work. Teachers create, implement, and iteratively refine social, behavioral, and academic practices as they design curricula, interaction patterns, communication structures, and discipline-specific inquiries (Schön, 1983), as well as relationships with families and the wider school community (Clapp & Jimenez, 2016). Like designers, they frame problems, generate multiple solutions, and make decisions in complex and uncertain situations (Elwood & Jordan, 2022; Jordan, 2016; Penuel & Gallagher, 2009). A growing body of research emphasizes that teaching extends beyond curriculum delivery to the design of inclusive, situated, and meaningful learning environments (Ahn, 2019; Penuel, 2019). Kirschner (2015) similarly argues that expert teachers must move fluidly between practitioner and designer roles, while adopting a designer's perspective enables them to address systemic educational challenges with empathy, creativity, and openness to ambiguity (Henriksen et al., 2020).

In this view, lesson development becomes a complex and creative process of framing and reframing instructional purposes, testing new ideas, and combining resources and methods that best fit the local teaching context (Elwood & Jordan, 2022; Henriksen et al., 2017; Koh et al., 2015). Conceptualizing teaching as design requires sensitivity to sociocultural, pedagogical, and technological dimensions of learning, along with sustained attention to learners' diverse needs (Ahn, 2019). Teachers design curricular and pedagogical structures as well as the social and material dimensions of learning spaces while navigating the uncertainty inherent in open-ended creative work (Schön, 1983). These perspectives position teaching as a complex, ill-structured, and reflexive activity involving continuous decision-making and adaptation (Jordan, 2016).

Reflection is central to this design-oriented view of teaching. Dewey (1938) emphasized that experiences become educational when they are reflected upon, thereby fostering growth. Schön (1983, 1987) extended this through the concept of the reflective practitioner, distinguishing reflection-in-action—an ongoing dialogue with the situation—from reflection-on-action, the retrospective analysis of choices and outcomes. In DME, where uncertainty, iteration, and material experimentation are inherent, reflection supports teachers in reframing challenges, testing alternatives, and developing adaptive expertise over time (Härkki et al., 2021; Sawyer, 2011; Schön, 1983).

Reflective practice encompasses cognitive, affective, and social dimensions, involving reasoning, emotions, attitudes, and professional identity (Baykal et al., 2021; Schön, 1987). It supports the evaluation of strategies, the sharing of insights, and the recognition of both successes and failures (Baykal et al., 2021; Kinnula & Iivari, 2019). Reflection is not automatic but is often triggered by moments of confusion or contradiction, and it enables teachers to reframe challenges, value mistakes as part of learning, and model reflective inquiry for students (Becker & Jacobsen, 2020; Kafai & Fields, 2018). Hjorth et al. (2016) explored how reflections enabled teachers to gain a deeper understanding of complex design processes, the importance of working with diverse materials, and the development of a more flexible mindset. Recent work by ElSayary (2025) demonstrates that reflective practice significantly contributes to teachers' DT mindsets, fostering empathy, creative confidence, and the ability to navigate uncertainty.

Some theoretical frameworks, models, and design principles aim to support teachers in designing learning related to DME (Bekker et al., 2015; Herro et al., 2019; Kafai & Fields, 2018; Veldhuis et al., 2021). These frameworks emphasize experimental activities, real-world connections, empathy-building, user-centeredness, clear learning outcomes, and opportunities for reflection (Aflatoony et al., 2018; Barendregt et al., 2016; Eriksson & Torgersson, 2021; Lor, 2017). While often developed in research–practice collaborations, these frameworks can be difficult to access or adapt for many practicing teachers, underscoring the need to translate these frameworks into usable tools for everyday classroom design.

Teachers can nevertheless use the DT approach to develop engaging, student-centered learning experiences across educational levels. This involves empathizing with students' interests and needs, defining objectives, ideating teaching strategies, prototyping and implementing activities, and reflecting on these processes while gathering feedback (Henriksen et al., 2020). Empathy in classrooms goes beyond knowing students' interests; it requires acknowledging historical contexts and students' identities, experiences, rituals, and languages (Carroll & McBain, 2021). Carroll and McBain (2021) caution that empathy should not be treated as a transactional act in which designers extract information from stakeholders for their own purposes. Instead, empathy must be treated as a co-constructed process of

mutual learning in which all parties act as designers. For educators, this requires setting aside assumptions and ingrained worldviews to gain insight into students' worlds and to design learning experiences that embody deeper, more authentic forms of empathy (Carroll & McBain, 2021).

At the same time, scholars note that many DT models oversimplify classroom realities and often overlook teachers' tacit knowledge, improvisation, and "backstage" design work (Cortés Loyola et al., 2020; Dreessen & Schepers, 2019; Warr et al., 2022). Teaching requires continual adaptation to students, materials, time constraints, and institutional demands. Teachers, therefore, play a crucial role in interpreting and tailoring design frameworks to authentic contexts, underscoring the need for research that recognizes their invisible, iterative, and situationally responsive design efforts (Henriksen et al., 2020; Nicholson et al., 2022; Viilo et al., 2018).

Viewing teachers as reflective learning experience designers highlights both their capacity to create innovative student-centered learning experiences and environments and their ability to grow through continuous reflection.

### 2.3.2 Facilitating Creative Learning Processes

In creative learning environments, facilitation extends well beyond delivering content. Teachers create the emotional, social, and structural conditions that enable students to explore ideas, take risks, and engage collaboratively with open-ended problems (Beghetto & Kaufman, 2014; Benton & Johnson, 2015). Effective facilitation involves ensuring psychological safety, supporting learners' social and emotional development, and helping them build perseverance and flexibility in navigating uncertainty (Cremin & Chappell, 2021; Richardson & Mishra, 2018; Sawyer, 2017). Teachers also connect classroom work to authentic contexts, strengthening students' sense of purpose and agency.

Carroll's (2014) research on DT in education emphasizes that facilitators benefit from adopting a prototyping mindset, embracing collaborative learning, using empathy in instructional design, and maintaining an action-oriented approach. Empathy further supports facilitation by helping teachers attune to learners' needs during uncertain and exploratory work, enhancing communication and sustaining engagement (Efilti & Gelmez, 2024).

In non-linear and open-ended design processes, teachers model curiosity and adaptability, learning alongside students and demonstrating that ambiguity can be a productive space for exploration. Facilitation in creative environments requires tolerance for unpredictability and balancing student autonomy with appropriate scaffolding. Such environments depend on a careful interplay between freedom and structure, enabling learners to exchange perspectives, challenge assumptions, and

co-develop solutions within an atmosphere of mutual respect (van der Zanden et al., 2020; Sawyer, 2018).

Facilitators nurture these conditions through strategies such as open-ended questioning, modeling, and encouraging multiple pathways for ideation. They guide students to explore multiple perspectives and co-create original, meaningful solutions (Mosely et al., 2018; Sawyer, 2017). Such facilitation positions creativity as an iterative, improvisational process rather than a search for a single correct answer (Patston et al., 2021; Sawyer, 2011). As Borge (2020) notes, effective facilitators orchestrate ongoing reflective activities that help learners articulate their thoughts, emotions, and experiences while developing shared goals and strategies for improvement.

Henriksen et al. (2020) describe facilitation in DT as a continual negotiation of multiple tensions. Facilitators work to keep learners within the process—encouraging them to examine problems from several angles rather than jumping too quickly to solutions—while guiding the creation of artifacts that give form to emerging ideas. They guide the flow of discussion, support diverse viewpoints, connect activities, and foster empathy and insight, while also attending to group dynamics, including uneven participation, psychological safety, and moments when more directive guidance is required. In practice, this means balancing planned structure with flexibility as the linear design model intersects with the inherently messy nature of real design work.

In DME, facilitation is centered on empathy, critical thinking, and iterative practice. Teachers encourage learners to engage in cycles of ideation, prototyping, and reflection, frequently emphasizing process-oriented assessment rather than focusing solely on final products (Andersen & Pitkänen, 2019; Carroll, 2014). Teaching for creativity in these contexts requires what Sawyer (2021) terms *adaptive structuring* and *disciplined improvisation*—the ability to maintain purposeful frameworks while responding flexibly to emergent needs. Härkki et al. (2023) similarly highlight the importance of on-demand scaffolding and teacher adaptability in supporting students' engagement with complex materials, tools, and collaborative problem-solving.

Despite the promise of DME, teachers often face significant challenges when facilitating these environments. Many teacher education programs do not yet adequately equip teachers with the competencies needed to guide complex design processes or digital fabrication (Andersen & Pitkänen, 2019; Calavia et al., 2023; Caratachea et al., 2023; Henriksen et al., 2017). Studies consistently report challenges in facilitating design-based learning, particularly when digital tools and high-tech materials are involved (Calavia et al., 2023; Jordan, 2016; McKenney et al., 2015; Smith et al., 2016; Walan & Gericke, 2023). Teachers frequently describe limited digital expertise, difficulties in scaffolding iterative design tasks, and a perceived loss of authority when transitioning from instructor to facilitator. This

tension reflects a broader struggle between the structured, goal-oriented culture of formal education and the exploratory, iterative nature of DME (Retna, 2016; Smith et al., 2016).

Teachers also navigate practical and emotional demands. Retna (2016) identifies challenges such as student resistance to new ways of thinking, limited material resources, and difficulties in teamwork. Johnson (2016) notes that teachers must manage their own uncertainty while supporting students through the inherent instability of creative work. Herro, Quigley, and Cian (2019) found that teachers struggle with pacing, planning, and assessment when coordinating open-ended projects within school constraints. At the organizational level, Carlgren et al. (2016a) identified several barriers to DT implementation, including misalignment with established practices, difficulty demonstrating measurable outcomes, and resistance rooted in existing power dynamics and communication patterns.

Taken together, the literature indicates that facilitation is central to creative DME learning but also demanding across personal, pedagogical, and institutional levels. Addressing these challenges requires professional development that strengthens teachers' confidence, creative competence, and reflective capacities. Ongoing collaboration, peer learning, and research–practice partnerships can support teachers in developing facilitative mindsets that embrace risk-taking, co-creation, and iterative experimentation (Ramey & Stevens, 2023; Retna, 2016).

# 3 Aim and Research Questions

The general aim of this dissertation is to examine the integration of a design thinking approach in formal K–9 design and maker education, with particular attention to the roles and practices of teachers in this process and to the manifestation of design empathy in students' design processes. To address this overall aim, the following research questions were formulated:

**RQ1: How were the dimensions of the design thinking approach implemented in facilitating and structuring the creative design process in formal K–9 design and maker education?**

**RQ2: What roles and practices do teachers enact when integrating the design thinking approach in formal K–9 design and maker education?**

**RQ3: How is design empathy manifested in students' design processes in formal K–9 design and maker education?**

The three studies address these research questions from complementary perspectives and collectively draw on data from a single case study. Studies I and II focus on teachers' perspectives and on pedagogical design, facilitation, and reflection in classroom contexts, whereas Study III examines students' design processes and the manifestation of design empathy.

# 4 Research Design

This chapter presents the overall research design and the methodological and analytical choices that guided this dissertation. It begins by outlining the qualitative case study approach and then discusses my role as a researcher. Subsequent sections describe the participants and research setting, the design brief and implementation process, and the procedures for data collection and management. The chapter concludes with an explanation of the qualitative analysis methods and addresses the ethical considerations of the study.

## 4.1 Qualitative Case Study Approach

This dissertation was designed as a qualitative case study examining a participatory design project situated in a lower-secondary craft education context. A qualitative case study methodology provided an appropriate lens for investigating the complexity of teaching and learning in an authentic school setting, enabling an in-depth exploration of processes, interactions, and contextual conditions as they unfolded in practice. Such an approach is particularly well suited to environments characterized by collaborative emergence, material engagement, and unpredictable trajectories (Merriam, 1998; Stake, 1995). Consistent with constructivist perspectives, knowledge in this dissertation is understood to be co-created through interactions between researchers and participants, and the methodology remained flexible and responsive to what unfolded in the field (Hamilton & Corbett-Whittier, 2014; Merriam, 1998; Stake, 1995).

Case study research emphasizes holistic and interpretive inquiry, enabling the investigation of multifaceted educational phenomena within their real-life contexts and generating insights that may inform future research (Stake, 1995; Yin, 2018). This approach supports a comprehensive analysis of both processes and their pedagogical, social, and material dimensions, which are central to design-oriented and participatory research. By attending to complexity rather than isolating variables, qualitative case study methodology provides a contextually grounded understanding of how educational practices unfold in authentic settings (Merriam, 1998; Stake, 1995).

The study was informed by pragmatist perspectives that emphasize the integration of theory and practice. Dewey's (1933) work on reflective inquiry and experiential learning, together with Schön's (1983) concepts of reflection-in-action and reflection-on-action, highlight the dynamic and improvisational nature of professional practice, where intuition, tacit knowledge, and experimentation guide decision-making. These ideas resonate closely with design-oriented learning and with the situated nature of the design processes examined in this dissertation. The sociocultural tradition further emphasizes inquiry-based learning, contextuality, and the role of social interaction in meaning-making, drawing on scholars such as Vygotsky (1978) and others who underline the importance of collaborative activity in learning (Hakkarainen et al., 2013).

The work was conducted in close collaboration with a practicing craft teacher and drew inspiration from Research–Practice Partnership principles that position researchers as active collaborators in co-design, implementation, and evaluation of educational innovations (Penuel, 2017). Consistent with these orientations, the aim was to produce knowledge while simultaneously engaging with and supporting local teaching and learning practices.

In this dissertation, the "case" comprised a participatory design project in which the Double Diamond model was enacted with lower-secondary students designing for preschool children as end users. The study was exploratory in nature and sought to understand how students, teachers, and the researcher engaged in participatory and design-oriented processes and how the dimensions of DT were enacted and reflected upon in classroom practice. The project served as an empirical site through which questions about DT integration, teachers' roles, and students' design empathy were investigated.

## 4.2 Researcher Position

Understanding and interpretation are central to qualitative case study research, in which the researcher serves as the primary instrument for data collection and analysis (Merriam, 1998). Knowledge is understood as situated and co-constructed within specific social and material contexts rather than as neutral or detached. The researcher's subjectivity is therefore not regarded as a bias to be eliminated but as a resource that requires ongoing reflexive examination (Stake, 1995). Acknowledging one's own positionality is therefore essential, as it influences both how the research is conducted and the interpretations that emerge from it. Positionality implies that the social, historical, and political location of the researcher shapes their orientations and perspectives, meaning that researchers cannot be separated from the social processes they seek to understand (Holmes, 2020).

In this dissertation, my role was shaped by overlapping positions—as teacher and researcher. This dual role is situated within the Finnish tradition of university-based, research-based teacher education. This tradition emphasizes teachers' capacity to analyze and justify pedagogical decisions, reflect on their own practice, engage with research literature, and develop their work both individually and collectively. Within this framework, research orientation is understood not merely as conducting formal research but as a professional stance that informs everyday pedagogical decision-making (Jyrhämä & Maaranen, 2016).

During the implementation of the project, my primary role was pedagogical: guiding the design process, scaffolding collaboration, and co-designing with students and the participating craft teacher. Simultaneously, I documented classroom interactions and material processes, collected multimodal data, and engaged in ongoing analytical reflection. In later phases, the researcher role became more pronounced as I interpreted and synthesized the data. This iterative movement between action and reflection resonates with Schön's (1987) description of reflection-in-action and reflection-on-action and reflects the dynamic interplay between practice and inquiry embedded in research-oriented teacher professionalism. At the same time, this positioning required continuous critical examination of my assumptions and interpretive influence throughout the research process.

This case study draws on the notion of bricolage, a stance that integrates multiple theoretical perspectives, methodological tools, and forms of knowledge to address complex educational phenomena (Denzin & Lincoln, 2011). Bricolage acknowledges the inherent complexity of research and requires reflexivity and epistemological awareness. As bricoleurs attend to the social construction of knowledge and subjectivity, they become conscious of their own historicity and positionality (Kincheloe, 2005). The research design was developed responsively in relation to the educational context, the research questions, and the evolving classroom processes.

Each researcher's professional history and personal values shape their research trajectory. My background in craft education, design studies, and earlier involvement in school-based design and maker projects informed the pedagogical structures and scaffolds used in the project. These experiences did not function as hidden influences but were explicitly acknowledged as part of the interpretive lens through which the case was constructed and understood. My familiarity with the school and prior collaboration with the participating craft teacher supported access, rapport, and co-teaching relationships, consistent with Connelly and Clandinin's (1990) argument that strong relationships are foundational to educational inquiry.

## 4.3 Participants and Settings of the Case Study

The case study was conducted in a Finnish public comprehensive school as part of an elective eighth-grade textile craft course during spring 2019. Located in the capital area, the school served students from diverse linguistic and socio-economic backgrounds. The study involved multiple stakeholders (Figure 2): me as a researcher-teacher, a craft teacher, ten students (aged 14–15), two preschool teachers, and 16 preschoolers (aged 6–7) from a local preschool. The PD tradition provided the value-based grounding for this study, shaping how participation, roles, and interactions were conceptualized. This orientation framed teachers and students as co-designers and co-learners rather than as research subjects and emphasized inclusion, dialogue, and reflection, assuming that all participants—students, teachers, and end users—can contribute meaningfully to the design process (Iversen & Smith, 2012).

The ten students had prior experience in textile crafts but none in PD, DT, e-textiles, or collaboration with preschoolers. The craft teacher divided the class into three teams, aiming to mix the groups to prevent generally unmotivated students from being placed together. The craft teacher and I co-designed a project in which the eighth-grade students designed and made products for the preschoolers, who served as end users and co-creators.

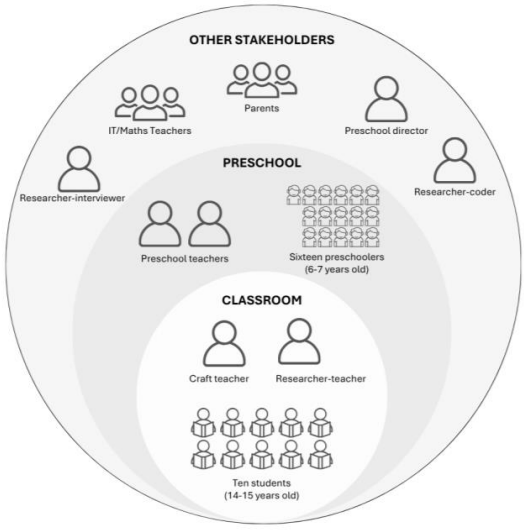



**Figure 2** Stakeholders involved in the case study.

Preparation for this multi-stakeholder case study required careful planning and collaboration. Following Stake's (1995) principles for field-based case studies, the process included identifying participants, refining the project concept, and organizing the necessary logistical arrangements. Participants were selected

through purposive sampling (Merriam, 1998), which enabled an in-depth exploration of a specific educational context rather than seeking generalizability.

The craft teacher, with whom I had previously collaborated, was invited to participate due to her expertise in craft teaching and openness to experimentation. She selected one elective textile craft group of ten students. Both teachers held master's degrees in craft education and bachelor's degrees in textile design, providing a strong foundation for guiding a multi-material design process. In Finland, craft teachers have considerable autonomy to design open-ended learning tasks. The project's structure, learning goals, and assignments were initially designed by me as a teacher-researcher and then refined collaboratively with the craft teacher responsible for the class, curriculum, and assessment. Continuous contact was maintained throughout the planning phase through meetings and messaging.

To include authentic end users, I contacted the director of a nearby preschool and collaborated with a preschool teacher, her teaching assistant, and their group of 16 preschoolers. We planned the schedule, materials, and data collection procedures with the adult participants. The preschool teacher introduced the children's ongoing themes—such as forests, gardening, emotions, and seasons—which helped to shape the design brief. Extensive preparation was required to coordinate schedules, resources, permissions, and collaboration across the groups. Informed consent was obtained from the school, the participating craft teacher, all students, and their guardians. Preschoolers' parents were informed about the project. Two students did not grant consent for video recording, which limited the scope of audiovisual data collection.

The project was integrated into regular craft lessons and implemented primarily in the school's textile classroom, equipped with sewing machines, tools, and materials familiar to both students and the teacher. I was familiar with the classroom environment and its routines. Two visits were also made to the nearby preschool, a familiar place for some of the students, providing an authentic and age-appropriate setting for interaction and co-design between the two age groups.

## 4.4 Design Brief and the Implementation Process

In this project, the value base informed by PD shaped the intention to involve preschoolers as active participants whose perspectives and experiences inform the co-design of the technologies they use, support authentic interactions, and position students as designers working for and with real users. This orientation emphasized participation, mutual learning, and attention to end users' experiences. At the same time, the project was pedagogically structured through a DT approach, which served as an instructional framework providing concrete phases and methods to guide students' inquiry, ideation, prototyping, and reflection.

The foundation of the educational DT project was a design brief that articulated the overall goals and constraints without prescribing a specific problem for students to solve. The theme and brief were developed collaboratively with the participating preschool teachers. Because preschool is mandatory in Finland, all students were familiar with its routines and activities, which helped them to understand the end users' needs. In this project, the preschool teachers and preschoolers were considered as end users of the design outcomes, while the students served as participatory designers.

The aim was to offer students a meaningful learning experience by engaging them in a collaborative, open-ended, real-world project in which they designed and made useful products for the preschoolers. In the We Design & Make project, the design brief was formulated as: "Co-design and make an e-textile product for preschoolers according to their wishes and needs." The brief emphasized collaboration within student teams, attention to others' ideas and needs, and creative thinking about the role of technology in the products. At the same time, it remained open-ended, allowing students to explore and define their specific design challenges as the process unfolded.

The project followed the Double Diamond design model (Design Council, 2005), chosen for its clear structure and emphasis on empathy. Adapted from professional design practice, the model consists of two "diamonds" that represent the phases of discovering and defining challenges and developing and delivering solutions. Each phase involves both divergent and convergent thinking: the first focuses on understanding the context and user needs, and the second on ideation, prototyping, and implementation.

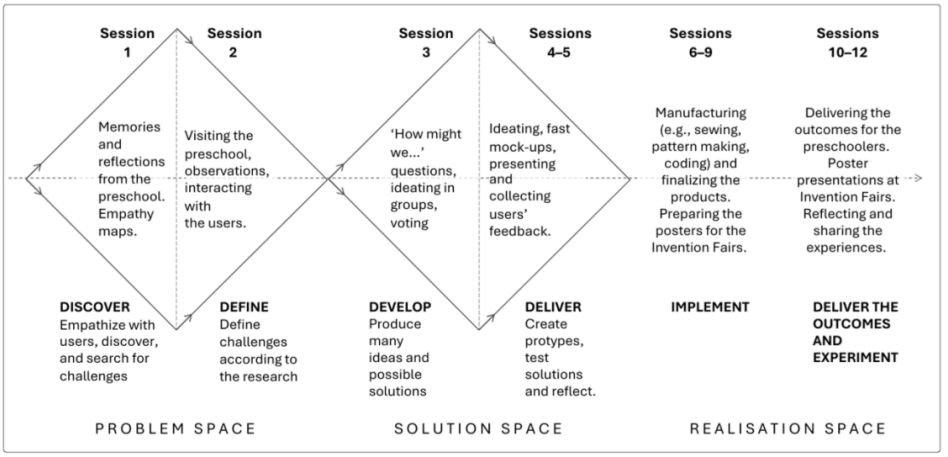



**Figure 3** The We Design & Make process adapted from the Double Diamond design model (Design Council, 2005). Adapted from Bosch et al. (2025), International Journal of Child-Computer Interaction, 43, 100695. Licensed under CC BY 4.0.

The class met 12 times for weekly 90-minute sessions, with the final three sessions dedicated to presentations and post-questionnaires. One session was cancelled due to a student climate strike connected to the international *Fridays for Future* school climate protests, and two additional sessions were later added to allow the products to be completed. Figure 3 illustrates how the process progressed from empathy and discovery to ideation, prototyping, and final manufacturing.

In Session 1, students explored the design context by recalling their preschool experiences, documenting memories on Post-it notes, and creating empathy maps. In Session 2, they visited the preschool to conduct user research and observations using interview forms and materials prepared by the researcher. Based on these findings, I formulated a set of "How might we…?" questions to guide ideation in Session 3, during which students brainstormed and selected their preferred concepts. Mock-ups were created and presented to the preschoolers for feedback in Session 4, after which students refined their designs in Session 5 and began manufacturing in Session 6.

The finished products (Figure 4) were delivered to the preschool in Session 10, followed by a public presentation at the Invention Fair organized by the University of Helsinki research team in Session 11. The project concluded with final reflection and post-questionnaires in Session 12. Throughout the project, students documented their progress and reflections in a digital Seesaw portfolio using predefined reflection prompts. To support collaboration, teams were assigned flexible roles, including a group leader, a documenter, and a technology designer.

During the project, the student teams created three functional, needs-based design products. The Season Tree and the Strength Crow were developed to provide tangible, engaging tools to support preschool children's learning. The main function of the Season Tree was to demonstrate different seasons in a more realistic and motivating way, as children could change the leaves, flowers, and snowflakes by themselves. The Strength Crow was developed for playing, supporting strength-based education, and measuring noise levels. During the preschool visit, the team observed that the preschool classroom was small and noisy, which inspired the idea of incorporating the programmable e-textile board as a noise sensor. The idea for the Encouragement Toy emerged from the challenge that the children's independent dressing in winter clothing often took a long time. The team designed a motivational support toy: once a child completed the task, they pressed a button, and when all 16 children were ready, a fanfare sounded to signal their collective achievement.



**Figure 4** The three final products created by the student teams. Photographs by the author.

## 4.5 Data Collection and Management

This study employed multiple data sources typical of qualitative case studies, collected between January and June 2019. The flexible nature of the data collection generated a substantial dataset, providing a comprehensive view of DT and making processes in a formal school context. Data sources included classroom video recordings, pedagogical materials, photographs of students' design process and final design artifacts, field notes and a reflective diary, audio reflections, interviews, and students' pre- and post-questionnaires.

The dataset comprised approximately 18 hours of classroom video recordings from Sessions 1–9, which formed the core material for Studies I and III. Three GoPro cameras were used to capture the lessons: one documented whole-class activity and teacher–researcher guidance, while two focused on selected student teams and were repositioned as needed. Wireless microphones were placed on tables to enhance sound quality. Some sessions were only partially recorded due to technical or consent-related limitations, for example, Sessions 2 and 10 (preschool visits), Session 7 (an open day), and Session 11 (a public event). Session 12 focused on individual reflection and questionnaires and was therefore not recorded. One team experienced minor sound loss in Sessions 6 and 8 due to frequent movement during those sessions.

Pedagogical materials consisted of a PowerPoint presentation with more than 70 session-specific slides, as well as various design tools and assignments, such as empathy maps, "How might we…?" prompts, observation forms, and Kanban-style process boards for each team.

Data on students' design processes and final products were collected after each session through photographs. These materials included photographs (approx. 250) of empathy maps, observation forms, ideation notes, mock-ups, process

management boards, and final products and posters. These data supported the analysis of end-user considerations in Study III and the examination of final outcomes reported in Bosch et al. (2021).

I maintained field notes and a reflective diary after each session, combining descriptive documentation with analytical reflection. Personal interpretations were marked in parentheses to distinguish them from observational content. These materials provided important contextual and reflexive insights, particularly for Study II.

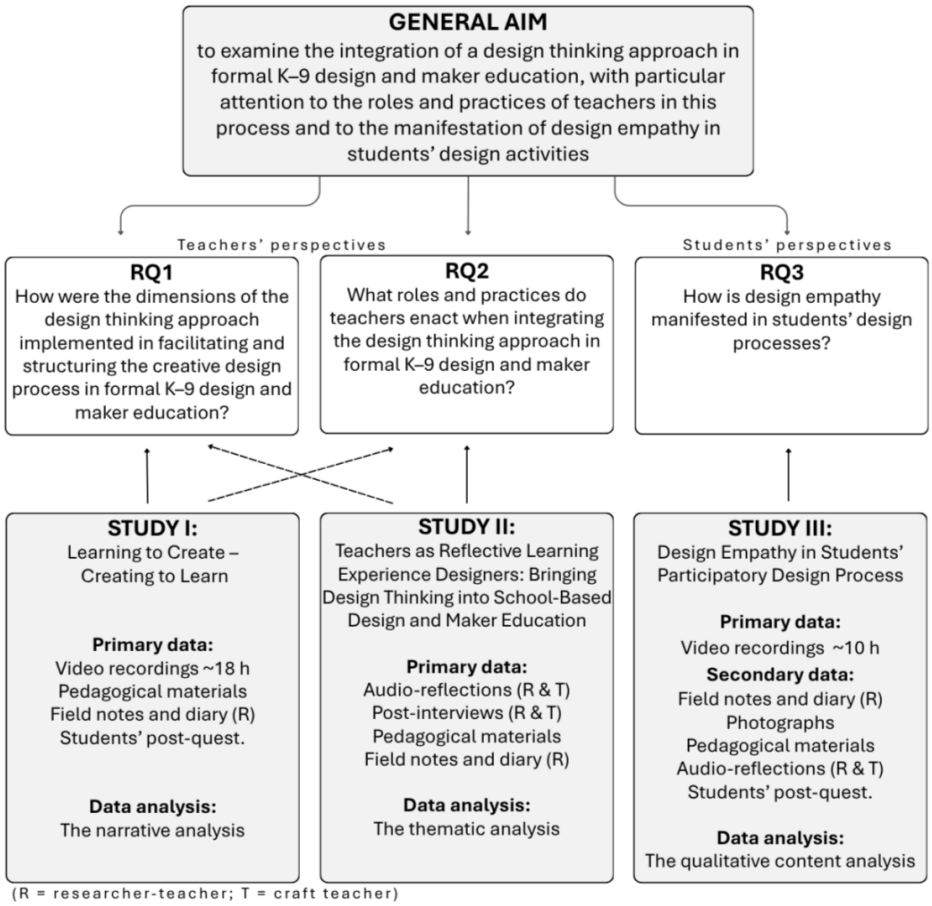
After each class, the craft teacher and I recorded short, unstructured audio reflections on a mobile phone, which served as the basis for the analysis in Study II. These 12 audio recordings (excluding Sessions 2 and 10–12) captured immediate reactions, emerging challenges, and ideas for subsequent sessions. The audio format replaced a written diary, which was impractical given the teacher's workload, and offered rich, real-time insights into classroom facilitation.

Semi-structured post-interviews were conducted a few weeks after the project to deepen the understanding of the design and facilitation process. I interviewed the craft teacher, and an external researcher from the same research group interviewed me. These interviews informed the analysis in Study II.

Students completed post-questionnaires during Session 12, consisting of open- and closed-ended items developed with other researchers and pilot tested with a 14-year-old to ensure clarity. These responses contributed to Study I. Planned student post-interviews were cancelled due to scheduling constraints caused by their work experience placement (*TET-harjoittelu),* a compulsory component of the school year for all Finnish eighth-grade students.

In this dissertation, video recordings, my field notes, a reflective diary, audio reflections, post-interviews with the craft teacher, and pedagogical materials constituted the primary data sources (Figure 5). Photographs of students' sketches and mock-ups, ideation notes, final design artifacts, and students' post-questionnaires played a complementary role. Some materials collected were not directly used in the dissertation, including students' Seesaw e-portfolios, a pre-interview with the craft teacher, and students' pre-questionnaires gathered for the larger research project in which this study was situated.

All data were compiled, managed, and analyzed using MAXQDA 2022 for Mac (version 22.5.0) (VERBI Software, 2021), complemented by Microsoft Office tools for data organization.




**TOTAL EMPIRICAL CORPUS OF THE "WE DESIGN & MAKE" PROJECT**

| Data source | Quantity |
|---|---|
| Classroom video recordings | approx. 18 hours |
| Pedagogical materials | PowerPoint slides (70 pp.); other documents (10 pp.) |
| Photographs of students' design processes | approx. 250 |
| Researcher's field notes and research diary | 23 pp. |
| Researcher's and teacher's audio reflections | 12 recordings (4–12 minutes each) |
| Researcher's post-interview | approx. 1 hour |
| Teacher's pre-interview (not included) | 40 minutes |
| Teacher's post-interview | 46 minutes |
| Students' pre-questionnaires (not included) | 10 responses |
| Students' post-questionnaires | 10 responses |
| Students' Seesaw e-portfolios (not included) | 10 e-portfolios |

**Figure 5** Overview of the general aim, research questions, associated studies, analytical approaches, and the empirical corpus used across the three studies.

## 4.6 Qualitative Analysis Methods

Generally, qualitative data analysis involves a continual movement between empirical data and abstract conceptualization, using inductive, deductive, and abductive reasoning to generate meaningful insights (Merriam, 1998). Merriam (1998) describes the most basic level of analysis as organizing data chronologically or topically and presenting it as a descriptive narrative. More advanced analysis requires identifying patterns and constructing categories that interpret the phenomenon in relation to the study's objectives, while the highest level involves making inferences, developing models, or generating theoretical frameworks from empirical observations (Merriam, 1998; Miles & Huberman, 1994). In qualitative inquiry, the researcher is the primary instrument for data collection and interpretation, and subjectivity is considered an essential part of meaning-making rather than a limitation (Stake, 1995).

The analytical approach in this study followed an abductive form of reasoning (Dubois & Gadde, 2002; Hofmann et al., 2024; Timmermans & Tavory, 2012). Abduction combines empirical observation with theoretical interpretation through an iterative movement between data and concepts. Rather than beginning strictly from data (induction) or from theory (deduction), abduction operates between the two. Dubois and Gadde (2002) describe it as a process in which theoretical frameworks, empirical fieldwork, and case analysis evolve simultaneously. In this view, the purpose is both to generate new theory and to refine and extend existing frameworks through continuous interaction with empirical findings. Hofmann et al. (2024) further conceptualize abduction as a collaborative, practice-based process that links empirical inquiry with theoretical reflection. This stance also addresses challenges of generalization in qualitative research by relating context-specific findings to broader theoretical understandings.

In this study, abductive reasoning guided the interpretation of classroom interactions, design activities, and teacher reflections, allowing theory and data to inform one another in a reciprocal manner. This orientation positioned analysis as both systematic and creative, supporting the development of situated, theoretically informed understandings of design and learning processes.

My approach draws on diverse methods and representational forms in qualitative inquiry, as described by Denzin and Lincoln (2011). Their notion of the bricoleur captures the flexibility, creativity, and improvisation required when working with complex educational data. Bricolage involves using diverse tools, theories, and materials adaptively, valuing divergent thinking and openness to multiple interpretations (Heikkinen, 2018).

In the following sections, I describe the three complementary analytical approaches applied in the studies. Given the exploratory nature of this research, the dissertation adopts guiding research questions that function as orienting prompts guiding for the investigation rather than fixed, narrowly defined queries. Studies II

and III refine these into specific research questions appropriate to their empirical focus and methodological approach.

### 4.6.1 Study I: The Narrative Approach

A narrative approach, based on ethnographic traditions, emphasizes meaning making through storytelling (Derry et al., 2010). It is a flexible method that recognizes the capacity of narratives to interpret and communicate experiences, events, and phenomena. The narrative approach typically analyzes stories to understand lived experiences and the meanings individuals attribute to them—an approach often described as the *analysis of narratives*. In contrast, *narrative analysis* involves collecting actions and events as data and constructing explanatory stories that integrate them into coherent sequences through plot structuring, providing contextual significance to individual events (Connelly & Clandinin, 1990; Polkinghorne, 1995). This process links theoretical concepts with lived experience and the sociocultural dynamics of a setting (Polkinghorne, 1995). Narrative analysis is described as a synthetic rather than an analytic process: instead of breaking a whole into parts, it constructs a whole from individual elements. In this sense, analysis refers broadly to the interpretive work done on research materials, including narrative synthesis (Heikkinen, 2018).

The narrative approach does not assume objectivity; rather, it relies on interpretive understanding to portray the culture or phenomenon under investigation. In this study, video segments and other illustrative materials were selected to construct the narrative and illuminate the observed processes. As the analysis progressed, relevant episodes were identified and incorporated based on their contribution to the emerging storyline and interpretive framework (Derry et al., 2010). This iterative process highlights the contextual and constructed nature of the narrative approach.

Study I, published as a book chapter in Invention Pedagogy – The Finnish Approach to Maker Education (Korhonen et al., 2022), drew on a narrative approach to illustrate the complex processes and theoretical perspectives embedded within the case study. The chapter began with key theoretical themes of DT, followed by a descriptive narrative of classroom implementation. Video recordings, pedagogical materials, field notes, and reflective diary entries served as the primary analytical sources, and students' post-questionnaires supported this analysis. The study described the project's progression using the Double Diamond model, demonstrating how the four phases—discover, define, develop, and deliver—structured and supported students' creative design processes.

The chapter also examined the evolving roles of the craft teacher and the researcher in facilitating a creative learning environment. It documented the pedagogical strategies used to promote collaboration, empathy, and creative

confidence among students. To illustrate these processes, direct quotations from the teacher, researcher, and students were included, providing multiple perspectives and showing how the classroom culture developed over time. The chapter concluded with reflections on the competencies for creativity observed and developed throughout the project, highlighting the range of design-related competencies that can emerge through creative and participatory learning processes.

### 4.6.2 Study II: The Thematic Analysis

The aim of Study II was to identify key learning design elements derived from literature and from my professional expertise as both a design researcher and craft teacher and to describe how these elements were enacted within a tailored educational project for 14–15-year-old students. The analysis focused primarily on 12 in-situ and post-session reflective accounts and post-interviews from the craft teacher and me, deepening the understanding of how teachers integrate multidisciplinary, multi-material, and open-ended learning processes within the constraints of formal education. This approach was inspired by Schön's (1983) concepts of reflection-in-action and reflection-on-action, offering an authentic portrayal of the DT process that we undertook. Pedagogical materials, along with my diary and field notes, supported the reconstruction of how key elements were implemented throughout the project. Photographs were used to illustrate the students' design process and final products.

The analysis followed the six phases outlined by Braun and Clarke (2006, 2019), offering a flexible framework for identifying and interpreting teachers' reflections on the challenges and opportunities of implementing the project. A holistic perspective was adopted to examine how data-driven themes emerged within the existing design framework.

Because the study was grounded in collaborative discussions, shared experiences, and co-teaching practices, it also incorporated autoethnographic elements (Chang, 2016). Following Anderson's (2006) concept of analytic autoethnography, I participated as an active, visible member of the group, engaging in analytic reflexivity to generate theoretical insights into teaching and learning practices.

The coding process proceeded in iterative cycles, alternating between theory-driven coding—using the key design elements as initial codes—and open, inductive coding. Codes were refined throughout the process until no new insights emerged. The analysis moved from semantic to more latent levels of interpretation, emphasizing data-driven codes that originated in in-situ and post-session reflections. These codes were then grouped into broader categories that informed the final themes.

To strengthen the analysis and ensure robustness, emerging themes were collaboratively reviewed and discussed with co-authors. This process enabled multiple perspectives to be incorporated into the final thematic structure, resulting in a multifaceted and reflective interpretation of the data.

### 4.6.3 Study III: The Qualitative Content Analysis

Study III examined how design empathy manifested in students' design processes, recognizing empathy as a crucial transversal competency in DT and a key factor in how designers consider future users in their work. Approximately ten hours of video recordings from two student teams were analyzed in depth to capture discussions related to end users and identify empathic concerns, experiences, and reflections that emerged during the process. Additional data included photographs of sketches, mock-ups, ideation notes, final artifacts, pedagogical materials, students' post-questionnaires, and the researcher's field notes, reflective diary, and audio reflections.

The video recordings were analyzed cyclically and at multiple levels following Derry et al.'s (2010) approach, beginning with a content log to outline the overall process and identify key activities. The analysis proceeded iteratively through cycles of selecting, interpreting, evaluating, and presenting content. Using qualitative content analysis, 72 end-user-related episodes were identified from the team discussions. Transcripts of these episodes were then used to construct a process table similar to Ash's (2007) flow chart, integrating visual materials such as Post-it notes, sketches, mock-ups, and final artifacts to support process tracking. Throughout the analysis, analytic memos were written to document category definitions, emerging questions, and interpretive insights.

The first research question explored which design aspects students considered during end-user-related episodes and how these considerations reflected their emerging empathy. A combined data-driven and theory-guided approach (Hsieh & Shannon, 2005) was used to identify key design aspects. The analysis distinguished between product-centric aspects (functional, technical, and visual/aesthetic) and human-oriented aspects (self-oriented and other-oriented), drawing on Hess and Fila's (2016) model.

The second research question examined how design empathy was expressed in students' end-user-related discussions. The analysis employed the framework by Smeenk et al. (2019a), which outlines four dimensions of empathy, and refined category descriptions using insights from earlier studies (Hess & Fila, 2016; Smeenk et al., 2016; van Rijn et al., 2011). Signs of empathy included empathic expressions, references to personal experiences, inquiries into user needs, and statements of user-related knowledge (van Rijn et al., 2011). These signs were coded

across the four empathy dimensions, providing a comprehensive account of how empathic awareness and reasoning emerged in the students' DT processes.

### 4.6.4 Ethical Considerations

The project followed the ethical guidelines for scholarly research established by the University of Helsinki and the Finnish National Board on Research Integrity TENK (2019). This required responsibility, transparency, and careful consideration, particularly because the study involved children, a group considered to be vulnerable in research. The study also adhered to the EU General Data Protection Regulation (GDPR), including protocols for anonymizing, storing, and accessing data.

Data collection was integrated into regular school activities, and participation was voluntary. Informed consent was obtained from all participating students, their guardians, and the craft teacher. The consent forms explained the purpose of the study, the types of data collected, procedures for data storage and use, participants' right to withdraw at any time, and the protection of anonymity. While not all students agreed to appear in video-recorded team data, permission for general observational data collection was obtained from all participants.

The preschool teacher and children were not treated as formal research participants in this study; therefore, individual consent forms were not required. However, parents were informed about the activity. All data were handled securely and used solely for research purposes in accordance with institutional and national ethical standards.

# 5 Findings

This chapter first provides an overview of the three studies and, in Section 5.4, synthesizes the key findings in relation to the research questions. Detailed descriptions of the research settings, methods, and analyses are presented in the original publications. Studies I and II focus on teachers' perspectives, including pedagogical design, facilitation, and reflection in classroom contexts, whereas Study III examines students' design processes and the manifestation of design empathy.

## 5.1 Study I: Learning to Create – Creating to Learn

Study I examines how a DT framework, combined with design and maker approaches, structured and supported students' creative design processes. The study emphasizes the dynamic nature of design processes, showing how cognitive, affective, and material forms of learning intersect throughout the project.

A strong human-centered orientation guided the work. Students used empathy maps, observed preschool environments, and interviewed preschoolers and their teachers to understand user needs and define design challenges. These activities helped ensure that final solutions were creative and meaningful to their intended users.

A visual representation of the Double Diamond model provided structure and orientation as students navigated the messy, nonlinear process of empathizing, defining, ideating, prototyping, and testing. During ideation, students generated multiple ideas using visual prompts, idea maps, and large cardboard sheets that made thinking visible and supported communication and reflection among peers, the teacher, and the researcher.

Prototyping and testing enabled students to externalize ideas, gather feedback, and iteratively refine solutions. In the final phase of making, prototypes were transformed into functional products while balancing constraints such as material availability, skill levels, and time.

Teachers played an important role by guiding students' creative engagement while supporting autonomy, collaboration, and risk-taking. They cultivated a trusting and supportive classroom culture using emotional support, dialogic strategies, and modeling of both tasks and attitudes. By emphasizing processes over

products, students were encouraged to experiment freely and develop confidence in their creative abilities. Teachers created a psychologically safe environment in which students felt supported in taking risks and learning from mistakes. This atmosphere was reinforced through humor, emotional support, and continuous encouragement.

The project offered opportunities to practice a broad set of cognitive and socio-emotional competencies, including adaptability, resilience, collaboration, and foundational design and making skills. Students alternated between divergent thinking to generate ideas and convergent thinking to evaluate and refine them. They learned to work with uncertainty, respond constructively to setbacks, and integrate empathy and perspective-taking into their teamwork. Alongside these competencies, students developed practical skills such as sewing with conductive thread and programming e-textile components, which supported the creation of functional prototypes.

Despite these learning opportunities, the project also revealed challenges. The open-ended nature of the work created uncertainty for both teachers and students, and the craft teacher found it demanding to shift from a traditional "all-knowing" role to a facilitative stance. Coordinating a multidisciplinary project within the constraints of formal schooling, especially regarding time and scheduling, presented notable challenges. Nevertheless, students valued the project's authenticity, real-world relevance, and opportunities for hands-on exploration and collaboration.

## 5.2 Study II: Teachers as Reflective Learning Experience Designers: Bringing Design Thinking into School-Based Design and Maker Education

Study II explores the role of teachers in integrating DT and maker practices into formal education, focusing on how they design, lead, and reflect on creative, hands-on projects that foster 21st-century skills. It emphasizes teachers as reflective designers of learning experiences, particularly within DME for students aged 14–15.

The project's pedagogical framework drew on several key learning design elements identified through theory and practice. Empathy served as a guiding principle, making creativity relational and human-centered. Participation was strengthened through cross-generational interaction, with preschoolers becoming partners in the process. Clear learning goals and assessment criteria connected activities with intended outcomes, ensuring that work remained purposeful and measurable. The authentic design brief grounded the work in a real-world context, motivating students and adding relevance, and the structured DT framework, along with clear assignments and pedagogical materials, supported students' navigation

between the divergent and convergent phases of the lengthy process. The availability of hands-on materials and digital tools encouraged experimentation, iteration, and learning by doing. Collaboration between students and teachers, along with reflective activities such as e-portfolios and feedback sessions, supported communication, mutual learning, and critical thinking. Teachers' multifaceted roles—facilitating, co-designing, and modeling a growth mindset—played a central role, particularly when working with unfamiliar technologies. Together, these elements created a supportive environment in which students could explore, experiment, and develop meaningful solutions.

A thematic, theory- and data-driven analysis drew on 12 in-situ audio reflections recorded after classroom sessions, post-interviews with both the craft teacher and the researcher-teacher, and the researcher-teacher's research diary entries. This provided a holistic understanding of the interplay between theoretical frameworks and classroom practice. While all key elements appeared in the data, three new, data-driven themes emerged: **1. Teachers as design leaders**: Teachers guided students through the iterative DT process while balancing open-ended exploration with practical constraints. They actively contributed ideas and demonstrated techniques, ensuring that students retained ownership of their final design decisions. **2. Collaboration and co-teaching**: Teachers shared responsibilities, divided tasks according to expertise, and supported each other in managing challenges related to technology use and open-ended projects. The need for clearer role definitions and more time for joint planning emerged. **3. (Co-) reflection**: Ongoing reflection supported adaptive decision-making, helped teachers manage uncertainty, and illuminated both pedagogical challenges and professional growth opportunities. These reflective moments modeled resilience and adaptability for students, while being constrained by the time limitations of formal schooling.

Overall, the findings suggest how the key elements of learning design were integrated into the DME process and how teachers' reflections illuminated both the challenges and opportunities associated with their evolving roles.

## 5.3 Study III: Design Empathy in Students' Participatory Design Process

Study III investigates how empathy manifests in students' PD processes and how empathic understanding supports user-centered design. Empathy, recognized as a key transversal competency, was central throughout the project.

Students interacted directly with preschoolers, observed their environments, and incorporated user feedback into their designs. The analysis drew on 72 end-user-related design episodes from two teams, examining how empathy appeared in their discussions and considerations.

Findings show that students considered a range of design aspects categorized into product-centric and human-oriented aspects. These categories often overlapped as students moved fluidly between product considerations (functionality, technical feasibility, aesthetics) and user considerations (needs, emotions, experiences).

Human-oriented aspects included both self-oriented reflections—memories, emotions, and personal experience—and other-oriented considerations directly grounded in user needs, situations, wishes, and feedback (based on the model of Hess & Fila, 2016). Further analysis applied the four dimensions of empathy proposed by Smeenk et al. (2019b) to students' interactions. These are personal experience, sensitivity, emotional interest, and self-awareness. Evidence of all four dimensions appeared throughout the process, showing how cognitive–affective and self–other empathic interactions shaped students' reasoning.

Direct interaction with preschoolers emerged as a particularly influential element of the process. Activities such as empathy mapping, observation, and feedback sessions deepened students' understanding of user needs and motivations. These user insights influenced decisions about materials, colors, functionality, and safety.

The two teams created functional, needs-based products: an interactive Season Tree for understanding seasonal changes and a Strength Crow, a soft toy that supported strength-based learning and functioned as a noise-level indicator. Both evolved through iterative refinement grounded in empathy-driven insights.

The study suggests that eighth graders can engage meaningfully in empathic design by integrating end-user perspectives throughout the process. Design empathy was evident in various user-centered discussions and considerations, resulting in meaningful, user-friendly products. Facilitating conditions included tailored design tasks, guided inquiry, continuous teacher facilitation, and structured support.

The findings indicate that empathy is a dynamic, relational, and reflective process that provides valuable opportunities for educational and design practices. Engaging with real users appeared to support students in developing a nuanced understanding of design as a human-centered process.

## 5.4 Summary of the Findings in Relation to the RQ's

This section summarizes the main findings in relation to the research questions. While the previous subsections examined each study individually, this synthesis illustrates how DT was implemented in practice, how teachers shaped these processes, and how empathy emerged in students' learning.

**The first research question** examined how the four dimensions of the DT approach—process, methods, mindset, and empathy—were implemented in formal

K–9 design and maker education to facilitate and structure the creative process. Across the studies, the DT process was structured through a visual framework that supported students' movement between divergent and convergent phases and made the length and non-linearity of creative work visible. Human-centered, participatory methods engaged students with real end users and enabled the refinement of ideas. These methods helped students understand design as an iterative, material, and collaborative practice rather than a linear sequence of steps.

The mindset dimension emphasized creativity, resilience, and the belief that everyone can contribute meaningfully. Students were encouraged to balance analytical and intuitive reasoning, tolerate uncertainty, and understand mistakes as part of the learning process. Their confidence grew as their ideas became more defined. Empathy remained central: students drew on memories, observations, and interactions with preschoolers to understand user needs and adjust their concepts. In addition, the studies identified key elements of learning design—such as collaboration, authentic briefs, hands-on environments, and clear goals—that enabled these dimensions of DT to operate effectively within the realities of school-based craft education.

**The second research question** investigated the roles and practices of the two teachers—including myself as the researcher-teacher—in integrating and facilitating DT in formal K–9 design and maker education. The findings show that teachers enacted multiple overlapping roles: teacher, facilitator, co-designer, co-learner, reflective learning experience designer, and design leader. These roles shaped the pedagogical conditions that enabled students to engage in open-ended, collaborative design work. Teachers supported learning by guiding ideation, modeling techniques and mindsets, and cultivating psychological safety. They helped students navigate uncertainty through dialogue, questioning, and emotional support. They also modelled flexibility and empathy, particularly when working with unfamiliar digital fabrication tools.

Collaboration played a central role. The craft teacher and researcher co-designed and co-taught the project, adapted plans as challenges emerged, and shared responsibilities according to expertise. Partnerships with preschool teachers and technology experts expanded participation and provided additional resources. At the same time, teachers encountered structural challenges—such as rigid schedules and time constraints—and pedagogical challenges related to integrating digital technologies. Yet these challenges also created opportunities for professional learning. Ongoing co-reflection supported adaptive decision-making and strengthened trust and collaboration.

Overall, the findings suggest that teaching DT is itself a design process—complex, relational, and iterative. Teachers mediated between curricular demands, user needs, time constraints, and students' ideas, and their multifaceted roles are central to enabling collaborative, empathic, and creative learning.

**The third research question** examined how design empathy was manifested in students' design processes in formal K–9 design and maker education. The analysis showed that empathy emerged as both a cognitive and affective process. Students moved fluidly between product-centric and human-oriented considerations.

All four empathy dimensions based on the model proposed by Smeenk et al. (2019b) appeared throughout the process and were often intertwined. Empathic interactions shaped how students framed problems and developed solutions. Students applied end-user insights to refine ideas and make decisions about aesthetics, functionality, and safety.

Taken together, the findings demonstrate that a DT approach can be meaningfully integrated into formal education when enacted through structured, participatory, and pedagogically grounded practices. Across the three studies, a coherent picture emerges of DT as a promising approach for fostering creative, user-centered, and collaborative learning in formal schooling. Although the three studies examine different aspects of the case, together they provide a multidimensional and complementary account of how DT was enacted in this classroom context.

# 6 Discussion

This chapter interprets the dissertation's overall contributions by synthesizing the findings from the three studies and examining how they advance theoretical and pedagogical understandings of design thinking (DT) in formal K–9 design and maker education (DME). It begins with a general discussion that integrates the main findings with prior literature and is structured around three interconnected themes. The chapter then reflects on methodological and contextual limitations, outlines pedagogical implications, and concludes with directions for future research.

## 6.1 General Discussion

This dissertation set out to examine the integration of a DT approach in formal K–9 DME, with particular attention to the roles and practices of teachers in this process and to the manifestation of design empathy in students' design processes. The discussion is organized around three interconnected themes. First, DT is examined as a multidimensional concept. While process models and methods have been widely discussed in prior research, less attention has been paid to how mindset and empathy function in relation to these dimensions in classroom practice. Second, empathy is considered to be a cross-cutting pedagogical principle that shapes both instructional design and students' engagement in design activity. Third, the discussion addresses teachers' multifaceted roles in facilitating, structuring, and sustaining design-oriented learning processes.

### 6.1.1 Design Thinking as a Multidimensional Concept

Across the three studies, DT was approached as a multidimensional concept encompassing process, methods, mindset, and empathy. Examining these dimensions in relation to one another provided a lens for understanding how DT unfolded in classroom practice. This perspective resonates with recent calls to conceptualize DT as a complex, flexible, and situationally responsive creative practice rather than a linear or managerial step model (Cross, 2011; Warr et al., 2022).

The findings indicate that DT in classrooms is inherently messy, iterative, and uncertain, mirroring the complexity of real-world problem spaces. This echoes Dorst's (2011) argument that design problems are "wicked" because they involve reframing, negotiation, and interpretation rather than predictable pathways to solutions. Rather than being a weakness, this complexity can be understood as a defining feature of DT: real-world problems are often ill-defined, situated, and entangled with social and material conditions (Cross, 2011; Warr et al., 2022).

The process and methods dimensions helped structure this inherent messiness. The Double Diamond model (Design Council, 2005) functioned as a shared pedagogical framework that supported students' movement between divergent and convergent thinking. Divergence broadened problem framing as students generated multiple possible concepts, while convergence enabled testing, refining, and decision-making that narrowed feasible options in relation to available materials, tools, skills, and the needs of future end users—patterns well documented in creativity and design research (Noweski et al., 2012; Sawyer, 2011).

The findings highlight the importance of allocating sufficient time to the Define phase, echoing the emphasis of Noweski et al. (2012) and Dorst (2011) on careful problem framing. Students initially wanted to move quickly toward solutions and fabrication, a tendency also noted by Henriksen et al. (2020) in higher education. Extended attention to defining user needs enabled students to understand users' contexts and perspectives, ultimately supporting more grounded and meaningful design concepts. Different DT methods further enriched idea generation, stimulated reflective dialogue among peers and teachers, and helped students understand design as relational, situated, and co-constructed rather than an individual act (Kimbell, 2011; Sanders & Stappers, 2008).

Material and embodied engagement also played a key role. Sketching, modeling, and rapid prototyping externalized students' ideas and supported Schön's (1983, 1993) notion of reflection-in-action, in which thinking and making co-evolve through material engagement. Hands-on exploration functioned as a form of embodied reasoning (Groth, 2016), linking cognition, emotion, and sensory experience. Through prototyping, ideas were externalized, hypotheses were tested, and feedback was used to guide iterative improvement. During testing and feedback sessions, students learned to revise their designs based on real-world use.

The mindset dimension centered on creativity, resilience, and openness. Kelley and Kelley (2013) conceptualize this as creative confidence: the ability to question habitual approaches, trust one's intuition, cope with ambiguity, and remain curious about others. They argue that while young children naturally display these qualities, they often diminish as learners encounter environments that privilege correct answers over creative ideas. This tendency was evident when students frequently sought reassurance that they were doing things "correctly." Students were encouraged to combine analytical and intuitive approaches, embrace uncertainty,

and treat mistakes as integral to learning. Emphasizing that there is no single "right" answer supported risk-taking, experimentation, and divergent thinking. Students' confidence increased as their ideas began to take shape. Similarly, Glen et al.'s (2015) study found that business students gradually built confidence in managing uncertainty through assignments that emphasized iterative exploration.

Nevertheless, a DT mindset can feel unfamiliar in schooling contexts that favor predictable tasks and explicit guidance. Process-based approaches may rely too heavily on predetermined steps and overlook intuition, personal experience, and situational responsiveness (Schön, 1983). Tracey and Hutchinson (2016) similarly argue that DT requires a tolerance for uncertainty and the ability to work without clear solutions—conditions that can challenge beginners accustomed to systematic tasks and explicit direction (Wu & Mejía, 2025). Students often described "not knowing what they were doing," but they were encouraged to start making before fully knowing the outcome and to let ideas evolve through experimentation. This reflects Sawyer's (2025) view that "the idea comes through the process" and Schön's (1993) insight that material engagement advances thinking. Stepping into uncertainty ultimately shifted classroom culture from rule-following to inquiry, negotiation, and sustained meaning-making.

Empathy was a central dimension of the process and will be discussed in greater depth in Section 6.1.2.

The findings also reinforce sociocultural perspectives in which creativity—and DT more broadly—is distributed, collective, and socio-material (Clapp, 2017; Sawyer, 2018). Ideas seldom originated from a single student; rather, they emerged through dialogue, negotiation, and material experimentation. Teachers and students often co-created ideas to the extent that their origins became indistinguishable, echoing the observations by Guha et al. (2013). This shifts the focus from individual creativity toward participation in collaborative design processes, corresponding with Clapp's (2017) view and Breti's (2024) argument that creativity must be intentionally designed into educational practice.

Finally, design doing—the creation of tangible solutions—was essential. Even though there has been discussion about the significance of the outcome versus the process itself, the teachers insisted that the products be completed and delivered to the preschoolers to add meaningfulness and foster student agency. This emphasis echoes Meyer and Norman's (2020) and Norman and Stappers' (2015) critique that DT becomes superficial when it remains at the level of ideation without material implementation. In this study, DT was enacted through action: conceptual ideas gained meaning through making. Mejia et al. (2023) also propose DT as a broader concept that includes knowing through doing.

Taken together, the analysis draws attention to the centrality of design doing in classroom enactments of DT. While process, methods, mindset, and empathy structured the work, the material realization of ideas through making appeared

inseparable from the development of meaning. Framing DT in education as "design thinking + doing" helps foreground the role of iterative material exploration, prototyping, and tangible artifact creation in this context (Figure 6).

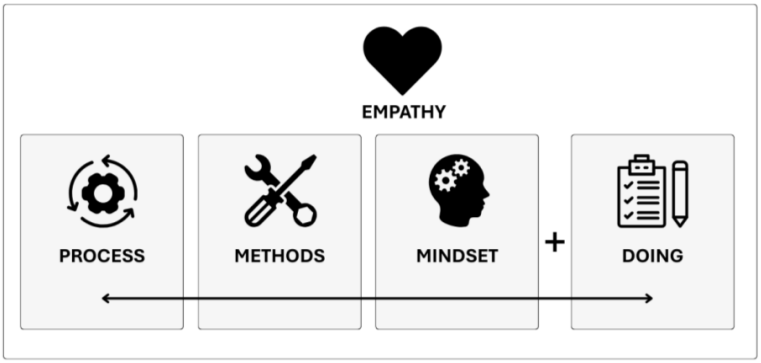



**Figure 6** The dimensions of design thinking + doing, with empathy as a cross-cutting pedagogical principle.

### 6.1.2 Empathy as a Cross-Cutting Pedagogical Principle

Empathy appeared as a central dimension throughout the project. It guided students' interactions with end users and informed teachers' design of learning experiences. Prior research shows that design projects that engage learners with diverse perspectives foster inclusivity and help students see themselves as active contributors to their communities (Goldman & Kabayadondo, 2016). In this project, well-framed constraints further supported the design process by providing focus without limiting possibilities (Sawyer, 2017). The authentic design brief—co-designing an e-textile product for preschoolers—offered direction while leaving room for student agency, connecting with Kapkın and Joines' (2021) view that strong design briefs can catalyze creativity. It also linked classroom work to the broader community (Clapp, 2017), enhancing the relevance and purpose of the students' efforts. Following Sun (2017), empathy in design involves attending to human needs and experiences as an integral part of defining problems and generating solutions, as evidenced throughout the work of both students and teachers.

Empathy was supported through multiple pedagogical means and consistently appeared across students' design discussions and considerations. It functioned as both a desired learning outcome and a mechanism that supported meaningful and purpose-driven design work. Empathy was fostered through students' personal memories of preschool, direct observations of end users, in-situ feedback interactions, and engagement with the preschool environment. This multifaceted and evolving process corresponds with Kouprie and Sleeswijk Visser's (2009) view

of empathy as a dynamic phenomenon integrating both cognitive and affective dimensions.

Empathy and creativity were tightly intertwined. Recent studies similarly highlight a positive relationship between the two: Li, Chen, and Fu (2024) found that empathy positively predicts creativity, while Demetriou and Nicholl (2022) demonstrated that learners receiving empathy instruction in design tasks exhibit higher levels of both emotional and cognitive creativity. In this study, empathy appeared to help students define meaningful problems and evaluate emerging solutions, while creative experimentation enabled them to transform empathic understanding into tangible outcomes.

Prior research in higher education also shows that personal connection, autobiographical memories, and direct interaction with end users enhance designers' sensitivity and motivation and lead to more relevant design decisions (Hess & Fila, 2016; Mattelmäki et al., 2014; Smeenk et al., 2016; van Rijn et al., 2011). The findings here support the argument by Voigt et al. (2019) that empathy depends on a personal connection to the problem. The combination of personal memories and real encounters with preschoolers served as a strong connector, making the design task real and enabling meaningful perspective-taking.

In this study, design empathy was analyzed as it unfolded moment by moment through in-situ video recordings. Rather than relying solely on interviews, questionnaires, or evaluations of final artifacts (Demetriou & Nicholl, 2022; Van Mechelen et al., 2018), the process-oriented analysis revealed how empathy was entangled with technical reasoning, collaborative interaction, and material experimentation. It was embedded throughout the design process as an integral element rather than as a discrete "step."

The extended, open-ended nature of the project also provided insights into how empathy interacted with functional and technical decision-making. Students frequently drew on their previous experiences with sewing or coding when materializing their designs, echoing Hess and Fila's (2016) observation that empathic and non-empathic elements often coexist in design practice.

Empathy was also essential in teachers' work. Designing and facilitating DT projects in increasingly diverse and multicultural classrooms requires sensitivity to students' backgrounds, experiences, and identities (Carlson & Dobson, 2020; Carroll & McBain, 2021). Empathy informed teachers' decisions about how to structure tasks, scaffold participation, and create emotionally and socially safe learning conditions. In this way, empathy operated on multiple levels: between students and end users, among students, and between teachers and students.

However, the findings reinforce that theories of empathy in design remain underdeveloped, particularly regarding how empathy functions in practice and how it can be intentionally supported in educational contexts (Hess & Fila, 2016; Smeenk et al. 2019a; Surma-aho & Hölttä-Otto, 2022). Kolko's (2018) critique of

"empathy lite" similarly warns against assuming that deep connections with users can emerge within hours or days. Empathy is best understood as developing over time and across multiple design experiences rather than within a single design project or the short timescales typical of school-based interventions. Rather, such projects can offer opportunities to observe and support early forms of empathic stance-taking in formal education (Carlson & Dobson, 2020). A more nuanced understanding is therefore needed: while DT projects can activate and strengthen empathy, deeper empathic development requires sustained opportunities, time, and continuity (Yeung & Ng, 2024). Empathy underpins the cognitive, affective, and social dimensions of design and is cultivated through interaction, exploration, and negotiation rather than through predefined tools (Björgvinsson et al., 2012).

Taken together, the analysis suggests that empathy functioned as a cross-cutting pedagogical principle within the project. It shaped teachers' understanding of learners, informed the creation of authentic and meaningful design briefs, and supported emotionally and socially engaging learning experiences. In this context, designing with empathy moved classroom practice beyond abstract problem-solving toward engagement with human needs, values, and perspectives. Prior work similarly highlights empathy's motivational power in design learning, emphasizing its role in fostering students' commitment to improving the lives of others (Cook & Bush, 2018), highlighting its central role in DT-oriented learning in formal education.

### 6.1.3 Teachers' Evolving Roles

Research on creative and design-based pedagogies consistently shows that teachers' work extends beyond traditional instruction toward facilitation, co-design, guidance, and co-learning (Cremin & Chappell, 2021; Richardson & Mishra, 2018; Sawyer, 2017). The findings from this study resonate with this expanded view. Throughout the project, we operated simultaneously as teachers, facilitators, co-designers, co-learners, design leaders, and reflective learning experience designers, navigating pedagogical, curricular, and material demands (Aflatoony et al., 2018; Smith et al., 2016).

A further dimension of our work reflected elements of design leadership, involving critical design decisions that supported student teams in producing meaningful, user-centered outcomes while retaining ownership of their work. This illustrates how deeply the teacher's role is intertwined with students' open-ended design and making processes, particularly at the K–9 level. Kolko (2024) similarly frames design leadership as anticipating needs, managing time and resources, supporting the emotional demands of creative work, providing direction through early models and examples, and projecting confidence throughout the process.

Because DT is inherently messy and non-linear (Cross, 2011), teachers needed to cultivate a learning environment in which uncertainty, risk-taking, and exploration were normalized. Facilitation involved guiding ideation through targeted questioning, modeling creative and technical approaches, and establishing psychological safety—conditions known to support creativity (Beghetto & Kaufman, 2014). Socio-emotional dimensions such as empathy, trust, and mutual respect required sustained attention (Edmondson & Mogelof, 2006), especially as students sought reassurance or encountered frustration with the non-linear process and unfamiliar digital tools. Gajda et al. (2017) make a similar argument that socio-emotional support can be more crucial for creative learning than other forms of encouragement.

Sawyer's (2011) observation that expert teachers "use more structures and yet improvise more" captures the balance enacted in this project. While curricula, the Double Diamond model, and key learning design elements provided structure, improvisation was necessary to respond to students' emerging needs. Recent DME research similarly highlights the importance of adaptive structuring and on-demand scaffolding (Härkki et al., 2023).

Collaboration between teachers and with external partners was central. In this project, the craft teacher and I co-designed and co-taught the project. Despite these challenges, co-teaching was rewarding, as our different strengths complemented each other and supported the process. Co-teaching served as professional learning-by-design (Andersen & Pitkänen, 2019; Voogt et al., 2015), enabling joint problem-solving, shared reflection, and collective decision-making. Collaboration extended to preschool teachers, a programming expert, and one parent, forming temporary learning networks that broadened participation and distributed expertise (Penuel, 2017).

Schön (1987) argued that traditional theories of professional knowledge are often too rigid and fail to capture the complexities and uncertainties of real-world practice. The ability to reflect on one's work helps teachers navigate these complexities and adapt their knowledge to specific contexts. Such reflective engagement enables professionals to evolve and improve continuously (Becker & Jacobsen, 2020). Co-reflection before, during, and after lessons played an essential role in facilitating, leading, and redesigning the process. It strengthened adaptive decision-making, created space for teachers to share small successes and failures, as well as uncertainties and frustrations. However, the strict time constraints of formal schooling made reflection challenging for both teachers and students.

Reflections frequently addressed teachers' roles, teaching modes, and emerging mindsets and practices, and they also generated ideas for future development, corresponding with earlier literature (Andersen & Pitkänen, 2019; Bekker et al., 2015). While prior research notes that teachers often struggle with design-process knowledge (Smith et al., 2016; Van Mechelen et al., 2021), our backgrounds in craft

and design pedagogy mitigated these issues. Instead, the most significant gaps emerged around digital fabrication, echoing studies showing that teachers often lack training in programming and physical computing (Hjorth et al., 2016; Smith et al., 2016; Walan & Gericke, 2023).

Although Kirschner (2015) argues that technology is only one component of the broader educational ecology, adopting new tools often encounters intrinsic barriers related to teachers' attitudes, skills, and established routines (Nicholson et al., 2022). The craft teacher found it demanding to shift from a traditional "all-knowing" role to a more facilitative stance and at times felt embarrassed by her unfamiliarity with digital tools. Teaching through DT required tolerating uncertainty, relinquishing control, and trusting the process (Sawyer, 2011), even in situations in which the appropriate course of action was unclear. Parker's (2021) study similarly identifies this mindset shift as a central learning outcome for teachers engaging with DT.

Approaching digital technology with a designer–maker mindset and lacking prior experience, we sought assistance from colleagues, a programming expert, parents, and other community members. Through this, the teachers modeled key DT mindsets by embracing mistakes, navigating uncertainty, seeking help, and fostering collaboration across groups and stakeholders (Kafai & Fields, 2018). As novices in programming, we learned alongside students, often through trial and error. While challenging, this dynamic appeared to foster mutual learning in which teachers and students developed similar competencies—problem-solving, troubleshooting, resilience, collaboration, and comfort with uncertainty (Vossoughi et al., 2021). Learning through DT thus becomes reciprocal and relational, with teachers and students learning together through shared inquiry, reflection, and creative problem-solving.

Beyond facilitation, the project illuminated the teachers' role as learning experience designers. Although teachers routinely design curricula, interactions, and learning environments, this work is not consistently conceptualized as design practice (Goldman et al., 2020; Jordan, 2016). In this project, teaching explicitly became design work, requiring continual goal framing, plan adaptation, and iterative adjustments as the design and making progressed (Elwood & Jordan, 2022; Henriksen et al., 2017; Koh et al., 2015). The project also highlighted the extensive "backstage" work of teaching (Dreessen & Schepers, 2019)—the often-invisible coordination, planning, negotiation, and troubleshooting that sustain the visible work of students (Viilo et al., 2018). In this context, the DT approach appeared to be particularly helpful in supporting teachers in creating learning situations that are themselves ill-structured or uncertain (Elwood & Jordan, 2022).

As gatekeepers of curriculum implementation, teachers must balance the knowledge and skills required for non-linear DME practices with the constraints of formal schooling (Rouse & Rouse, 2022). Yet formal schooling is characterized by

structural asymmetries, as teachers retain responsibility for curriculum goals, assessment, safety, and progression. Acknowledging these power dynamics was essential for supporting participation while maintaining direction (Guha et al., 2013).

The challenges with digital tools prompted deeper reflection on the role of digital technologies in craft education and raised practical questions about whether teachers can realistically keep pace with rapid technological change and what kinds of support structures are needed. The craft teacher emphasized that without sustained support from the school or broader community, she would be unlikely to undertake a similar process again.

These findings support earlier work showing that teachers rarely implement DT alone and benefit from sustained professional communities and cross-institutional partnerships (Penuel, 2019). School-based DME research echoes this: Härkki et al. (2021) highlight that addressing challenges in DME adoption requires collective effort from teachers, school leadership, and teacher education. Scholars increasingly call for collaborative, participatory approaches among teachers, researchers, and school leaders to develop DME curricula and digital fabrication practices (Caratachea et al., 2023; Smith et al., 2023). Clark (2024) adds that broader systemic actors—such as administration, government, universities, and the public—are also implicated.

Penuel (2019) emphasizes that research–practice partnerships and co-design with teachers are essential for redesigning classroom infrastructures and routines. Because teachers often lack external support, building the expertise needed for complex learning-design implementations depends on collaboration across horizontal and vertical networks (Bødker et al., 2017). Therefore, teachers' pedagogical perspectives and collaborative practices remain central to DME research and development (Nicholson et al., 2022).

## 6.2 Limitations and Methodological Reflections

This dissertation is based on a single qualitative case study conducted in Finnish lower-secondary craft education involving 14–15-year-old students. While this design enabled an in-depth and process-oriented examination of how a DT approach and its dimensions were enacted in an authentic classroom setting, it also sets clear boundaries for interpretation, transferability, and generalization (Eriksson & Koistinen, 2014). The findings may be analytically transferable, but their applicability requires careful contextual interpretation rather than direct generalization.

The study was conducted in Finland, where high levels of teacher autonomy, a low-hierarchical school culture, and relatively relaxed teacher–student relationships may have supported the co-construction of ideas and artifacts. These

conditions may limit the applicability of the findings in educational settings with different institutional structures or cultural expectations, particularly outside Northern Europe.

The curricular and infrastructural conditions of Finnish craft education represent a substantial limitation in terms of transferability. Finnish basic education provides relatively flexible curriculum structures, dedicated craft facilities, access to diverse materials and digital fabrication tools, and a high degree of teacher autonomy in designing learning experiences. These structural conditions made it possible to integrate DT in ways that may not be directly replicable in systems where subject time is limited, learning environments are less materially equipped, or curricular objectives are more tightly prescribed. The learning goals of Finnish craft education emphasize holistic processes, multi-materiality, and creative production, aligning closely with design-oriented pedagogies. In other educational contexts—such as tightly structured disciplinary subjects or informal makerspaces operating outside formal curricula—DT implementation may therefore take different forms.

A further methodological limitation concerns the close intertwining of researcher and teacher roles. My dual positioning provided pedagogical insight, sustained engagement, and contextual sensitivity, but it also increased the likelihood that facilitation decisions may have influenced the processes and outcomes that were later analyzed. Because I actively participated in structuring tasks, scaffolding reflection, and guiding interactions, it is not possible to fully separate pedagogical intervention from empirical observation.

This dual positioning reflects an insider–outsider dynamic in educational research. As an insider, I had access to deep contextual knowledge of the community, culture, and pedagogical practices, supporting nuanced interpretation of classroom processes. At the same time, this proximity introduced the risk that personal experiences and prior assumptions might shape the research process and its outcomes. Conversely, adopting an outsider perspective enabled the questioning of taken-for-granted assumptions and the identification of alternative interpretations (Holmes, 2020).

A reflexive approach was therefore essential throughout the research process. During the analysis phase, I remained attentive to how my own background, experiences, and professional perspectives might influence the interpretation of the material. Reflexivity involves such continuous examination of how the researcher's positionality shapes both the research process and the knowledge produced (Holmes, 2020).

The findings should therefore be understood as a situated interpretation of how DT dimensions were enacted within a particular relational, curricular, and instructional configuration. While reflexive documentation, transparency regarding positionality, collegial discussions, and the use of multiple data sources

were employed to enhance credibility and methodological rigor, the findings still represent an interpretation shaped by this dual role.

Interpretive case study research is grounded in the understanding that multiple, situated versions of reality coexist and are shaped by participants' histories, perspectives, and interactions (Denzin & Lincoln, 2011; Eriksson & Koistinen, 2014). From this perspective, research outcomes are understood as constructions that emerge through the researcher's engagement with the field and cannot be separated from the tools, theories, and positionality that inform them. Every researcher's background, expertise, and personal history shape analytical choices, making each qualitative study inherently unique and difficult to reproduce in the same way (Denzin & Lincoln, 2011).

The study relied on multiple data sources and analytic approaches, which provided a rich picture but also posed challenges. Because I was simultaneously teaching and facilitating, not all classroom interactions could be observed in real time, and some video sequences were incomplete as student groups moved across the learning environment. Although concurrent analysis is often recommended (Merriam, 1998), the project's pace required analysis to begin after data collection. As a novice researcher, working with a large and heterogeneous dataset was demanding and required combining systematic video coding, thematic analysis, and narrative writing.

While multiple methods and data sources enabled a holistic view of the process, they also highlighted that different analytical lenses illuminate certain aspects while obscuring others. For example, design empathy was primarily examined through students' verbal expressions rather than through affective or teacher-mediated indicators. Discussions with colleagues broadened interpretations rather than aiming for consensus. Taken together, these strategies strengthened the trustworthiness of the study but also highlight the methodological constraints of examining open-ended design processes in authentic school settings, where the researcher's presence is inseparable from the knowledge produced.

In addition, case-based research conducted in regular classrooms inevitably includes constraints such as fluctuating student motivation, interruptions, assessment-related power dynamics, and uneven participation, all of which shape what could be observed, documented, and interpreted.

The pedagogical implications outlined in this dissertation should be interpreted within the structural and cultural conditions of Finnish basic education. Educational systems with different curricular structures, levels of teacher autonomy, material infrastructures, and access to collaborative partners or time for reflection may encounter substantially different constraints when attempting similar implementations. The applicability of these insights therefore depends on careful contextual interpretation rather than direct transfer.

At the same time, following Gutiérrez and Penuel's (2014) view that relevance to practice is a criterion for rigor, the value of this study lies in engaging directly with the complexity of authentic educational settings rather than abstracting from them. By explicitly acknowledging contextual, developmental, methodological, and ethical boundaries, the dissertation aims to balance conceptual articulation with analytical caution while contributing situated insights into how DT may be enacted in formal K–9 education.

## 6.3 Pedagogical Implications and Suggestions

The three studies suggest that integrating DT in formal K–9 DME is closely associated with teachers' ability to take on evolving roles, navigate uncertainty, and design meaningful, human-centered learning experiences. These findings highlight two broad areas of pedagogical implication: (1) strengthening teacher education and teachers' professional development, and (2) supporting teachers in learning experience design and facilitation through an initial conceptual framework. Together, these implications point toward a possible shift in how teachers' professional identities may be conceptualized—toward becoming reflective and adaptive designers of learning.

The pedagogical implications discussed below emerge from a case study situated in Finnish lower-secondary craft education, characterized by high levels of teacher autonomy, established craft traditions, and specific material infrastructures. These contextual conditions shaped the implementation of DT in this dissertation. The implications are therefore presented as contextually grounded considerations rather than prescriptive recommendations for other educational settings.

### 6.3.1 Implications for Teacher Education and Professional Development

This dissertation aligns with earlier research emphasizing that teachers require both conceptual and practical competence in DT and digital fabrication to guide students through exploratory and iterative processes (Hjorth, 2019; Hjorth et al., 2016; Smith et al., 2016). Van Mechelen et al. (2021) demonstrate that limited design training may restrict teachers' capacity to manage open-ended processes and move flexibly between pedagogical roles. Similarly, Nicholson et al. (2022) highlight the potential of design practices for building teachers' DT competencies, particularly when complex technologies are introduced into classroom practice.

Scholars further note that teachers benefit from professional development that provides cross-curricular models, coherent structures, and practical resources for integrating new practices into everyday instruction (Bødker et al., 2017; Van Mechelen et al., 2021). In addition to technological knowledge, effectively

leveraging emerging tools appears to require design-oriented thinking that enables teachers to transform existing knowledge into contextually grounded learning experiences and to see themselves as active learning designers and knowledge constructors within their local environments (Lee & Chung, 2025). While teachers must continue to learn new technologies, including AI, VR, and emerging forms of digital fabrication, the findings in this dissertation suggest that design competence and mindset are equally important. These competencies help teachers navigate ambiguity, support collaboration, and foreground human needs in complex learning situations (Davis, 1998).

Leading creative and open-ended projects appeared to involve design methodological awareness, confidence, and adaptive judgment. These abilities can be developed through hands-on mentorship, co-teaching, and collaborative professional practice. The findings from this case suggest that design leadership may become an increasingly visible dimension of teaching work, raising questions about how teacher education might prepare educators to orchestrate nonlinear learning processes while balancing openness with pedagogical and institutional constraints. Scholars argue that teacher education should help educators navigate the complex, unpredictable challenges of practice (Calavia et al., 2023; Jordan, 2016; Schön, 1987), thereby strengthening their capacity to design engaging learning experiences and support students' participation in creative problem-solving.

Integrating DT into teacher education may therefore benefit from sustained opportunities for co-design, mentoring, practice-based inquiry, and reflection-in-action. Teachers may gain from working collaboratively on authentic design challenges, building prototypes, and reflecting on their pedagogical reasoning. Blundell's (2025) study of a year-long professional learning initiative shows that DT provides an actionable approach for engaging with the complexity of teacher practice, particularly in digital technology integration. It highlights that traditional, skills-focused professional development often fails because it separates technology from the realities of classroom practice. DT-based professional development supports teachers in reframing problems, making their assumptions explicit, experimenting with new pedagogical routines, and iterating on their work in response to feedback. It also fosters collaborative learning ecologies and surfaces shifts in roles and power dynamics, thereby enabling teachers to embrace complexity rather than avoid it.

These suggestions align with a growing body of work advocating the integration of DT in teacher education to cultivate reflective, adaptive, and empathic pedagogical mindsets (Calavia et al., 2023; Henriksen et al., 2017; Koh et al., 2015; Liu et al., 2024; Mosely et al., 2018; Norton & Hathaway, 2015). As Mosely (2025) emphasizes, design processes function effectively only when facilitators possess the requisite knowledge, dispositions, and personal capabilities. Despite the centrality

of design to teachers' everyday work—designing materials, activities, and learning environments—formal preparation in design remains limited (Elwood et al., 2016; Goldman et al., 2020; Henriksen et al., 2017).

These findings further support earlier arguments for long-term, practice-oriented professional development rather than short, skills-focused workshops (Carroll et al., 2010; Koh et al., 2015; Retna, 2016). However, systematic research on how teacher education should cultivate teachers' design competencies remains limited (Liu et al., 2024). This dissertation contributes to this discussion by articulating the key conditions, competencies, and pedagogical considerations that appear important when teachers implement DT in K–9 design- and maker-oriented learning contexts.

### 6.3.2 Implications for Learning Experience Design and Facilitation

In addition to informing teacher education and professional development, the findings reported in this dissertation also support the articulation of an initial conceptual framework for learning experience design in formal K–9 DME, grounded in DT, empathy, and PD-informed participatory values.

Existing frameworks, such as the Reflective Design-Based Learning Framework (Bekker et al., 2015) and the DT & ME Curriculum Blueprint (Veldhuis et al., 2022), have provided structured approaches for embedding iteration, openness, and problem framing in school contexts. These frameworks emphasize alignment between learning goals, design briefs, assignments, collaboration, and scaffolding, as well as reflective practice. Becker and Jacobsen (2020) emphasize that learning designs should engage senses and minds, support inquiry-based learning, and address teachers' experiences of failure and uncertainty, while Clark et al. (2024) argue that the field of education could draw more deeply from design literature when conceptualizing frameworks to support K–9 teachers in design.

This dissertation proposes an initial conceptual framework by synthesizing insights from prior research on DT together with PD-informed values and design-oriented learning, alongside empirical findings from the three studies. The framework emerged through an iterative process of theoretical interpretation and empirical analysis.

Studies I and III together informed the articulation of the dimensions of the DT approach, examining how these dimensions structure and support students' creative design processes. Studies I and II primarily focused on the teacher's role in facilitating design-oriented learning environments and integrating DT into classroom practice. Study III explored the manifestation of design empathy in students' design activities. Although this study approached empathy from the

students' perspective, its findings further supported the central role of empathy within the framework.

The key pedagogical elements of the framework are primarily derived from the findings of Study II, where they are described and analyzed in detail. More comprehensive descriptions, characteristics, references, and examples of implementation can therefore be found in that study.

Rather than presenting a prescriptive implementation model, the framework offers a structured conceptual articulation of pedagogical considerations that emerged through iterative engagement with both theory and classroom practice. It can therefore be understood as a conceptual synthesis linking theoretical perspectives on design-oriented learning with empirical insights from classroom practice. The framework is illustrated in Figure 7 and discussed through its key elements below.

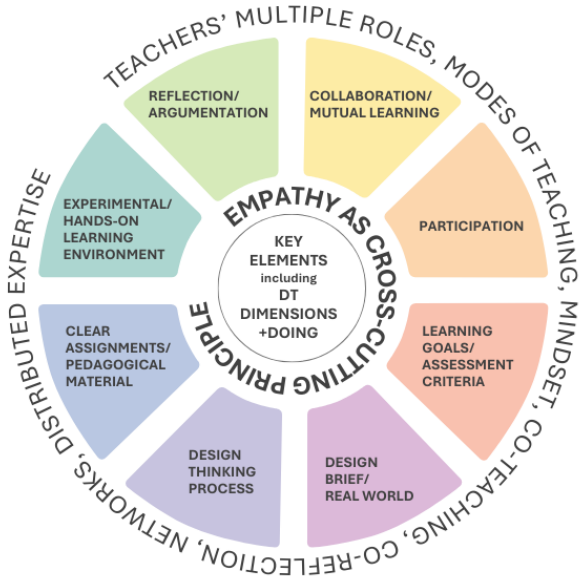



**Figure 7** Initial conceptual framework synthesizing insights from the three studies and relevant literature.

Empathy is considered a core principle within the framework, functioning both as a pedagogical stance and as a dimension of DT. In the case examined, empathy informed the framing of design briefs, the facilitation of perspective-taking, and students' consideration of users' needs. Rather than being confined to an initial phase of the design process, empathy appeared to operate throughout the design activity.

The framework includes eight interrelated elements: (1) collaboration and mutual learning as essential parts of the design process; (2) participation that is

meaningful, contextual, and educational and that acknowledges inherent power issues involved; (3) purposely designed and clearly communicated learning goals and assessment criteria; (4) real-world design briefs that connect to students' own experiences; (5) a non-linear DT process; (6) clear assignments and pedagogical materials that articulate the potential outcomes of activities; (7) an experimental and hands-on learning environment that supports exploration with diverse materials, tools, technologies, and spaces; and (8) structured opportunities for reflection and argumentation. These elements should not be interpreted as fixed components of a model but as analytically derived and theoretically informed considerations.

In this context, these elements were associated with sustained participation and engagement. However, their relevance and applicability in other institutional, cultural, or subject-specific settings remain open questions that require further empirical investigation.

The articulation of teachers' evolving roles forms an integral part of this framework. Teachers were understood as facilitators, co-designers, co-learners, design leaders, and reflective learning experience designers who balanced openness and structure while navigating uncertainty. Co-teaching, collaborative reflection, and temporary learning networks appeared particularly significant in managing technological uncertainty and sustaining supportive learning environments. Because these roles were articulated within a Finnish lower-secondary craft context characterized by high levels of teacher autonomy and established craft traditions, their transferability to other educational systems and subject domains should be approached with caution.

Taken together, the implications point to the potential value of holistic learning experience design that integrates cognitive, social, emotional, and embodied dimensions of learning. At the same time, the initial conceptual framework should be understood as an exploratory synthesis emerging from a specific case study and its theoretical grounding, inviting further refinement and testing in diverse educational contexts. Because existing DT models often fail to capture the complexity of real-world practice and the tacit pedagogical reasoning involved in design and making processes (Warr et al., 2022), such frameworks are best treated not as definitive models but as conceptual resources for ongoing reflection and development.

## 6.4 Concluding Remarks

With this dissertation, the aim was to examine the integration of a DT approach in formal K–9 DME, with particular attention to the roles and practices of teachers and to the manifestation of design empathy in students' design activities. The work addressed this aim through three interconnected studies that explored the

implementation of DT in Finnish lower-secondary craft education from complementary perspectives. The intention was to promote a more holistic approach to applying DT approach in formal K–9 education by integrating its multiple dimensions into the project, an approach that remains relatively underexplored at this educational level.

A central value base for this dissertation stems from the tradition of PD, which informed commitments to participation and mutual learning. By combining these commitments with DT's structured process, the project created conditions in which students could act as designers in an authentic community context. The processes frequently involved empathy, perspective-taking, and mutual learning by students, teachers, and other stakeholders. The involvement of preschool children as future users and the collaboration among teachers and external stakeholders illustrate how participatory principles can be enacted in formal schooling. Recent insights on teaching PD in higher education further reinforce these implications: D'Andrea et al. (2024) show that PD pedagogy depends on mutual learning, reflection-in-action, and authentic collaboration with external stakeholders. These principles echo the conditions observed in this dissertation, where co-teaching, shared facilitation, and iterative reflection shaped the quality of the design process. In this way, the dissertation contributes to an emerging body of research examining how PD-informed values and DT practices can intersect productively in compulsory education.

Conceptually, the dissertation advances discussions on DT in compulsory schooling by articulating a multidimensional view of DT encompassing process, methods, mindset, and empathy within an authentic classroom context. While previous research has often emphasized individual dimensions of DT, fewer studies have examined how these dimensions interact relationally in everyday classroom practice. This dissertation makes that interaction explicit by analyzing how process, methods, mindset, and empathy co-evolve within a single authentic school project. In this articulation, empathy is positioned not merely as an initial stage of the design process but as a cross-cutting pedagogical principle shaping both teachers' design decisions and students' engagement throughout the design process.

Across all studies, DT functioned as a bridge between structure and creativity, theory and practice, and individual and collective learning. The synthesis illustrates how DT can provide both a conceptual lens and a practical methodology for transforming school learning into participatory, human-centered, and reflective practice. Rather than a linear or technical sequence, DT emerged as an open-ended, messy, iterative, reflective, and situated practice involving problem framing, divergent and convergent thinking, collaboration, and sustained engagement with uncertainty (Cross, 2011; Sawyer, 2017). These characteristics link closely with the realities of contemporary society, where complexity and ambiguity are pervasive, and learners need flexible, creative, and empathic capacities to navigate and shape

their environments. This dissertation suggests that DT in education requires greater attention to mindset and empathy, in addition to design processes and methods, so that students experience that what they design matters both to themselves and to others.

Empirically, the dissertation provides a detailed case-based account of how DT and participatory approaches can be enacted in Finnish lower-secondary craft education. Through the complementary perspectives of three studies, the research illustrates how students engage in participatory design processes, how design empathy emerges in situated interactions, and how teachers structure and facilitate open-ended creative work within the constraints of everyday schooling. The findings across the three studies indicate that students can take on participatory and empathic roles when supported by appropriate structures, methods, materials, and socio-emotional scaffolding. Through DT, students practiced perspective-taking, justified their design decisions, and engaged in the collection and interpretation of information and experiences. Their design discussions, reflections, and final products highlighted the importance of attending to users' needs while drawing on personal experiences. These findings align with prior research suggesting that creativity develops through iterative action, reflection, and collaboration rather than through isolated moments of inspiration (Clapp, 2017; Sawyer, 2025).

Pedagogically, the findings also make visible the complexity of teachers' professional roles in design-oriented learning. Teachers acted as facilitators, co-designers, design leaders, and reflective learning experience designers, balancing curricular constraints, technological uncertainty, and socio-emotional demands. Their work required sensitivity to students' experiences, the ability to scaffold ideation and iteration, and the capacity to orchestrate collaborative activities that were both purposeful and flexible. This complexity also manifested in teachers' uncertainty about adopting DT more broadly, particularly in relation to open-ended design processes, shifting pedagogical roles, and, in some cases, emerging technologies and digital fabrication.

The cumulative contribution of this dissertation does not lie in a linear progression across the three studies but in their complementary examination of the same educational case from different analytical perspectives. Together, these perspectives provide a layered understanding of how DT can be integrated into formal K–9 schooling through structural, pedagogical, and experiential lenses. The proposed initial conceptual framework synthesizes key pedagogical, social, and material elements identified across the three studies. Rather than representing a validated implementation model, the framework should be understood as an empirically informed conceptual articulation that integrates insights from theory and classroom practice.

Taken together, this dissertation contributes to research on design-oriented education by (1) articulating DT as a multidimensional and relational pedagogical construct, (2) conceptualizing empathy as a cross-cutting principle embedded in both teaching and student design processes, and (3) making explicit the evolving professional roles required when integrating DT into compulsory education. These contributions emerge from a single interpretive case study situated within Finnish lower-secondary craft education. They do not claim universal applicability; rather, they offer a theoretically grounded and empirically informed articulation of how DT may be integrated into formal schooling and invite further research across diverse educational contexts.

At the same time, the conclusions must be interpreted within the specific curricular and cultural context of Finnish basic education, characterized by high levels of teacher autonomy and well-established craft infrastructures. The small-scale, collaborative nature of the case, and the age group involved limit the transferability of the findings. Rather than offering universal prescriptions, the dissertation provides situated insights into how DT and PD-informed approaches can be enacted within formal schooling.

Beyond classroom practice, the findings also speak to broader educational and societal questions. By connecting DT with a PD-informed value base, this dissertation foregrounds the values of inclusion, equity, and community engagement. Technologies are created for people, and all learners—including children—should have opportunities to shape them (Blikstein, 2013). In this sense, DT can be understood not only as a problem-solving approach but also as a pedagogical orientation that supports democratic participation, critical reflection, and computational empowerment (Dindler et al., 2020). Participatory, human-centered design processes bring multiple voices into design and may be particularly empowering for girls and other underrepresented groups (Kijima et al., 2021; Peppler et al., 2022). Designing for community contexts supports the development of transversal competencies while helping students experience their work as socially meaningful (Blikstein & Worsley, 2016; Clapp, 2016).

By bringing together DT, PD-informed values, and design-oriented learning in a sustained classroom context, this dissertation highlights how design-driven pedagogies can contribute to more participatory, human-centered, and reflective forms of learning in formal schooling.

## 6.5 Future Research

Several directions for future research emerge from this dissertation. First, comparative and longitudinal studies could examine how DT and PD are enacted across different age groups, subject areas, and educational contexts. Such studies could explore how curricular goals, material learning environments, and levels of

teacher autonomy influence the ways in which design-oriented pedagogies can be implemented in schools.

Future research could also investigate how assessment practices might better capture the broader learning outcomes associated with design-oriented learning, including transformative and socio-emotional competencies (OECD, 2019), which are often difficult to measure through traditional evaluation methods.

Second, the initial conceptual framework introduced in this dissertation would benefit from further development and testing in different educational contexts. Future studies could explore how teachers interpret and adapt the learning design elements identified in this dissertation in their own classrooms and how these elements can be sustained over time in everyday school practice.

Third, further research is needed to explore how teachers develop design-oriented professional identities and how teacher education can systematically cultivate design leadership, reflective practice, and technological fluency. The rapid emergence of technologies such as artificial intelligence adds urgency to questions of ethical and responsible design, digital design literacy, and computational empowerment (Schaper et al. 2023; Smith et al., 2023), particularly in compulsory education. This calls for multidisciplinary collaboration linking education, Child–Computer Interaction (CCI), and design research (Ahn & Clegg, 2018; Gutiérrez & Penuel, 2014; Van Mechelen et al., 2023).

Finally, future studies should continue to investigate design processes in authentic classroom environments. Research conducted "in the messy wild" of everyday schooling can deepen our understanding of how creativity, empathy, and participation unfold in practice and how design-oriented pedagogies can be sustained within institutional constraints.

Taken together, these directions suggest that DT and PD-informed approaches hold significant, yet still underdeveloped, potential for reimagining compulsory education. A design orientation can support the development of new possibilities, and emerging approaches—such as critical, social, sustainable, non-human, and pluriversal design—could guide educators in reflecting on current practices and moving the field of education toward more sustainable futures. Long-term, participatory research–practice partnerships could help develop sustainable communities of practice around DME, PD-informed approaches, and DT, supporting teachers in navigating uncertainty, emerging technologies, and changing curricular demands (Penuel, 2019; Schaper et al., 2024; Van Mechelen et al., 2023).

By continuing to develop collaborative frameworks, research–practice partnerships, and teacher education programs grounded in design, future work can advance learning environments that support students' design learning and empower them to participate thoughtfully and creatively in shaping their communities and futures through design.

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