



Toddlers' Interactions, Agency, and Concept Formation in Mechanical Technology Activities in Early Childhood Education

Sara Eliasson



UNIVERSITY OF
GOTHENBURG

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Abstract

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The aim of this doctoral thesis is to contribute knowledge to the field of early childhood mechanical technology education. This is pursued through a systematic review and synthesis of existing research, alongside empirical explorations of video documented hands-on mechanical technology activities in preschool. The thesis is theoretically informed by sociocultural perspectives on interaction and development (Vygotsky, 2016; Wertsch, 1998) and by DiGironimo's (2011) framework for understanding the nature of technology. Three overarching research questions frame this thesis:

RQ1: How is technology education in early childhood education conceptualised in recent research and enacted in hands-on preschool activities when analysed through a framework of the nature of technology?

RQ2: How is technology mediated when intersubjectivity is established, and how are everyday and scientific conceptualisations related to technology negotiated and interrelated in teacher–child interactions preschool technology activities?

RQ3: How do teacher–child interactions and toddlers' agency shape the enactment and development of technology knowledge in preschool technology activities?

The thesis encompasses four separate studies, of which Studies I and II were conducted as part of my licentiate thesis. In Study I, the research field of technology education in early childhood and empirical studies are scrutinised to identify significant patterns and analyse how technology and

technology education in ECE are conceptualised and which dimensions of the nature of technology (DiGironimo, 2011) emerge in the studies. In the subsequent three studies, empirical data encompassing video observations of technology activities involving 12 children (2–5 years old) and four preschool teachers from three preschool groups in Sweden are scrutinised, informed by a sociocultural perspective on learning, concept formation and agency (Vygotsky, 2016). In Study II, toddlers' and preschool teachers' interactions in preschool technology activities are studied to explore which dimensions of the nature of technology (DiGironimo, 2011) emerge when intersubjectivity (Linell, 2014; Rommetveit, 1974) is established between participants. In Study III, toddlers' concept formation is explored in terms of how everyday and scientific conceptualisations (Vygotsky, 2016) of technology are initiated and interrelated in toddlers' and preschool teachers' interactions. In Study IV, the interactions between toddlers and preschool teachers are explored in relation to toddlers' agency (Wertsch et al., 1993).

The results highlight recent empirical research on early childhood technology education as a broad, multidimensional and still-evolving subject field, both in reference to technology education as a research field and as a curricular subject area in early childhood educational settings. Furthermore, the results suggest that toddlers in early childhood education practices are offered varied technology activities, in which four of the five dimensions in DiGironimo's (2011) framework of the nature of technology are well represented. However, the historical dimension was shown to be absent in both previous research studies scrutinised in Study I and in the empirically studied toddlers' and preschool teachers' interactions in Study II.

The results of the thesis emphasise the contributions of toddlers' initiatives and active participation in preschool technology activities, specifically regarding (i) how various dimensions of technology knowledge emerge in their interactions; (ii) how intersubjectivity is established, challenged and negotiated; (iii) how toddlers contribute with both everyday and emerging scientific conceptualisations of technology; and (iv) how toddlers' initiatives to exercise agency contribute to and expand the technology knowledge as well as the organisation of the activity by means of non-verbal and verbal conceptual or tangible cultural tools in interactions and negotiations. These aspects are further discussed in the thesis in relation to key theoretical concepts and previous research as well as implications for the research field and the profession.

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Chapter 1 Introduction

In this thesis, early childhood technology education is explored, with particular emphasis on toddlers' and preschool teachers' interactions related to mechanical technology in preschool technology activities. A systematic literature review, Study I, first maps the field. Next, three subsequent empirical studies (Studies II, III and IV) empirically explore various aspects of toddlers' interactions related to mechanical technology, foregrounding peer-to-peer and child-teacher interactions as prerequisites for learning about technology. The first two studies – Study I, a systematic literature review, and Study II, an empirical study – were previously published as part of my licentiate thesis.

My interest in this field originates from my professional curiosity as a preschool teacher about how children learn about technology. My own experiences with various scientifically flawed conceptualisations of technology and a general belief that it involves almost exclusively digital technology have also motivated my research interest in mechanical technology. At the time of starting my PhD education, technology as a subject area had just been expanded and emphasised in the Swedish preschool curriculum (Swedish National Agency for Education, 2018). These new accentuations raised questions about preschool teachers' knowledge of technology education and, consequently, pedagogical and didactic¹ questions related to what early childhood technology education can be. In other words, what kind of technology knowledge is it possible for toddlers to learn about, and what do they need to develop a sound foundation for future technology education? This and other questions guided my initial research interest. Orchestrating learning activities involving mechanical technology with toddlers can be far from straightforward: the research base is still emerging

¹ In this thesis, the term didactic is used in the Nordic and continental European sense, referring to theoretically informed questions concerning educational content, teaching, learning and the organisation of pedagogical encounters. It should therefore not be understood in the everyday English sense of didactic as moralising or overly instructive (Krogh et al., 2021).

and practitioner-oriented guidance is sparse. Thus, there is a pressing need to understand how toddlers encounter, make sense of and gradually learn about the foundational principles of technology. Consequently, my thesis is motivated by the need to contribute empirical evidence and pedagogical insight to an underexplored field. I would also like to highlight the significance of mechanical technology in laying the groundwork for toddlers' broader technological understanding in a society where human and technology advancements are intertwined and often result in non-transparent technological artefacts and systems.

Mechanical Technology in Human Society

For centuries, humankind has relied on foundational mechanical systems, such as wheels, axles and pulleys, which continue to remain at the heart of many of today's complex technological artefacts (de Vries, 2016). However, human advancement and dependence on technology have produced complex technological inventions (Arthur, 2009). These include digital technologies, in which the underlying mechanical systems are largely invisible (Säljö, 2009). Much of the contemporary digital tools and objects that now permeate everyday life in Western societies rest on these foundational mechanical principles, and many children now grow up in digitally infused and highly technological societies (Livingstone & Third, 2017). As a result, children are surrounded by tools they may be able to use but the underlying principles of which they do not necessarily understand. A democratic society in which humans are dependent on and recurrently involved in using and developing advanced technology, however, requires citizens who are able not only to operate technological systems but also to reason about how they work (de Vries, 2016; Williams, 2009).

Toddlers' emerging knowledge of technology principles related to mechanical technology is imperative for building a solid foundation of technology knowledge for future schooling. From a larger perspective, it is also important for developing an understanding of how human society and technology are intertwined in a reciprocal relationship involving challenges that require democratic responsibilities and careful considerations of ethical, social and economic considerations. Such reasoning cannot be postponed until later schooling but needs to be cultivated from an early age (Sundqvist, 2020). It is therefore essential, even in the early preschool years, to provide

children with opportunities to recognise that technology does not merely comprise digital inventions, but fundamental technology principles intertwined with the history and future of human societies.

In this thesis, I use the term *mechanical technology* to describe tangible technology artefacts and activities that involve foundational technology principles related to mechanics, energy, force and motion. In the engineering literature, these principles are referred to as *simple machines*, but in this thesis, theoretically and conceptually grounded within the field of early childhood education, I wish to move away from the term *simple* since it can misleadingly give the impression that these mechanical principles are simple in the sense of being of lesser significance. On the contrary, the principles of mechanical technology form the foundation for early technology solutions and every technological advancement that has followed. Moreover, mechanical technology is often overlooked in everyday discussions about early childhood technology education. Instead, when referring to technology education, it is often implicitly understood as digital technology (cf. Sundqvist, 2020; Undheim, 2022). Similarly, the initial searches in various databases matched an abundance of research studies claiming technology as their research interest. However, they predominantly involved digital technology and often digital technology as tools for learning another subject. This narrow focus risks obscuring the importance of cultivating broad technological knowledge. Mechanical systems, precisely because they are tangible and transparent, offer children unique opportunities to understand the underlying relationships and to see technology as something that can be reasoned about, questioned, modified and combined in new ways. When young children are offered opportunities to explore foundational technological principles through hands-on experiences, they are better equipped to develop an abstract and transferable understanding of technology (Åkerblom & Thorshag, 2021; Fler, 2000; Sundqvist & Nilsson, 2018; Sundqvist et al., 2025). To conceptualise mechanical technology in this thesis, I adopt the framework of DiGironimo (2011), which involves five dimensions of the nature of technology: *technology as artefacts*, *technology as creation processes*, *technology as human practices* and *a historical dimension of technology* and *technology in contemporary society*. This framework is further elaborated on in Chapter 3.

Early Childhood Technology Education

The emerging research field of technology education in early childhood education (see Chapter 3 for a more extensive presentation) is characterised by research that explores teachers' understanding of technology and technology education, as well as by various design studies and is recurrently described as descriptive and, in some cases, normative (cf. Axell & Boström, 2021; DiGironimo, 2011). It is an emerging interdisciplinary field involving several other subjects. However, when defining the understandings of early childhood technology and technology education, it can prove fruitful to separate these from other fields to enable in-depth scrutiny. Previous research emphasises the need to develop a conceptual framework for early childhood technology education (de Vries, 2016; DiGironimo, 2011), which further highlights the urgency of conducting empirical studies on early childhood technology education.

Several studies have focused on educational contexts, including hands-on tangible technology (e.g. Åkerblom & Thorshag, 2021; Boström et al., 2022; Sundqvist, 2020, 2022; Sundqvist et al., 2025) and digital technology (e.g. Nolan et al., 2022; Su et al., 2024) involving children from the age of five. A research gap was identified in the initial systematic literature review conducted as part of this thesis (Study I) concerning research that focuses on mechanical technology education with children under the age of five. Because toddlers meet technology daily, both in terms of mechanical technology and digital technology, to become active participants in a democratic society, they need educational practices that reflect these local and global realities (Edmonds, 2019). It is thus arguably important that toddlers are offered opportunities to learn about various aspects of technology and its relationship to humankind from an early age. Many technological tools in today's societies entail advanced and combined technology principles and solutions. Digital technology, in particular, is often abstract and intertwined with other subject fields, such as science, which makes it difficult to understand the technological knowledge embedded within them, even for adults.

However, understanding technology and its reciprocal development and changes in relation to societies and human needs entails an awareness of how preceding technology knowledge is embedded in new technology knowledge and of mechanical technologies as a foundation for advanced digital

technology. As previously mentioned, children's experiences involving tangible technology artefacts in hands-on explorative activities are recognised as significant for developing an emerging understanding of technology principles (e.g. Åkerblom & Thorshag, 2021; Bartholomew et al., 2019; Johansson, 2021; Yliveronen et al., 2018). How technology and technology education are defined and positioned within early childhood education will be further elaborated on in Chapter 3.

In this thesis, toddlers' and preschool teachers' interactions in technology activities are explored as a means of advancing the understanding of early childhood technology education, with a particular focus on mechanical technology. Empirical data were generated through video observations. Technology is conceptualised through DiGironimo's (2011) framework of the nature of technology, with its different dimensions informing how technology is understood in the thesis (see Chapter 3). Sociocultural perspectives, drawing on Vygotsky (1934/1987/2016) and Wertsch (1998), guide the analysis of child–teacher interactions (see Chapter 2) and the unit of analysis comprises the mediated knowledge and conceptualisations (Säljö, 2009) that emerge in the interactions between children and preschool teachers concerning technology. DiGironimo's (2011) framework is thus used to conceptualise technology as content, while the sociocultural perspective serves as the main analytical framework for exploring how technology knowledge becomes available, negotiated, and appropriated in child–teacher interactions.

From a sociocultural perspective, learning is understood as the *appropriation* (Vygotsky, 2016; Wertsch, 1998) of knowledge *mediated* through interactions with various *cultural tools* (Vygotsky, 2016; Säljö, 2009). Within this theoretical framework, participants negotiate and coordinate their perspectives, striving to temporarily establish *intersubjectivity* (Linell, 2014; Rommetveit, 1974). From a sociocultural perspective, concept formation is understood as a dialectic movement between *everyday concepts* and *scientific concepts* in interactions (Vygotsky, 2016). Moreover, a sociocultural notion of *agency* highlights toddlers' engagement in meaningful and purposeful activities during which they communicate, share, and reshape knowledge (Wertsch et al., 1993). Thus, by analysing empirical data through the lens of sociocultural theory and focusing on interactions, concept formation, and agency, I explore how toddlers and teachers engage in technology activities

in preschool to contribute both theoretical and empirical knowledge to the field of early childhood technology education.

The young age of the children, which was not deliberate, informed my use of the term *toddlers* in relation to the empirical study conducted in this thesis. Eleven of the 12 participating children were aged between 2 years and 5 months and 3 years and 10 months, while the twelfth child was 5 years and 8 months old. The term *toddler* generally refers to a child between 1 and 3 years of age (www.merriam-webster.com) and is therefore applicable to 11 of the 12 children participating in the empirical study. In the analytical processes, empirical sequences were identified and systematically selected to illustrate the results of each study, and all of these sequences involve children between 2 and 3 years old. Hence, I decided to focus on toddlers in technology activities and to use the term toddlers in this thesis. However, when I refer to previous research that almost exclusively involved children older than 3 years, I use the term *children*. I also use the term *young children* when referring to general notions related to the youngest children in early childhood technology education, that is, children between 1 and 5 years old.

Research Aim and Research Questions

The overarching aim of this doctoral thesis is to contribute knowledge to the field of early childhood mechanical technology education. This aim is pursued through a systematic review and synthesis of existing research alongside empirical explorations of hands-on mechanical technology activities in early childhood settings. Across the four papers, the thesis is guided by the following research questions:

RQ1: How is technology education in early childhood education conceptualised in recent research and enacted in hands-on preschool activities when analysed through a framework of the nature of technology?

RQ2: How is technology mediated when intersubjectivity is established, and how are everyday and scientific conceptualisations related to technology negotiated and interrelated in teacher–child interactions in preschool technology activities?

RQ3: How do teacher–child interactions and toddlers' agency shape the enactment and development of technology knowledge in preschool technology activities?

While there are several common aspects of interest between the separate studies in this thesis and they each answer various aspects of all the research questions, research question 1 is primarily answered by Studies I and II. Research question 2 is answered primarily by Studies II and III and research question 3 is answered by Studies II, III and IV.

Disposition of the Thesis

The thesis consists of two parts. The first part is a comprehensive summary (kappa) in which the background of the study, its theoretical and methodological foundations and the overall results are presented and discussed. The second part consists of the four studies encompassed by this thesis: one systematic literature review and three empirical studies.

Following this introduction (Chapter 1), in Chapter 2, I discuss the theoretical perspectives and key concepts relevant to this thesis. Chapter 3 outlines how technology and early childhood technology education are conceptualised within this thesis and presents relevant previous research. In Chapter 4, the methodological aspects regarding empirical context, research design, ecological validity and ethical considerations are accounted for, which is followed by the results and summaries of the four studies in Chapter 5. In Chapter 6, the results are discussed and in final Chapter 7, a Swedish summary is presented.

The following studies are included and are referred to in the kappa as Studies I, II, III, and IV:

Study I

Eliasson, S., Peterson, L., & Lantz-Andersson, A. (2023). A systematic literature review of empirical research on technology education in early childhood education. *International Journal of Technology and Design Education*, 33(3), 793–818.

<https://doi.org/10.1007/s10798-022-09764-z>

Study II

Eliasson, S., Peterson, L., & Lantz-Andersson, A. (2024). You Don't Have to Re-invent the Wheel to Implement Technology Activities in Early Childhood Education. *Early Childhood Education Journal*, 52(2), 387–399.

<https://doi.org/10.1007/s10643-022-01441-z>

Study III

Eliasson, S., Peterson, L., & Lantz-Andersson, A. (2026). The Interrelation Between Everyday and Scientific Conceptualization in Preschool Technology Activities. *Journal of Research in Childhood Education*, 40(2), 209–223.

<https://doi.org/10.1080/02568543.2024.2425374>

Study IV

Eliasson, S. (under review). Exploring toddlers' agency in preschool technology activities.

Chapter 2 Theoretical Perspectives

This chapter outlines the theoretical perspectives and key analytical concepts relevant to this thesis. Guided by sociocultural perspectives on learning grounded in the work of Lev Vygotsky (1934/1987/2016) and further developed by scholars, among others, James Wertsch (1998), Roger Säljö (2009), Per Linell (2014), and Ragnar Rommetveit (1974, 1985), this thesis adopts a dialogic approach. Thus, toddlers' learning and development are here understood as the gradual appropriation of new knowledge mediated by cultural tools, along with their increasing ability to use these tools in meaningful social contexts. Learning is understood as a joint interplay in which the collective knowledge of humankind is mediated by cultural tools and developed both individually and collectively (Vygotsky, 2016). From these theoretical foundations, the unit of analysis of the thesis, of Studies II, III, and IV in particular, is the mediated knowledge and understandings related to mechanical technology that emerge in the interactions between toddlers and preschool teachers in technology activities.

In the following sections, I present the key concepts guiding the analyses of empirical data generated for this thesis: situated learning, cultural tools, appropriation, intersubjectivity, alterity, everyday and scientific conceptualisations, and exercised agency. These concepts have been crucial in analytically supporting the understanding of how technology knowledge is mediated and made available for toddlers to develop knowledge about teacher–child interactions in preschool technology activities. This is followed by a clarification of how teaching is conceptualised in the thesis.

Situated Learning

Sociocultural perspectives entail an understanding of human knowledge and learning as situated within their specific social, cultural, and historical contexts (Vygotsky, 2016; Säljö, 2009). From this perspective, toddlers' and preschool teachers' interactions and how they establish, negotiate and re-establish their understandings of technology are explored within a Swedish

preschool context. Consequently, toddlers' and preschool teachers' ways of thinking about the world and their opportunities to appropriate technology knowledge are contingent on their participation in various social interactions within their preschool contexts and on how they engage with and make use of the cultural tools available within these contexts. This implies that toddlers' learning about, for example wheels, encompasses handling specific tangible objects in their specific immediate preschool context. The situatedness of the context also encompasses abstract conceptualisations of wheels through verbal interactions, gestures and gazes that are communicated or enacted in the specific group of toddlers' and preschool teachers' interactions that are engaged in the activity that day. The preschool teachers' intended goals with the activity as related to the Swedish preschool curriculum (Swedish National Agency for Education, 2025) are also considered relevant to the specific context. Technology artefacts and concepts entail a historical dimension in terms of cultural tools encompassing aggregated human knowledge related to conceptual and tangible aspects regarding their designs, properties, and functions. Thus, the individual's knowledge and humankind's aggregated knowledge entailed within cultural tools are understood as historically situated. In Studies II, III, and IV, the interactions between toddlers and preschool teachers are explored by studying how physical and conceptual cultural tools are employed in technology activities within the specific context of a Swedish preschool in relation to establishing intersubjectivity related to technology (Study II), how technology is conceptualised in everyday and/or scientific ways (Study III), and in relation to toddlers' exercised agency (Study IV).

Cultural Tools for Mediating Knowledge

In this thesis, the cultural tools adopted by toddlers and preschool teachers in technology activities are understood to include both physical and tangible tools (artefacts), such as books, wheels, and hammers, and conceptual and intellectual tools, such as verbal concepts, non-verbal symbols and gestures. As mentioned, the children participating in the technology activities explored in this thesis are very young, which implies that their interactions and how they establish intersubjectivity must be understood specifically in relation to their age. This includes a stronger focus on non-verbal interactions as cultural tools for sharing and negotiating knowledge related to technology.

Consequently, particular attention is directed towards gestures, sounds, and the handling of artefacts to scrutinise if – and if so, how – their interactions entail knowledge related to technology. In this way, toddlers’ and preschool teachers’ understandings of technology can be understood to emerge in their interactions, which therefore can be analysed in relation to various aspects and dimensions of technology knowledge.

Cultural tools mediate knowledge about the world and embody knowledge within their very designs (Vygotsky, 2016). For example, a wheel is round, and its shape entails historical aspects of human knowledge of its technological principles as well as human, technological and societal development from using logs to move heavy objects to a modern wheel attached to hubs and wheel axles. Hence, human knowledge is conceptually contained within cultural tools in the shape of both tangible cultural tools (artefacts) and conceptual cultural tools that, in turn, represent the ever-growing collective knowledge of humankind. In relation to the empirical studies in this thesis, a sociocultural conceptual understanding of learning as appropriation offers a relevant analytical framework for exploring how cultural tools, such as the technology artefacts, principles, and concepts introduced in the technology activities, are used, negotiated, appropriated, and conceptualised in the interactions between toddlers and preschool teachers.

Viewing knowledge as discursive, language is regarded as humankind’s most significant conceptual cultural tool; by means of thought and non-verbal and verbal communication, we interpret and structure our experiences conceptually (Säljö, 2009; Vygotsky, 2016). Concept formation is understood as more than learning new words; rather, it refers to the expanding capacity to conceptually structure one’s actions and intellectual understanding of the world. Conceptual cultural tools are critical for how humans collectively structure and organise knowledge. Throughout the history of humankind, cultural tools have and will continue to develop and change over time, depending on and influencing how societies develop and change. Understanding this reciprocal development is also essential for grasping technology as a concept, including how mechanical technologies have laid the groundwork for today’s advanced digital society.

Appropriation of Knowledge

In this thesis, Studies II, III, and IV focus on toddlers' and preschool teachers' use of cultural tools related to technology by exploring their interactions within the context of preschool technology activities. A sociocultural perspective (Vygotsky, 2016; Säljö, 2009) frames toddlers' learning as *appropriating* knowledge mediated in social interactions (Wertsch, 1998). The three empirical studies included in this thesis explore how knowledge related to technology emerges in interactions between toddlers and preschool teachers. Through externalising and sharing their individual knowledge, toddlers and preschool teachers make it explicit, collective, and available for joint negotiations in meaningful interactions (Vygotsky, 2016; Säljö, 2009; Wertsch, 1998). This implies that by engaging in interactions, employing both tangible and conceptual cultural tools and sharing and negotiating their understandings with others' slightly different understandings of the same phenomenon, they gradually appropriate new knowledge in a contextually relevant way. In relation to toddlers, externalising one's understanding and knowledge encompasses a strong notion of non-verbal interactions, since their verbal communication skills are still developing.

Intersubjectivity and Alterity

The concept of *intersubjectivity* (Linell, 2014; Rommetveit, 1974) is employed in the thesis as an analytical lens to explore which dimensions of technology knowledge emerge in the toddlers' and preschool teachers' interactions once a shared understanding has been established. Intersubjectivity is understood as the coordination and negotiation of toddlers' and teachers' perspectives by means of cultural tools, producing a temporary joint comprehension of the phenomenon sufficient for the activity to proceed (Linell, 2014; Pramling & Säljö, 2015; Rommetveit, 1974). The analysis therefore focused on interactional sequences in which intersubjectivity was negotiated and established related to technology. Because the participating children are very young, the notion of interactions includes non-verbal interactions, such as gestures, gazes, and the handling of objects, alongside spoken language (Linell, 2014; Vygotsky, 2016).

Intersubjectivity is supported by negotiable responsive interactions that involve alterity—that is, new directions in interactions (Linell, 2014). Such new directions encompass differences in toddlers' and preschool teachers' perspectives and understandings of technology knowledge and generate further negotiations of these various understandings so that intersubjectivity can be re-established. In this way, alterity is understood as the potential for establishing intersubjectivity (Linell, 2014). Intersubjectivity is analytically understood as being *partially determined* (Rommetveit, 1985); that is, toddlers' and preschool teachers' understandings of a phenomenon are temporarily established and continually negotiated and re-established in interactions. In addition, a prerequisite for sustaining meaningful interaction is *presumed intersubjectivity* (Rommetveit, 1985). This implies that toddlers and teachers, to some extent, must take their joint understanding sufficiently for granted for their interactions to continue.

By studying the interactions between teachers and toddlers in technology activities within an educational context, the concept of intersubjectivity enables analyses of toddlers' and preschool teachers' initiatives to negotiate and coordinate each other's technology knowledge in interactions. The analytical focus is on how they respond to each other's actions and how they share and negotiate each other's perspectives on aspects related to technology knowledge, artefacts, and principles (see Chapter 5). In this interplay, the joint endeavour of appropriating technology knowledge emerges, as do toddlers' and preschool teachers' various ways of conceptualising technology, which, in this thesis, are then analysed through the lens of DiGironimo's (2011) five dimensions of the nature of technology, as well as in relation to how technology is conceptualised in everyday and scientific ways.

Everyday and Scientific Conceptualisations

Concept formation can be understood as occurring in two dialectically interrelated ways of making sense of the world through everyday and scientific concepts. While Vygotsky (2016) used the terms *everyday and scientific concepts*, this thesis also adopts the active expression of *conceptualising technology in everyday and scientific ways* to emphasise that individuals actively engage in this interplay. However, when referring specifically to Vygotsky's views on the process, his original terminology is retained.

According to Vygotsky (2016), appropriating everyday concepts requires that toddlers conceptualise the immediate surrounding world by engaging directly with tangible cultural tools and conceptual cultural tools, such as verbal interaction. This involves developing an intuitive understanding of how to do things, such as rolling a wheel, without understanding its underlying technology principles. It concerns *know-how* and problem-solving knowledge rather than understanding the scientific knowledge behind these actions.

Scientific concepts, on the other hand, typically develop in the context of more formal schooling and function as structural formations of everyday concepts. While everyday concepts are embedded in their immediate contexts in direct relation to one's experiences with tangible objects, scientific concepts are abstract, disembedded, and generalised and can be applied in new situations without losing their meaning. These respective characterisations also indicate their respective weaknesses: children's incapacity to abstract everyday concepts may result in incorrect ways of using them, while scientific concepts can appear abstract and weakly connected to practical experience (Vygotsky, 2016).

When analysing empirical data, these theoretical concepts enabled me to examine aspects related to toddlers' and preschool teachers' everyday and scientific conceptualisations in interactions. Everyday conceptualisations entail technology concepts in relation to actual objects or handling objects in the immediate context, deictic references (such as *here*, *this*, and *over there*), deictic gestures like pointing at objects, using alternative familiar everyday terms, like *stick* for *spokes* and sequences in which toddlers' and preschool teachers' focus is on tangible objects and their functions (Fleer, 2009; Vygotsky, 2016). In contrast, aspects that relate to scientific conceptualisations entail the notion of disembedded concepts that are critical for understanding the underlying technology principles. For example, to understand the abstract concept of wheels, you need to understand and use concepts describing their function and properties, such as round, circle-shaped, roll, rotate, spin and so on (DiGironimo, 2011). Thus, analysing empirical data also includes examining interactions related to abstract and generalised terms that fit a range of non-subject-specific phenomena, abstract and collective terms (for example, using the term *wheel* for different kinds of circular objects) and sequences when the toddlers' and preschool teachers' focus is on technology principles (Fleer, 2009; Vygotsky, 2016).

Everyday concepts are critical to the present context of this thesis, not least because they create the potential for the development of scientific concepts (Vygotsky, 2016). Everyday and scientific conceptualisations are not clearly confined; instead, they are strongly related; they merge and depend on each other in ongoing learning activities. Everyday conceptualisations can be visualised as an upward movement enabling scientific concepts to move downward, structuring everyday concepts. An example of such interactions from Study II describes how the preschool teacher in a technology activity links the everyday concept *sticks* with the scientific concept *spokes*, while at the same time pointing out the actual spokes of a bike wheel to the children.

Vygotsky (2016) introduced the concept of *the zone of proximal development* to describe the difference and relationship between what a learner can do or know without help and the knowledge they can appropriate in collaboration with more knowledgeable peers and adults. Consequently, children use everyday conceptualisations in interaction with others who already possess generalised and scientific conceptual knowledge. In this way, everyday and scientific conceptualisations are mediated, bridged and interrelated in interactions (Vygotsky, 2016). In this thesis, analytical tools for studying how everyday and scientific conceptualisations are interrelated in toddlers' and preschool teachers' interactions entail examining instances in which everyday and scientific concepts and conceptualisations are interrelated in the interaction of establishing intersubjectivity. Such instances include the following: when everyday concepts are used within a meaningful scientific context, when scientific concepts are linked to toddlers' expressed previous knowledge and/or experiences and when the everyday handling of technology objects is linked to scientific concepts. The analytical process entails asking questions regarding, for example, whether it is enough for toddlers to handle objects and hear a technology concept for the interactions to be defined as interrelating everyday and scientific conceptualisations. In relation to research question 2, how everyday and scientific conceptualisations are interrelated in interactions, sequences during which toddlers, non-verbally or verbally, conceptualise, initiate, or respond to everyday and/or scientific conceptualisations related to technology are included. In addition, sequences are included that entail technology knowledge generalised by means of non-verbal interactions, such as using

different objects for the same action of exploring the functionalities or properties of a technology object, as exemplified in Study III.

A recurring analytical challenge is the potential ambiguity of certain technology concepts that might appear as everyday concepts when linked to tangible, present objects. Simultaneously, the very same technology concept can be interpreted as scientific when employed to articulate subject-specific technology knowledge as a structural frame. This would include the scientific conceptualisation of an artefact's functions, properties and significance for humans and society, both historically, presently and in the conceivable future. These challenges were addressed by means of the thorough examinations of empirical data and iteratively analysing video data, transcripts and theoretical considerations. Exploring toddlers' understandings of technology concepts can be challenging, and I do not claim to address this issue. Instead, my research interest has been in how toddlers' interactions may convey how they conceptualise technology in everyday and scientific ways. The young age of the participating toddlers necessitates a strong focus on their non-verbal interactions, a matter that is further discussed in Chapter 4.

A Sociocultural Perspective on Agency

From different theoretical perspectives, children's agency is conceptualised in slightly different ways. In this thesis, a sociocultural perspective on agency is adopted and toddlers' agency is thus understood as their engagement in meaningful activities with a purpose whereby they participate, communicate, share and reshape knowledge mediated by cultural tools (Wertsch et al., 1993). In this way, agency is conceptually understood as being closely related to children's initiatives to engage in dialogic interactions and negotiations (Pramling et al., 2024). Toddlers' agency is here conceptually understood as *toddlers exercising agency* (cf. Pramling et al., 2024; Sairanen et al., 2024) to emphasise that toddlers are capable of deliberate and purposeful initiatives and responses, of making informed and meaningful decisions based on their past and present experiences (cf. Sairanen et al., 2022) and taking on authoritative positions rather than merely responding to external incentives (Pramling et al., 2024; Vygotsky, 2016; Wertsch et al., 1993). From a sociocultural perspective, the social dimension of agency is fundamental and extends beyond the individual exercising agency since it occurs as a

collaborative interplay and is shaped and confined by interactions with others and by the available cultural tools (Wertsch & Rupert, 1993). This implies that exercising agency is a mutual dynamic that is embedded and shaped within its social and cultural practice; it is socioculturally situated (Wertsch & Rupert, 1993).

Understanding how children exercise agency in relation to their locally situated context of early childhood educational settings (Edmonds, 2019; Wertsch & Rupert, 1993) implies the notion of children's opportunities to practice and engage in democratic processes. In addition, it includes toddlers' opportunities to voice and enact their ideas and knowledge to influence and change matters of relevance to them (cf. Borg & Pramling Samuelsson, 2022). To enable this, children need equal and creative spaces where they can independently decide if and how they wish to participate by contributing to and/or changing the activity (Borg & Pramling Samuelsson, 2022). This notion of agency also comprises children's participation in terms of challenging or resisting interactions that may generate creativity or change (Pramling et al., 2024; Sairanen et al., 2022). Whatever their participation or outcome, their interactions are understood as children exercising agency.

In this thesis and in relation to early childhood technology education, agency is understood as toddlers' initiatives that are continuously shared, negotiated, and shaped in interactions within their situated and social practices. Opportunities for toddlers to exercise agency are presumed to emerge when they initiate and contribute to interactions related to technology by means of the various cultural tools available within the technology activities. Consequently, the unit of analysis relates to toddlers' and preschool teachers' non-verbal and verbal interactions related to technology concepts and principles as well as gestures, gazes and handling of technology objects in technology activities (cf. Pramling et al., 2024; Sairanen et al., 2022). These factors warrant analytical exploration of how opportunities for toddlers to exercise agency emerge in empirical data. When considering technology concepts as the unit of analysis, the distinction between *term* and *concept* becomes critical, since words can be analytically understood as words as such (terminological level) and as their meaning (conceptual level). Reification—that is, the transformation of active interplay, such as learning and developing into static things—is common within scientific contexts and language and can change and reduce our understanding of these ongoing and dynamic interactions into objects that

are static and limited by both space and time (Pramling, 2023). As discussed earlier in this chapter, I deliberately aim to avoid reification to emphasise the participants' interactions. In the few instances where I employ reification, it is not as an ontological claim but to enhance the clarity and readability of the text.

Conceptualising Teaching for this Thesis

I am aware of the prevalent discussion in Sweden, as well as internationally, concerning the concept of teaching (often in relation to the concept of play) and its implications for early childhood education (cf. Sheridan & Williams, 2018). Although this thesis does not engage in that broader debate, a brief clarification regarding how teaching is conceptualised in the context of this thesis is provided.

In this thesis, references to teaching specifically concern responsive actions in interactions between preschool teachers and toddlers in relation to technology (Vygotsky, 2016; Pramling & Wallerstedt, 2019). Learning is understood as toddlers' active appropriation of collective knowledge in meaningful interactions, depending on the social and cultural context and the available cultural tools. Toddlers' learning is, thus, not necessarily a consequence of teaching but rather viewed as a joint endeavour. Theoretically, I use the concept of technology education to describe activities that are initiated, planned, and organised by the teacher, who employs cultural tools to organise and initiate interactions on specific subject knowledge and where the focus of the interactions is technology knowledge. They encompass artefacts, toddlers' initiatives, and teachers' responsive interactions within a Swedish preschool context. This aligns with the *educare* approach (Eidevald, 2018), which emphasises toddlers as participants and active contributors to the interactions where play, teaching, learning, development, and care are valued as equal parts of Swedish early childhood education.

Summary

The theoretical positioning of any study has implications for its methodology and limitations. A sociocultural perspective emphasises learning as the joint discursive sharing of knowledge and conceptualisations in social interactions.

This is the lens through which I have scrutinised and presented previous research. The unit of analysis, therefore, comprises the toddlers' and preschool teachers' mediated knowledge and conceptualisations (Säljö, 2009) concerning technology as it emerges in their interactions. Its situated context involves technology knowledge mediated in toddlers' and preschool teachers' non-verbal and verbal interactions by means of the available conceptual and other cultural tools in a Swedish preschool context.

Chapter 3 Background and Previous Research

In this chapter, initially, a philosophical perspective on technology and technology education is first presented to position the thesis within the field of early childhood technology education and to specify its research interest. In the second part of this chapter, I seek to map out key issues and identify gaps in the existing research literature on early childhood technology education, paying specific attention to research involving toddlers, mechanical technology, concept formation, and toddlers' agency.

Positioning Early Childhood Technology Education for this Thesis

Depending on one's theoretical perspective and research questions, there are various ways to conceptualise technology. This thesis is situated within the cultural and historical context of Western society, which shapes its knowledge production, including empirical data generation, access to previous research, and theoretical frameworks. In this section, I outline key aspects of philosophical perspectives of technology and technology education and introduce the specific frameworks applied in this thesis. Thereafter, I reflect on technology within its Swedish educational context and present the definitions of technology and technology education that underpin this thesis.

Embracing a philosophical approach to the nature of technology, this thesis recognises the holistic, interdependent, and multifaceted relationship between humankind, society and technology as critical. This relationship is central to understanding technology as something more than just objects and tools, and to understanding its significance to human society and education. In this respect, a philosophical approach to technology can be understood as closely associated with the sociocultural theoretical principles guiding this thesis. The philosophical perspectives clarify how technology is

conceptualised in this thesis, whereas the sociocultural perspectives clarify how technology knowledge is understood to become available, negotiated, and appropriated in interactions. This implies that technology is more than just artefacts and that technology artefacts mediate the interrelated human, cultural, societal, and technological knowledge, creativity, innovation and development embedded within them.

Five Dimensions of the Nature of Technology

This thesis is situated within a philosophical perspective on technology that acknowledges its intertwinement with human needs and purposes and its social and cultural contexts. It adopts a conceptualisation of technology and technology education as embedded in social, cultural and historical contexts, as outlined in the framework on the nature of technology by Nicole DiGironimo (2011), underpinned by a philosophical perspective on the nature of technology. In addition, the framework incorporates educational and historical perspectives on the nature of technology and was specifically developed to analyse empirical data in educational contexts, making it particularly relevant for this research and its sociocultural foundation. In this thesis, technology knowledge is hence understood as 'human activity in the enterprise of technology', as conceptualised by DiGironimo (2011, p. 1341).

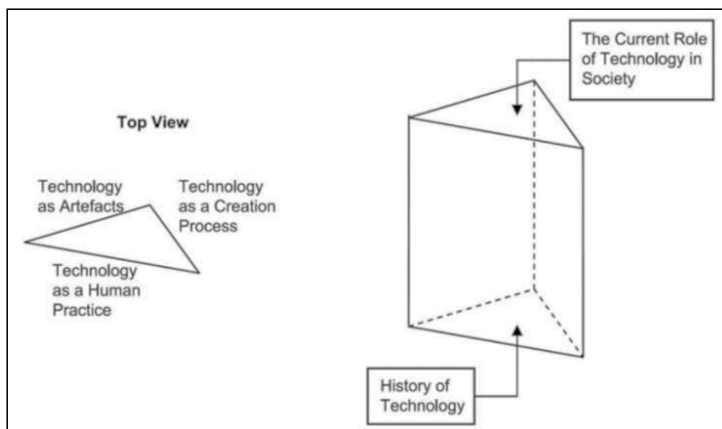


Figure 1. Dimensions of the nature of technology.

Source: DiGironimo, 2011, p. 1341. The figure is used with permission by Nicole DiGironimo, personal communication 04-10-21.

The framework consists of the five dimensions of the nature of technology illustrated in the shape of a triangular-based prism, where the three sides of the prism represent technology as (i) artefacts; (ii) creation processes and the prerequisites to engage in these processes, including tangible technology objects and specific subject-specific knowledge; and (iii) human practices comprising societal, cultural, environmental, ethical and gender aspects. These three merging and interdependent dimensions entail what DiGironimo defines as ‘the shape and structure of technology’ (DiGironimo, 2011, p. 1341). The dimension of *technology as artefacts* entails technology objects and processes as end products of technology innovation. *Technology as creation processes* encompasses the action of engaging in activities such as designing, innovation and engineering, and the intellectual tools needed to engage in these processes, that is, physical technology tools and/or subject specific knowledge. *Technology as human practices* embraces technology as a human and social endeavour influenced by ‘political, cultural, societal, ethical, environmental, economic, and personal values and beliefs’ (DiGironimo, 2011, p. 1342). The fourth and fifth dimensions encompass (iv) a *historical dimension of technology* and (v) *technology in contemporary society* and are represented by the prism’s base and top, respectively and comprise what DiGironimo called ‘the enterprise of technology’ (DiGironimo, 2011, p. 1341).

The dimensions in DiGironimo’s (2011) model are understood as interdependent and merge with one another. However, for analytical purposes, the five dimensions can be separated with the intention of facilitating the identification of the specific dimensions of the nature of technology as they emerge in the empirical data. Importantly, such separation is for methodological rather than ontological purposes, as individual interactional sequences may draw upon knowledge related to several dimensions of the nature of technology. In other words, the categorisations in DiGironimo’s framework are used in this thesis as a tool for structuring empirical data for analytical purposes rather than as a claim about the nature of reality. The standing prism incorporates a vertical time span in a continuous upwards motion and entails a historical dimension of the nature of technology as resting on its fundamental principles and developing from its past, ever evolving and slowly cumulating within its social and cultural context. This brings us to technology and its current and ever-changing role

in society and its interdependence with other disciplines and social, societal, cultural and educational developments and beliefs.

While the framework of DiGironimo (2011) can be criticised for its limited philosophical depth and instead comprising a more practical application to research, it is precisely this utilitarian aspect that I argue makes it suitable for empirical research in educational contexts. Its explicit conceptual categories provide analytical tools for identifying how technology is enacted, negotiated, and made sense of in interactions. The framework enables the tracing of how artefacts, activities, and practices are intertwined with historical and contemporary dimensions of technology as they unfold in preschool activities with an emphasis on meaning-making. DiGironimo's definition of technology artefacts as 'products of technological innovation' (DiGironimo; 2011, p. 1342) may appear imprecise; however, this ambiguity also allows the framework to accommodate multiple interpretations that reflect cultural, historical, and social variations. On the same note, the dimension of *technology as a human practice* includes various complex aspects of technology, some of which can also be connected to the dimension of *technology in contemporary society* and the *historical dimension of technology*. This implies that the respective dimensions and relevant concepts can be subject to various interpretations depending on individual, cultural and historical contexts. This has been experienced, recognised and repeatedly examined during the research process of this thesis, especially related to Studies I and II. In this thesis, the concept of *technology artefacts* is therefore understood to describe *technology objects* in terms of their human intention and social, cultural and historical contexts. While the concept of *technology objects* embraces physical objects as the tangible products of technological processes, *technology artefacts* move beyond their physical forms and are interpreted as cultural tools mediating human intentions, using technology knowledge and recognising its significance to human societies over time (DiGironimo, 2011; Mitcham, 1994; Vygotsky, 2016). This interpretation underscores the value of DiGironimo's framework for educational research, as it connects the tangible and conceptual aspects of technology with the interactions of toddlers and teachers. Thus, it provides a productive lens for exploring technological knowledge as a collaborative endeavour in preschool settings, making it especially valuable for this study's focus on interactions.

A Philosophical Approach to the Nature of Technology

Other scholars adopting philosophical perspectives on technology also guide the perspective of technology adopted in this thesis. Carl Mitcham (1994), an influential contributor to this field, identified four distinctions of technology: (i) as practical and theoretical knowledge; (ii) as volition entailing human will and intentionality as shaping technology development; (iii) as tangible objects; and (iv) as activity and engagement in technology processes. The four parts of the framework are interdependent in terms of how technology objects are the products of technology activities spurred on by human technology knowledge as well as how purposes and desires can impact changes in human knowledge, activities and innovation. Mitcham's (1994) approach highlights the human relationships and ethical dimensions of technology and understands technology knowledge as contextual and embodied conceptualisations.

The framework of Marc J. de Vries (2016, 2018), another key contributor to the field, similarly views technology in a broad philosophical sense of human activity in which knowledge, natural resources, and cultural resources are transformed by humans to meet their needs. With an emphasis on the educational and practical dimensions of technology, technology knowledge is understood as structured, purpose-driven, and connected to design and innovation. Technology objects are regarded as the outcome of purposeful human technology activity, including technical, design, and functional knowledge (Pavlova & de Vries, 2018; de Vries, 2016). Technology is conceptualised as a gradual and cumulative human endeavour embedded in and interdependent in its social and cultural context. To actively and critically appraise the ethical, societal, ecological, and economic aspects of technology, individuals need knowledge and practical experience of these various dimensions. In this sense, technology knowledge is inseparable from the educational dimension (de Vries, 2016). The social and cultural dimensions of humankind and technology suggest the significance of toddlers' participation within their locally situated contexts (Edmonds, 2019), that is, the preschool context, and equal opportunities to critically and ethically initiate and engage in creative technology processes (Pavlova & de Vries, 2018; de Vries, 2018). This implies that technology knowledge in early childhood technology education can be conceptually and physically related

to hands-on activities with a defined purpose and characterised by open-ended and problem-solving exploration and design processes.

William Brian Arthur (2009) also highlights human intention as a critical aspect for applying technology knowledge in novel and transformative combinations that can bring about changes in paradigms related to human thought and societal changes. These creative and innovative dimensions of technology, involving technology knowledge and natural and cultural resources to serve human purposes, are acknowledged as prerequisites for democratic participation in technology activities (Arthur, 2009; de Vries, 2016).

Technology and Technology Education within a Swedish Context

The Swedish preschool context explored in this thesis is underpinned by educational principles and policies grounded in an *educare* approach (Eidevald, 2018). This entails that learning, teaching, development, play, and care are considered equal parts of a holistic approach to early childhood education. Young children's participation in sustainable learning, both in the present and for the future, as well as organising for them to influence and speak their voices, are central to the Swedish preschool curriculum. Historically, technology has been referenced in Swedish state childcare policy documents since the 20th century in terms of creative arts and crafts and construction work using various materials and techniques, including Froebel's blocks, woodwork, and needle work (SOU, 1972; Pedagogiskt program för förskolan; 1987; Swedish National Agency for Education, 2025). Technology as a specific subject area has gradually gained more focus in preschool curriculum texts over the last three decades. This process is closely associated with various inquiries and investments in resources to strengthen the technology knowledge of even the youngest children in educational practices. These have been conducted by the state, often motivated by market and labour interests in the fields of technology and engineering (Swedish School Inspectorate, 2017; Swedish Ministry of Education and Research, 2008).

Philosophical views of technology can guide preschool staff when considering curricula content and didactic strategies to create meaningful learning and engagement in educational activities related to technology (de

Vries, 2016). Studies show that children's learning about various kinds of technology knowledge is promoted in Swedish preschools, mainly related to technology objects, everyday technology, construction, design, and creative processes (Boström et al., 2022; Sundqvist, 2019; Sundqvist 2022; Sundqvist et al., 2025). These areas have also been specifically addressed as a technology subject area in the Swedish Preschool Curriculum since 1998 (Swedish National Agency for Education, 1998, 2018, 2025). In 2018, goals regarding the exploration and development of adequate knowledge related to digital technology were added to the curriculum (Swedish National Agency for Education, 2018). However, in its latest edition (Swedish National Agency for Education, 2025), goals related to digital technology specifically have been removed and digital tools are now referred to, among other analogue tools, as *learning tools*. Instead, the subject area of technology in the current preschool curriculum is now addressed in terms of developing children's interest in technology and supporting their exploration of and communication about everyday technology objects and knowledge about how to use them. Preschool education is expected to provide opportunities for hands-on construction and crafting using various materials and techniques, which are also expressed as aspirational goals, as well as everyday problem-solving and developing an understanding of everyday technological development.

Before proceeding, a brief terminological clarification is required. The Swedish word *teknik* contains two related yet distinct meanings: *technology* referring to technology knowledge and *technique* referring to the various techniques used to perform a task or activity. These close but separate meanings of the Swedish term for technology in combination with the close relationship and interdependence between technology and science are believed to be contributing factors for fostering culturally confused or flawed understandings of the concept of technology and what it entails (cf. Sundqvist & Nilsson, 2018).

Specifying the Research Field

The notion of technology has and will continue to change over time in response to developments within its own field and in adjacent disciplines, as well as in broader social and cultural contexts. While technology and STEM/STEAM (Science, Technology, Engineering, /Arts/, and

Mathematics) are widely researched fields and can offer multi-dimensional approaches, de Vries (2006) acknowledges the challenge of educationally combining these fields in a way that children understand as naturally related combinations. This informs the focus on technology as a separate subject in this thesis, which is also supported by research that addresses preschool teachers' responsiveness to children's previous knowledge and experiences (Sundqvist, 2019). Another important consideration is that preschool teachers sometimes adopt the strategy of oblivious avoidance in response to children's initiatives involving technology (Öqvist & Högström, 2018), since these responses can conceal the technology principles in problem-solving preschool activities.

Even the youngest children, toddlers, are surrounded daily by technology. Their emerging technology knowledge relates to technology principles and how they can be applied in everyday life as creativity and for problem solving and initiating changes, which is crucial for their sustainable participation in and contributions to the social enterprise of technology (de Vries, 2016; DiGironimo, 2011) and its future changes and developments. Because of its interdisciplinary nature, de Vries (2016) adopted the theoretical stance that technology is best learned in holistic processes involving learning-by-doing, especially at the preschool level. However, in recent research involving young children (3–6 years), the problematic aspects of adopting a holistic approach have been highlighted by, for example, Kilbrink et al. (2014) and Sundqvist (2020), since this can obscure the intended goal related to the critical aspects of technology principles. This implies a need to balance a holistic approach with a distinct focus and emphasis on technology knowledge related to tangible artefacts in technology activities involving toddlers. In addition, a general uncertainty about technology as a subject among preschool teachers (cf. Öqvist & Högström, 2018; Sundqvist & Nilsson, 2018) suggests a need to separate technology from science and to distinguish and enhance preschool teachers' knowledge about technology to teach young children about it.

Mechanical Technology

In this thesis, the focus on toddlers' and preschool teachers' interactions involving mechanical technology provides opportunities to explore how knowledge and conceptualisations related to fundamental knowledge about essential technology principles can be mediated. As a concept, mechanical

technology is not commonly employed in early childhood education. It is more commonly used in the field of engineering, where it refers to the application of physical principles of force, energy and motion with an emphasis on problem solving, creativity and functionality. The engineering concept of *simple machines* includes, for example, engines, levers, pulleys and hydraulics. However, as previously mentioned, my decision to use the concept of *mechanical technology* rather than simple machines is intended to emphasise the significance of the principles of mechanical technology as the foundation of technological advancement.

This decision is grounded in the aspiration to address a broad understanding of technology artefacts as technological solutions that toddlers encounter daily and can explore in hands-on activities, making these activities suitable for early childhood technology education (cf. Öqvist & Högström, 2018). This also arises from the need to clearly distinguish educational hands-on activities involving technology artefacts from digital technology activities (cf. de Vries, 2016; Sundqvist et al., 2025; Undheim, 2022). Mechanical technology related to early childhood education can be understood as the tangible and conceptual knowledge of technology knowledge and the principles that support toddlers' emerging understanding of technology as a broad and interdisciplinary field embedded in the human, historical and cultural aspects of society. By illuminating this aspect of early childhood technology education, this thesis endeavours to make a substantial contribution to the field.

Previous Research

In this section, the aligned search results associated with empirical research on early childhood technology activities involving toddlers' and young children's interactions related to mechanical technology and its principles are presented. This is followed by research related to the organisational aspects of early childhood technology education. Finally, previous research studies related to the theoretical framework guiding my research that concerns children's concept formation and agency involving mechanical technology are also included.

As a field, technology education is characterised by its breadth and interdisciplinarity. This is reflected in the positioning of this thesis within various fields, such as early childhood and care, pedagogical psychology, and

technology. The field of technology education involves disciplines like, among others, science, mathematics, and social sciences and addresses, for example, various ethical, environmental and gender aspects. In addition, it embraces technology that is mechanical, digital or both. The broad field of early childhood technology education is mirrored by the wide range of research foci in previous research. Although not the central concern of this thesis, studies on, for example, digital technology (e.g. Nolan et al., 2022; Su et al., 2024), the field of STEM/STEAM in early childhood education (Su et al., 2025), preschool teachers' conceptions of technology and technology education (e.g. Sundqvist, 2022; Svensson et al. 2023) and on the gender aspects of technology and technology education (Axell & Boström, 2021; Hallström et al., 2015; Hedlin & Gunnarsson, 2014) illustrate the diversity of perspectives in the field. Addressing all these subject areas would be beyond feasible in a single thesis. Accordingly, I have made deliberate delimitations to include studies relevant to the aim and research questions of this thesis.

I conducted literature searches in various databases, including ERIC, EBSCO, Scopus and Education Database. The search terms consisted of *technology*, *technology education*, *early childhood education*, *preschool*, *mechanical technology*, *agency*, *concept formation* and *everyday and scientific concepts*. Studies that involved digital technology and children older than 6 years were not included in the most recent searches for the thesis. However, in Study I, research involving children aged 0–8 years was included, as this age range falls within the broader definition of early childhood education. See Chapters 5 and 6 for an in-depth account of the search procedures. The synthesised results of Study I revealed two overarching themes: studies focusing on preschool teachers and preservice teachers and studies focusing on early childhood technology activities with children. Within each theme, two sub-themes were identified. In Study I, how technology was conceptualised in empirical research in relation to the five dimensions of the nature of technology (DiGironimo, 2011) was also explored (see Chapter 5).

In this section, I expand the results from the literature review conducted within the frame of this thesis (Study I) by examining recently published literature regarding technology education involving younger children. Grounded in the empirical results of my study, in which the majority of the technology activities observed involved mechanical technology, studies that explored preschool technology activities involving toddlers and mechanical technology are examined in this section. The concept of *early childhood*

education encompasses children from birth to 8 years. However, the majority of studies in early childhood technology education involve children aged 5 years and older (Nolan et al., 2022). In addition, a greater number of the many research studies that have examined this field involve digital technology (cf. Su et al., 2024). The lack of studies that involve toddlers (1–3 years) and mechanical technology exposes a gap in the research field that this thesis seeks to fill by studying toddlers’ interactions in activities involving mechanical technology. This implies that the previous research outlined below includes research involving children between 1 and 6 years old and technology in early childhood educational activities.

The Role of the Teacher

At the time of conducting Study I, two strands of focus could be identified in empirical studies exploring technology activities in early childhood education: one on preschool and pre-service teachers’ understandings of technology and the other on children’s technology activities in early childhood educational settings. In Study I, the significance of preschool teachers’ subject knowledge related to technology was found to be well established (e.g. Hallström et al., 2015; Hedlin & Gunnarsson, 2014; Öqvist & Högström, 2018). Preschool teachers’ subject-specific technology knowledge and didactic competence are emphasised as prerequisites for engaging children in goal-directed technology activities based on their interests and previous technology knowledge (Sundqvist, 2019). In previous research, the importance of preschool teachers’ and preservice teachers’ professional development related to organising and framing technology activities in play-based collaborative contexts has also been acknowledged (e.g. Hultén & Björkholm, 2016; Thorshag & Holmqvist, 2019; Yliveronen et al., 2018).

In more recent studies (Sundqvist et al., 2025; Svensson et al., 2023), the variations in preschool teachers’ understanding of technology in everyday situations noted in Study I are supported. However, Sundqvist et al. (2025) call attention to the fact that neither preschool teacher training, experience in teaching, nor technology-specific training could explain these variations. The historical dimension of technology was addressed by Johansson (2021) in terms of how teachers include questions regarding how artefacts have developed and why in technology education with children aged 6 years.

Preschool teachers' conceptions and use of various dimensions of technological artefacts in technology activities were explored and compared to teachers' education related to technology (Sundqvist et al., 2025). The results do not point to a consistent inclusion of artefacts and teaching their use, names, and problem-solving functions. The role of human development regarding technology is visible, while preschool teachers seldom address the temporal development, or historical dimension, of technology and how artefacts have evolved over time.

On the same note, the interactions between preschool children (3–5 years) and teachers in construction activities were explored in an action research project by Boström et al. (2022) to study how teachers can support children in developing knowledge about technology. The results point to four qualitatively different didactic actions regarding how teachers framed and organised an activity, namely, to engage, to guide, to coordinate and to show. In another study, Boström et al. (2023) showed how children who swiftly approached the activities with confidence and proposed solutions, which the researchers described as constitutive construction-focused actions, also more easily gained access to central roles in the design process and the teachers' approval. To support children's equal opportunities to engage in and contribute to construction activities, preschool teachers need to understand their role in legitimising or not legitimising certain ideas and solutions (Boström et al., 2023).

Organisational Aspects

Regarding how to organise technology activities in preschool settings, several studies identify the significant aspects related to children's participation and collaboration, for example, organising them as well-structured teacher-led activities (Looijenga et al., 2015; Thorshag & Holmqvist, 2019) or as free explorative play (Fox-Turnbull, 2018; Hallström et al., 2015; Johansson, 2021; Looijenga et al., 2016; Milne, 2013). As highlighted in Study I, a common finding in previous studies is the significance of collaboratively framing the activity in support of children's interactions related to technology. This is supported by Åkerblom and Thorshag (2021), who argued for the significance of dialogic spaces for children's (4–6 years) learning and the development of abstract thinking related to technology.

In addition, as emphasised in Study I, children's hands-on experiences of technology in interactional processes are recognised as imperative for supporting their learning about technology (Yliveronen et al., 2018). This resonates with more recent research in which tangible artefacts and a broad variety of technology content are highlighted as significant for children's learning about technology (Sundqvist, 2022). The results present various activities that preschool children engage in and in which knowledge related to technology artefacts and creative activities is promoted by the preschool staff, ranging from handling cutlery to purposeful construction and knowledge of the properties and functions of various construction materials. The significance of hands-on experiences is also supported by, among others, Åkerblom and Thorshag (2021), who claim that hands-on exploration in dialogic spaces offers possibilities for children's (4–6 years) exploration and conceptual and abstract thinking related to technology. Preschool teachers' talk about how they identify technology principles in children's non-verbal interactions and embodied knowledge in play is acknowledged by Svensson et al. (2023). They also emphasised the significance of communicating technology concepts and technology principles and linking children's experiences to challenge their learning about technology.

Children's Concept Formation Related to Technology

This section is intended to present research concerning toddlers' concept formation related to early childhood technology education. However, the research field is extremely limited and therefore this section refers to recent studies involving children of the ages 3–6. Svensson et al. (2019) recognised the significance of preschool teachers' use of subject-specific concepts related to tangible technology artefacts and processes to support children's contextualised concept formation related to technology. In a more recent study, Svensson et al. (2023) studied Swedish preschool teachers' experiences with technology concepts related to everyday technology. Similar to Study I, the results emphasise that preschool teachers' enhanced awareness and understanding of technology significantly influence their ability to support children's learning towards a more nuanced and complex understanding of technology itself (Svensson et al., 2023).

I identified only one study that specifically explored the interrelation between everyday concepts and scientific concepts related to mechanical technology activities, albeit with slightly older children aged 4–6 years (Åkerblom & Thorshag, 2021). In their study, Åkerblom and Thorshag (2021) explored how children conceptualise technology in preschool construction play and science. The results highlight the significance of dialogic spaces as possibilities for children to explore, invent and develop concepts and abstract thinking related to technology and science. These processes were shown to be grounded in hands-on experiences with real phenomena in activities designed to be responsive to children's perspectives (Åkerblom & Thorshag, 2021).

To the best of my knowledge, no additional research has been published that specifically addresses young children's or toddlers' concept formation related to mechanical technology since I conducted Study III. In recognition of this research gap, I refer instead to recent studies that explore young children's (3–6 years old) interactions, focusing on the interrelation between everyday and scientific concepts involving science because of its close relationship with technology. With notable theoretical understanding, Fleer and colleagues (e.g. Fleer, 2009; Fragkiadaki et al., 2024; Lewis et al., 2019) have contributed to children's concept formation in science. Common aspects that typically promote children's (3–4 years) everyday conceptualisations of science are highlighted in the studies as involving play-based activities that provide materials solely for exploration (Fleer, 2009; Fleer & Ridgway, 2007) and interactions in which teachers position themselves in equal or lower positions than that of the child (Lewis et al., 2019). Fleer and Ridgway (2007) argued that a lack of science concepts in children's (4–5 years) science play activities is related to children's random and unconnected interactions with the materials and with each other. Children's complex collectives, that is, structured explorative interactions involving science knowledge, were linked to their previous experiences, but not by definition to fundamental science concepts or principles. Conversely, a critical dialectical movement between the everyday and scientific conceptualisations of science was supported by preschool teachers' intentional teaching in play activities rich in resources (Fleer, 2009; Lewis et al., 2019). On the same note, it has been argued that everyday concepts and scientific concepts are brought together in structured science activities,

emphasising the teacher's central role as an active participant and mediator in these activities (Fleer, 2009; Larsson, 2016).

Turning to research studies that explore the reciprocity of everyday and scientific concepts related to science involving toddlers, Lindahl and Samuelsson (2002) argued that by exploring the functions and properties of various objects, toddlers experience different ways of exploring scientific content in playful activities. In addition, the physically embodied science knowledge, exemplified here by spinning round and flat objects enacted in the toddlers' actions, can be transferred to other similar objects, which indicates the generalised and abstract knowledge related to science. Building on Vygotsky's (2016) notions of real and ideal forms of phenomena, Fragkiadaki et al. (2024) introduced science concepts to infants and toddlers. According to Vygotsky (2016), real forms of knowledge relate to knowledge grounded in toddlers' everyday experiences, while ideal forms relate to abstract knowledge. Real and ideal forms are thus closely related to his reasoning on everyday and scientific concepts. Toddlers' movement from using real forms towards adopting ideal forms of science concepts indicates cognitive development and a shift from current abilities to potential abilities. It is empirically argued that everyday exploration and scientific concepts can be brought together in toddlers' hands-on interactions and that teachers, by integrating ideal forms of science concepts, can support toddlers' more advanced ways of thinking about scientific phenomena and their development of scientific concepts related to science (Fragkiadaki et al., 2024).

Children's Agency in Preschool Activities

This section presents research on children's agency related to early childhood education. Although there have been recent advancements in research on agency related to young children, studies involving mechanical technology remain limited. Instead, the existing research on agency and preschool technology education relates to agency and children's use of digital tools. It encompasses, for example, digital tools and their affordances related to children's agency (cf. Petersen, 2015), how agency can be designed for children in Educational Technology activities (Brod et al., 2023) and how children's agency in STEM activities can be favourably linked to children's creativity and enquiry skills (cf. Murcia et al., 2022; Stylianidou et al., 2018).

Teachers' responses to children's expressed agency in activities using digital tools (cf. Shengjergji, 2024), as well as what Pramling et al. (2024) conceptualise as *children's exercised agency* in storytelling activities using digital tools, have been explored. Furthermore, a general scarcity regarding recognition and conceptualisations of agency in the research field of early childhood technology education has been noted in two recent literature reviews that scrutinised the research on agency in connection with digital technology and creativity, one focusing on infants and toddlers (Nolan et al., 2022) and the other involving 3- and 4-year-olds (Murcia et al., 2022).

Therefore, the following sections present a short overview of research that adopt interactional theoretical perspectives and provide valuable insights related to agency and toddlers and slightly older children (3–6 years) involving subjects other than technology in early childhood education. These include areas such as literacy, natural sciences, and mathematics. Children's exercised agency is often conceptualised in terms of their possibilities for interaction and participation (Lagerlöf et al., 2023; Myklebust & Fagerbakke, 2024; Sairanen et al., 2022), their perspectives and voices, and their initiatives and choices (Lagerlöf et al., 2023; Magnusson and Bäckman, 2023). Children's agency are also related to children's opportunities to influence and change activities that are meaningful to them (cf. Houen et al., 2016; Lagerlöf et al., 2023; Magnusson & Bäckman, 2023; Sairanen et al., 2022). Sevón and Alasuutari (2026) highlighted children's agency in Finnish early childhood education (ECE) as relationally constructed and negotiated in social practices, linking children's agency to their participation and intentionality in interactions. This implies that children's agency and their right to participate are not fixed or absolute but are instead shaped and realised through ongoing processes of interpretation, adaptation and negotiation within educational and social practices.

Toddlers' (3-year-old) agency in non-verbal and verbal exploration of slugs in science activities when their verbal participation is limited was explored by Myklebust and Fagerbakke (2024). The results highlight preschool teachers' dialogic stances in support of toddlers' agency and concept development. This involves the teachers' supportive and sometimes passive approach, using closed questions as a strategic means to sustain toddlers' involvement and enhanced interactions related to science. Toddlers' interest and agency related to tangible objects, such as slugs, are stressed as critical for maintaining a shared focus and transforming the

interactions into opportunities for them to verbally conceptualise science knowledge (Myklebust & Fagerbakke, 2024). A recent study (Henriksson et al., 2025) explored how the agency of toddlers and children aged 2–4 years is supported in preschool open-ended play activities involving science. In their study, children’s non-verbal interactions were emphasised as triggers for collective interactions related to science if they were incorporated by teachers. For example, when one child behaved like a scared turtle retreating into its shell, another child pretended that an abacus was an engine. The results exemplify three ways in which toddlers’ and young children’s agency is supported: how their initiatives are supported to enhance both play and science content, how teachers enable children’s initiatives as opportunities to further explore science content; and teachers’ responses to and balancing acts between children’s various initiatives. The implications of the various ways of supporting children’s agency through teachers’ responsiveness and balancing children’s initiatives related to science content are acknowledged as sometimes missed opportunities for children’s learning about science. However, it is argued that science and play can be combined in joint activities sustaining a Swedish *educare* model involving care, play, learning and teaching (Henriksson et al., 2025).

The interaction between children (3–5 years old) and preschool teachers in a Swedish preschool play setting was studied by Lagerlöf and colleagues (2023). Guided by the United Nations Convention on the Rights of the Child (1989) and children’s rights to play involving their rights to *space*, *voice*, *audience*, and *influence*, their interactions were examined in terms of how narrative play allows children to express themselves. The preschool teacher’s role and responsiveness were emphasised to support the children’s initiatives to express their voices, which, in turn, changed and caused the play narrative to evolve. Consequently, in the results, the children were recognised as agents who participated, contributed to, and influenced narrative play (Lagerlöf et al., 2023). Magnusson and Bäckman (2023) studied how preschool children’s use of digital tools in art activities in a Swedish preschool context contributed to teachers’ pedagogical content knowledge in mathematics and science. The results indicate that open-ended play and creative explorations can support children’s creativity and initiatives in art activities and that this can support teachers’ understanding of how children develop knowledge related to STEM content.

Sairanen and colleagues (2022) explored initiative–response interactions between 5-year-olds and teachers during teacher-directed learning activities in Finnish ECE contexts. The activities involved an integrated learning object combined with nature, Finnish mythology, and multiliteracy in creative activities. The results underscore the relational nature of agency and demonstrate how teachers' responses that accept or adapt to children's initiations appear to support children's endeavours to influence and transform activities. Teachers' responses that rejected or ignored children's initiatives were identified as obstructing children's participation, thus diminishing their opportunities to exercise agency (Sairanen et al., 2022). Using an ethnomethodological approach, Houen and colleagues (2016) explored the interactions between children (3–5 years old) and their teachers in various learning activities in nine Australian preschool groups. The results highlight the significance of teachers' interactional strategy of using the phrase 'I wonder . . .', since it supported children's agency in terms of increasing the opportunities for how children chose to participate in activities. The study argued that a child's agency depends on the teacher's acceptance of the child's decision (Houen et al., 2016).

Adopting a sociocultural perspective, Pramling et al. (2024) studied storytelling activities where 4- and 5-year-olds used digital tools. The children's agency was explored in terms of changes in their authoring of the narrative and how they negotiated and positioned themselves as authorities in the re-telling and re-making of a narrative. In this study, children's exercised agency was conceptualised as continuous negotiations and redistributions of agency, indicating that it can also be conceptualised as children's resistance to change and instead maintaining their own perspectives in an activity (Pramling et al., 2024). One example of this is one child's resistance to creating a new version of a story and their choice to adhere to their original narrative.

Summary

This thesis adopts a philosophical approach to the nature of technology and recognises the holistic, interdependent, and multifaceted relationship between humankind, society, and technology as critical and closely associated with sociocultural theoretical principles. The thesis leans on the framework of the nature of technology proposed by Nicole DiGironimo (2011), which

is underpinned by philosophical, educational and historical perspectives. In recent research studies, the focus on older preschoolers, aged 4—6 years, is consistent, strong and clear. In this thesis, a knowledge gap is identified in the field of early childhood technology education concerning toddlers' interactions, concept formation, and agency related to mechanical technology. This substantiates the significant contributions to the field that involve several aspects related to early childhood technology education that have not been scrutinised in previous research. Therefore, the present thesis seeks to contribute to filling this gap and to further explore toddlers' contributions in preschool technology activities, specifically those related to knowledge of the nature of technology, concept formation and toddlers' exercised agency.

Chapter 4 Methodological Aspects

This thesis consists of four studies: one systematic literature review examining the research field and three empirical studies exploring toddlers' and preschool teachers' interactions in preschool technology activities by means of video observation. Various aspects of the empirical data generated are explored in the three separate studies: Studies II, III and IV.

Initially, this chapter outlines the research design of the systematic literature review (Study I), which describes the methodological choices regarding the search and selection criteria as well as the analytical framework and procedures. This is followed by an account of the research design of the empirical study (Studies II, III, and IV), describing the settings and contexts in which the studies were conducted, as well as the methodological choices related to generating and processing the data. Thereafter, it details the analytical processes applied in each empirical study. Finally, the selection criteria, methodological considerations, validity and reliability of the thesis in its entirety, as well as aspects regarding research ethics, are discussed.

Research Design of the Systematic Literature Review

The aim of the systematic literature review was to map out, synthesise and present an overview of the existing empirical research within the research field focusing on how technology is characterised in relation to the framework proposed by DiGironimo (2011), outlining the five dimensions of the nature of technology. Study I was guided by the following research questions:

- 1) What aligned outcomes of technology education in ECE can be drawn from the findings?
- 2) What conceptual dimensions of the nature of technology (DiGironimo, 2011) emerge in technology education studies in ECE?

Leaning on the strategy for systematic literature reviews suggested by Gough (2007), this review examined previous research to highlight and discuss their different aims and perspectives. It also explored the dimensions of the nature of technology that emerged in the data. Empirical data were generated through a systematic literature search within three major databases: (i) Scopus, (ii) a joint search of the Online Education Database and Education Resources Information Center (ERIC) databases (Proquest) and (iii) EBSCO Information Services. Scopus was selected for its numerous peer-reviewed and interdisciplinary studies across multiple fields. The EBSCO databases were selected for their specific focus on educational research.

The search terms used were *technology education* OR *technical education* AND *preschool* OR *kindergarten* OR *early childhood*. The inclusion criteria consisted of peer-reviewed empirical scientific studies in English. The time span was limited to studies published between 2013 and 2020, with the literature review on technology education by Jones, Bunting and de Vries (2013) as a reference point. The time span also allowed for the potential inclusion of research influenced by DiGironimo's (2011) analytical framework regarding the nature of technology. Another inclusion criterion concerned the age span dedicated to early childhood education, that is, children 0–8 years old. This age criterion, thus, differs from that of the empirical studies (Study II, III, and IV), where the age span was set to include 0–6-year-olds, reflecting the ages of children attending preschool in Sweden as well as participating in the empirical study. This was followed by manually excluding articles based on the established selection criteria. After removing duplicates, 125 articles remained.

During the initial review process, the three researchers read all the abstracts individually and screened the studies of the 125 records in relation to the inclusion criteria using the Rayyan web application. This screening resulted in 12 being included, 68 excluded and 45 conflicting (when two or three researchers disagreed on either inclusion and/or exclusion). A rereading of the 45 conflicting records followed, along with a further in-depth round of manual screening, to appraise their relevance to the review, resulting in another seven records being included. The outcome was 19 included articles and 106 excluded articles. The most pronounced exclusion reason was the irrelevance concerning topics, for example, digital technologies, mathematics, natural science, and biology (79). Other reasons for exclusion were the wrong age group (23) and that the studies were not

empirically grounded (4). To include articles that were not part of but frequently referred to in our corpus, a chain referral sampling method (Biernacki & Waldorf, 1981) was applied using the same selection criteria. Thus, another four articles were included, resulting in a final corpus of 23 articles that formed the basis for the literature review (see Table 1).

Analytical Process

In the analytical process, empirical studies were systematically reviewed by highlighting and discussing the aims, perspectives and categorisations of technology education that underpinned them (cf. Gough, 2007; Gough et al., 2012). The analysis proceeded by completing protocols to structure individual readings of the 23 studies. Bibliographical details regarding citations, year, author(s), title, journal, keywords, and geographical context were documented. In addition, aspects such as aims, theoretical frameworks, and methods were noted.

Deductive qualitative content analyses (Cohen et al., 2007) were applied to identify the emerging conceptual dimensions of the nature of technology education in the corpus in relation to DiGironimo's (2011) framework. Notably, the themes and subthemes of the studies partly overlapped, and thus, some have interests applicable to more than one theme (see, e.g. Milne & Edwards, 2013; Thorshag & Holmqvist, 2019). The dimensions represent five distinct but at the same time merging dimensions of an ever-changing human technology creation process, where technology is understood as (1) artefacts, (2) creation processes and (3) human practices, which together are conceptualised as the shape and structure of technology (the three sides of the prism; see Figure 1). These three dimensions are directly related to the enterprise of technology, consisting of the bottom of the prism as (4) the history of technology and the top of the prism as (5) the current role of technology in society.

Research Design of the Empirical Study

Underpinned by sociocultural perspectives, my research interest was directed towards the interactions between toddlers and preschool teachers in preschool technology activities. Technology education appears to be conducted infrequently in Swedish preschools (The Swedish Schools Inspectorate, 2017). Hence, following Derry et al. (2010), I made the strategic

choice to include preschools with an explicit focus on technology, based on the presumption that this would increase the likelihood of observing technology activity. A similar choice was also made regarding the geographical aspect of the participating preschools, with the criterion that they would be easily accessed within the timeframe of the PhD education.

Access to the Field

The process of gaining access to the field was initiated by contacting various preschools (see Appendix 1). Four preschool teachers from three separate preschool groups at two preschools agreed to participate in the study, and a first visit was booked to meet the teachers and the children and to explain the aim and design of the study. After obtaining access to the preschools, a process of establishing a trusting relationship between myself as a researcher and the participating preschool teachers followed. This included sharing their professional experiences of teacher training, collaborations and considering the classroom conditions related to technology education. Opportunities were created for the teachers to describe their objectives and plans for organising the technology activities, as well as for joint reflections regarding the physical aspects of the rooms, camera positioning, and the organisations of the larger group of children in relation to conducting the activity. My participation at an upcoming parents' meeting was also discussed and ultimately considered unnecessary from a nonresponse perspective by the preschool teachers since the parents were used to and positive about their children's participation in research studies. A plan of action was agreed on, and the letters for obtaining informed consent from parents were designed in collaboration with the teachers (see Appendices 2 and 3).

Participants and Settings

In this section, the participants and preschool settings are presented. Empirical data for the thesis project were generated in two Swedish preschools with a pronounced focus on technology. In this thesis, the preschools are named *Imagination Preschool* with *The Wedge Group* and *The Block Group* and *Creativity Preschool* with *The Lever Group*.²

² In Swedish texts reporting the results of this thesis, the names of the preschools and groups are as follows: Imagination Preschool - Lärby förskola, with the two groups The

The empirical setting is contextualised in Table 1, which provides an overview of the participating preschools, preschool groups, preschool teachers, and children. The table presents the participants using anonymised names and includes the children's ages, thereby situating the study across the different preschool groups.

Table 1. An overview of preschool groups and participating preschool teachers and children.

Imagination preschool		Creativity Preschool
The Wedge Group (WG)	The Block Group (BG)	The Lever Group (LG)
<u>Preschool teacher:</u> FIONA	<u>Preschool teacher:</u> FRIDA	<u>Preschool teachers:</u> FATIMA FELICIA
<u>Children:</u> Carl 3y1m, Martha 3y, Kerstin 2y6m, Philip 2y5m, David 2y10m	<u>Children:</u> Kurt 3y3m, Jon 2y6m, Sander 3y3m, Klara 2y6m	<u>Children:</u> Hector 5y8m, Ayla 3y10m, Hilda 3y2m

The selection of empirical material for the separate studies is specified in Table 2. The table presents the excerpts analysed in Studies II, III, and IV and shows which preschool teachers, children and activities were included in each study.

Table 2. An overview of the participants and activities in the separate studies.

	Study II	Study III	Study IV
Excerpt 1	WG:1 FIONA Philip Carl Martha	WG:1 FIONA Philip Carl Martha	BG:2 FRIDA Kurt Klara Jon
Excerpt 2	WG:3 FIONA David Kerstin	WG:3 FIONA David Kerstin	WG:2 FIONA Martha Kerstin David
Excerpt 3	WG:1 FIONA Philip Carl Martha	LG:4 FELICIA Hilda Ayla Hector	WG:2 FIONA Martha Kerstin David

Imagination Preschool

Imagination Preschool with six preschool groups is situated in a multicultural area in a small city. Two groups participated in the study: The Wedge Group consisted of 14 children aged 2–4 years, and The Block Group had 14 children aged 1–3 years. Imagination Preschool is a municipal preschool that started in 2011 with a pronounced focus on technology as part of the entire municipality's strategic investments in technology. All teaching staff at Imagination Preschool are offered a higher education course in science and technology. The preschool collaborates with the local technology college, and teaching staff are offered monthly theoretical and didactic in-service training. In this study, the preschool teachers Fiona and Frida³ with five and four children, respectively, participated in the activities.

In Table 3, the technology activities that were included in each video observation in the Wedge Group at Imagination Preschool are described, followed by illustrations from each activity (figures 2 – 4).

³ All participants in this thesis have been given fictitious names, which is further discussed in the section Ethical Considerations.

Table 3. An overview of technology activities in The Wedge Group.

The Wedge Group	Video observation WG:1	Video observation WG:2	Video observation WG:3
	Exploring the properties and functions of various wheels and a tape roll and going on a wheel hunt outside	Engaging in pretend play creating a vehicle out of a cardboard box and four stroller wheels	Designing and creating a model of a wheel using pen and paper and a wooden plank, nails and a hammer
	22 minutes	35 minutes	21 minutes
In total 78 minutes			

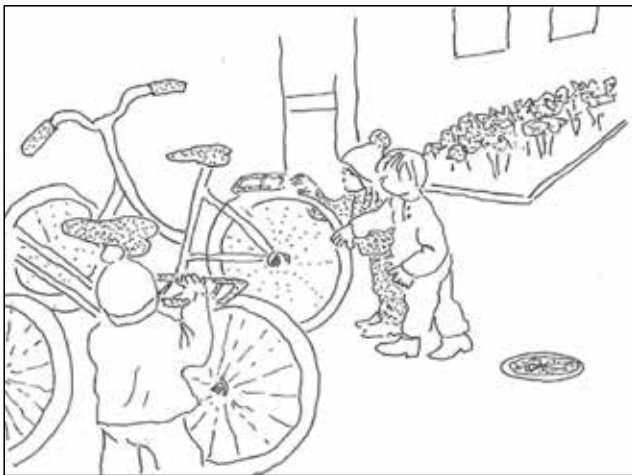


Figure 2. Interactions involving a wheel hunt outside.

Source: Frame from video observation WG:1. Illustration by Anne Marie Eliasson.

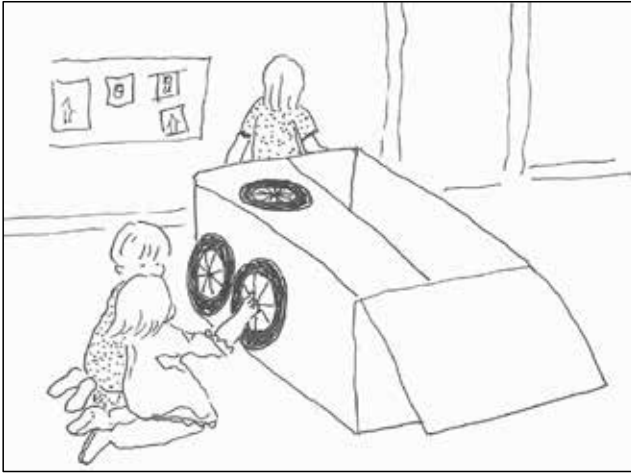


Figure 3. Interactions involving pretend play creating a vehicle.

Source: Frame from video observation WG:2. Illustration by Anne Marie Eliasson.



Figure 4. Interactions involving designing and creating a model of a wheel.

Source: Frame from video observation WG:3. Illustration by Anne Marie Eliasson.

In Table 4, the technology activities that were included in each video observation in the Block Group at Imagination Preschool are described, followed by illustrations from each activity (figures 5 – 7).

Table 4. An overview of technology activities in The Block Group.

The Block Group	Video observation BG:1	Video observation BG:2	Video observation BG:3
	Creative activity glueing various small objects and glitter to a model of a train coach made of a cardboard box	Exploring various trains and parts of a train station using photos, videos, toy trains and tracks	Creating a model of a train coach, glueing wheels to the wheel axle and randomly using various tools
	26 minutes	28 minutes	22 minutes
	In total 76 minutes		

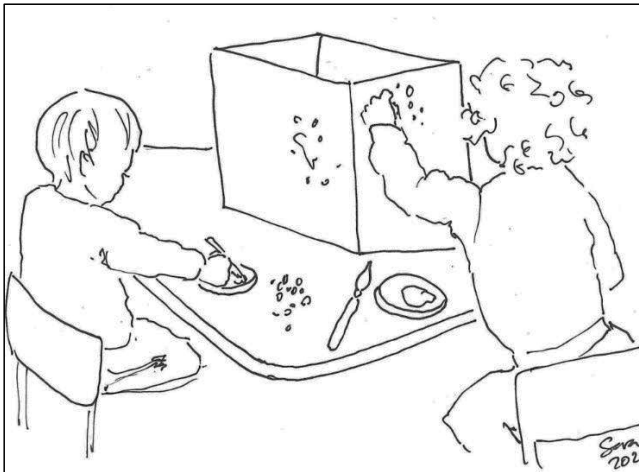


Figure 5. Interactions in creative activity involving glueing on a train model.

Source: Frame from video observation BG:1. Illustration by Sara Eliasson.

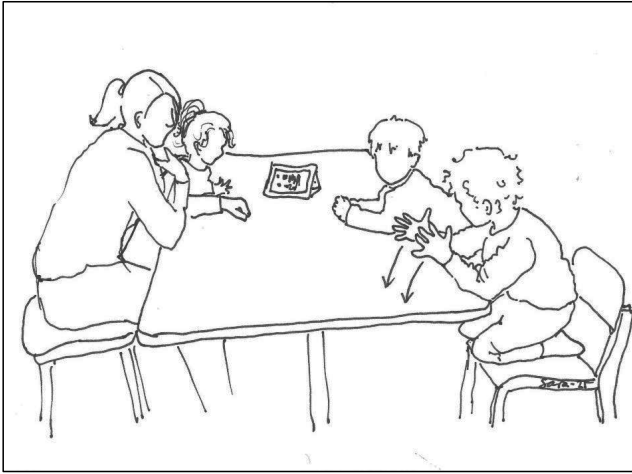


Figure 6. Interactions involving exploring trains and parts of a train station.

Source: Frame from video observation BG:2. Illustration by Sara Eliasson.

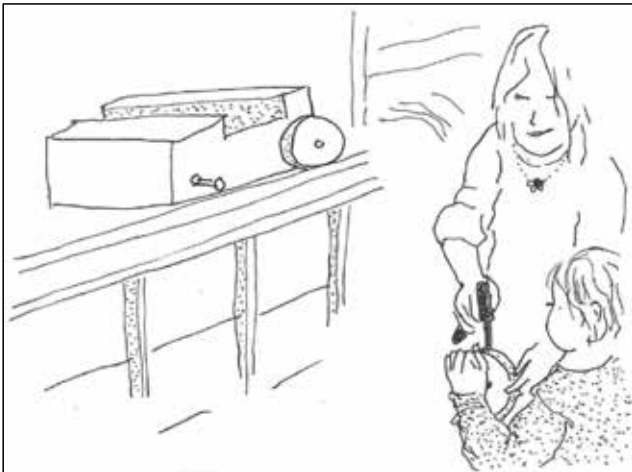


Figure 7. Interactions involving creating a model of a train coach.

Source: Frame from video observation BG:3. Illustration by Anne Marie Eliasson.

Creativity Preschool

At Creativity Preschool, situated in a multicultural area in a large city, there were four groups in total. The Lever Group, with 20 children aged 2–6 years, participated in the study. This municipal preschool has had a technology focus right from its start in 2018, and everyday technology, digitalisation and programming inform their practice. All the teaching staff at Creativity Preschool are offered in-service didactic training in collaboration with local technology companies. Participating in the study were preschool teachers Felicia and Fatima and three children. The two preschool teachers each planned and conducted two technology activities for this study.

In Table 5, the technology activities that were included in each of the four video observations at Creativity Preschool are described, followed by illustrations from each activity (figures 8 – 11).

Table 5. An overview of technology activities in The Lever Group.

The Lever Group	Video observation LG:1	Video observation LG:2	Video observation LG:3	Video observation LG:4
	Teacher and toddlers programming each other. Recreating a sequence of real objects	Sorting shapes and markers in pre-programmed patterns using the Ozmo application on a digital tablet	Coding routes for mini robots to move by using pen and paper and a digital tablet	A literacy activity recreating a story about mechanical inventions using small wooden characters
	14 minutes	35 minutes	19 minutes	15 minutes
				In total 83 minutes



Figure 8. Interactions involving recreating a sequence of real objects.

Source: Frame from video observation LG:1. Illustration by Anne Marie Eliasson.



Figure 9. Interactions involving sorting on a digital tablet.

Source: Frame from video observation LG:2. Illustration by Anne Marie Eliasson.



Figure 10. Interactions involving coding routes for mini robots.

Source: Frame from video observation LG:3. Illustration by Anne Marie Eliasson.



Figure 11. Interactions involving recreating a story about mechanical inventions.

Source: Frame from video observation LG:4. Illustration by Anne Marie Eliasson.

In total, ten activities were recorded and the participants of the study consisted of 12 children and four preschool teachers (see Table 1). The activities were chosen, planned and conducted by the participating preschool teachers in relation to the objectives, intentions and contexts of their ongoing didactic work in the groups and in relation to what the children showed an interest in. For example, the planned focus for The Block Group was going to be about wheels, but since the children showed a pronounced interest in trains, the teachers changed the focus of their thematic work to include trains instead. In The Wedge Group, the children and preschool teacher engaged in a planned project about wheels. In The Lever Group, the preschool teachers engaged the children in various activities of separate foci, involving both mechanical and digital technologies. The teachers also decided which children participated in the activities.

Presented previously in this chapter is an overview of the participating preschools, teachers and children (Table 1), as are short descriptions of the technology activities observed along with an overview of the participants and activities presented in each of the separate studies (Tables 2–5). Note that the presentation of the video observation is not linear and that the time aspects are further explained in Appendix 5.

Data Generation

Empirical data for this thesis were generated by means of video observation in three Swedish preschool groups over five weeks. The body of the data encompasses 10 technology activities engaging 12 children aged 2–5 years and four preschool teachers. Because the primary purpose was to explore children's and preschool teachers' interactions in technology activities, video observation was chosen for generating data, since it is well suited for close and repeated studies of both non-verbal and verbal interactions, such as tone of voice and energy, as well as their local and deictic language (Derry et al., 2010; Ivarsson, 2003; Jordan & Henderson, 1995). Video observations also enable collective analyses and data sharing with peer researchers, providing the means for repeated in-depth analyses, new perspectives and enriched interpretations of analysis processes, thereby supporting the study's validity (Derry et al., 2010; Jordan & Henderson, 1995). By providing detailed transcriptions and analyses of the video observations comprising the

empirical data, this thesis contributes methodological knowledge to the emerging field of early childhood technology education.

Video observations are, however, not a neutral way of conducting research (Lindgren & Sparrman, 2003; Lindwall, 2008), since the researcher's gaze is limited to practical aspects, such as the positioning, direction, and sound range of the camera, aspects that inevitably reflect the interests, approach and choices made by the researcher (Derry et al., 2010; Jordan & Henderson, 1995; Lantz-Andersson, 2009; Lindwall, 2008). In relation to this study, one video camera with one external microphone placed on the camera to favourably record all participants' interactions was placed on a tripod in a fixed spot in the room, with its height and angle adjusted to capture as much activity going on in the confined area as possible. A stationary camera was selected, since this, unlike a handheld camera, is less visible in the room and since its focus of attention is not subordinated to the researcher's subjective choices in the moment (Jordan & Henderson, 1995). Being seated facing the activity from another angle than the camera when taking field notes opened up perspectives other than what the camera related, thus ensuring more comprehensive observations of the activity. For example, the few times the children moved out of the camera's range, my notes at times added a more complete picture of the activity.

Even though the practical aspects of the video observations were considered prior to and during data generation, the sudden decision by one of the teachers to move the activity outside (see Study II) is an example of the impossibility of taking all eventualities into account beforehand. In this instance, quick assessments of the situation had to be made and various aspects weighed, such as having greater range for the camera outside and the implications of where to direct the camera. The choices that I made in the end consisted of turning off the camera and taking it off the tripod, helping the teacher to dress the children in winter clothes and continuing filming the activity outside while trying my best to direct the camera towards where I perceived the children's interactions to be focused on technology knowledge. One example of the consequences this caused for generating empirical data involved children moving out of view of the camera to explore bikes. However, on most of these occasions, they moved out of view one child at a time, and in line with the thesis being grounded in sociocultural perspectives on learning as occurring in interactions, the actual video

observations focused on instances when the children were engaged in interactions.

Transcriptions and Translations

Transcriptions and translations of empirical data are understood as parts of the data generation and selection processes in terms of how they are subjected to the eyes of the researcher, as well as in relation to the methodological and analytical focus informed by the theoretical perspective of the thesis (Jordan & Henderson, 1995; Ochs, 1979). The video observations were transcribed in accordance with a modified version of Jefferson's (2004) model for transcribing communication, which is recognised within various fields of research, such as Interaction Analysis and Conversation Analysis. Aspects related to studies involving toddlers have informed this modification. For example, Ochs (1979) argued for the importance of including young children's non-verbal interactions when transcribing. To emphasise equality between toddlers and adults and the significance of non-verbal interactions for intersubjectivity to be established, a choice was made in relation to transcription design to place the non-verbal interactions on the left-hand side to obtain the reader's immediate attention (see Figure 2). By shaping the transcripts into two columns, non-verbal and verbal interactions are highlighted as simultaneous and direct the reader towards a vertical reading of the occurrences (Ochs, 1979).

119.	TEACHER	Moves to a cupboard and comes back holding a small basket in her left hand and a broad roll of sellotape in her right hand.	What (. . .) is this? What is this thing?
120.	Martha	Holds the bike wheel upright in front of her and lifts it up from the floor, turning to face the teacher.	
121.	Philip	Still sitting on the chair, looking at the teacher.	Wheel!
122.	Carl	Picks up the stroller wheel and places it upright on the floor, then stands up holding the wheel and looks at Martha.	

Figure 12. An example of transcription from Study III.

Source: Excerpt 1, page 6, Eliasson et al., 2026.

Sequences selected for the separate studies were subjected to both basic and, later in the analysis process, refined transcription processes. The analytical focus in this thesis was the interactions between the toddlers and preschool teachers and how they initiated interactions and responded non-verbally and verbally in relation to technology. When transcribing, the main

objective was to illuminate these interactions and joint meaning making; thus, this was reflected in the level of detail conveyed in the transcriptions.

The initial transcriptions and subsequent analyses were conducted in Swedish and then translated into English. Regarding toddlers' and preschool teachers' verbal interactions, translations were conducted in relation to the specific context of preschool activities and the informal and incomplete utterances of toddlers. The essence of the verbal interactions was the focus, occasioning some instances when a word-for-word translation was deemed unsuitable. In such cases, this would not adhere to English grammar, making the excerpts hard to follow and to interpret or would change the core content of the utterance. One example of this entails Excerpt 3 in Study II, where the translation is as follows: 'Because, look here, if we stand it upright, we can't push it'. In Swedish, the teacher says, 'För titta här om man ställer den upp så kan man inte köra', and a direct word-for-word translation into English would be 'For look here, if one puts it up, then can one not drive'. This sentence is grammatically incorrect, does not really convey the Swedish meaning of the utterance and does not represent how one would talk to toddlers in English. In the case of the motorcycle (Excerpt 3, Study IV), it was decided to keep the child's own term 'blomma' in Swedish, since it did not appear to have a significance other than being a different and personal term for 'motorcycle'. Minor grammatical errors or mispronunciations were included and adapted to the English language to convey the original interactions. One example of this is from Study IV in Excerpt 1, when Kurt says, 'A this this this this ringed this ringed the bell ring ring'.

Analytical Process

In this section, an account is given of how empirical data were processed, including transcriptions, translations, and analytical procedures. Empirical data encompass a total of 237 minutes of recorded video observations, 157 pages of transcriptions and 200 pages of initial analyses. The transcripts were subjected to interaction analysis (Jordan & Henderson, 1995), which allowed studying the sometimes seemingly inconsistent non-verbal and verbal interactions between toddlers and preschool teachers, as well as their use of tangible objects. Socio-culturally informed Interaction Analysis (SIA) (Wallerstedt et al., 2022) was also employed, which frames learning as a process and relies on video observations to avoid preconceived notions. In

line with SIA, context is understood as an analytical concept, and generalisations are drawn at a conceptual level seeking empirical generalisations, pragmatic validity related to transcriptions and ecological validity. The initial stage of the analysis consisted of a broad and explorative reading of the transcribed empirical data. This was followed by iterative analyses, alternating between video observations, transcripts, and theoretical concepts.

Empirical data were analysed and organised by categories, such as participants, activities, non-verbal and verbal interactions, how activities were framed by toddlers and teachers and organised by teachers, metacommunication and artefacts included in the activities and time-stamped descriptions of the participants' foci in the activity. In interactional studies, all human interaction is meaningful, but a selection and reduction of empirical data must be conducted to enable analytical scrutiny (Derry et al., 2010; Pramling, 2023). In addition, empirical data were scrutinised with a focus on various aspects of interactions in relation to the theoretical perspectives and aims guiding the separate studies. Such aspects included identifying units of interaction in which intersubjectivity between the toddlers and the preschool teachers appeared to be or not to be established, the dimensions of technology that emerged in the interactions, the physical and conceptual tools used to conceptualise technology knowledge, everyday and scientific concepts, toddlers' initiatives, and their opportunities to exercise agency. Parts of this analytical process were conducted in collaboration with supervisors and research colleagues. Various patterns emerged in the empirical data, such as how the activities were organised, available technology artefacts, and emerging dimensions of the nature of technology. These patterns were used as references for further thematic analyses (Derry et al., 2010; Jordan & Henderson, 1995; Wallerstedt et al., 2022). Early on in these analytical and selection processes, it was noted that intersubjectivity was rarely shown to be established in the activities that included digital technology knowledge and that the children's and teachers' focus was mostly directed towards subjects other than technology, such as mathematics, turn taking and fairness. In the analytical process, selections were made continuously regarding aspects, such as the extent of detailed and exhaustive transcripts in relation to making analytical points, presenting a distinct, accessible and, at the same time, comprehensive text (Ochs, 1979),

as well as pragmatic aspects, such as selecting empirical excerpts suitable for conveying the analytical points of the study.

Typically, young children's interactional patterns differ from adult interactions in terms of defined turn-taking (Ochs, 1979). Instead, they are characterised by simultaneous non-verbal and verbal interactions, shorter attention spans and a tendency to 'tune out' (Ochs, 1979, p. 46) and become absorbed in other activities. In addition, toddlers often pause in their interactions, implying that their consecutive interactions are not always direct responses to other participants but delayed responses to previous interactions. Toddlers are more likely to respond to others' interactions when they engage in non-verbal interactions and often respond by making eye contact or copying body language (Ochs, 1979). This calls for extra attentiveness and accuracy when analysing and interpreting toddlers' non-verbal interactions and for directing the focus to several consecutive steps in to make their prolonged responses comprehensible. One example of this is from Excerpt 1 in Study II, where Carl appears to be absorbed in his pretend play (turn 103) but then appears to respond to the preschool teacher's interactions by becoming silent, turning his attention towards the wheel (turn 105) and then starts moving it as if to spin it (turn 111).

The analytical premise of this thesis, thus, infers a scrutiny of toddlers' and preschool teachers' non-verbal and verbal interactions and tangible artefacts directing each other's attention towards technology knowledge. It also encompasses scrutiny of how intersubjectivity is established, negotiated and re-established in the toddlers' and preschool teachers' interactions (Study II), as well as of how they conceptualise technology knowledge in everyday and scientific ways (Study III). Finally, the analytical premise entails the significance of toddlers' exercised agency in technology activities (Study IV). The separate analytical processes of the three respective empirical studies are presented in the next section.

Analytical Procedures Study II

Interaction analyses (Derry et al., 2010; Jordan & Henderson, 1995) guided the process of studying how intersubjectivity was established and negotiated in toddlers' and preschool teachers' interactions and how their conceptualisations related to the dimensions of the nature of technology (DiGironimo, 2011) emerged in the interactions. Two criteria guided this process: (i) sequences of interaction in which intersubjectivity is analysed as

being established, negotiated and re-established (Linell, 2014; Rommetveit, 1985) between toddlers and preschool teachers and (ii) instances in which the interactions involved knowledge related to any of the dimensions of the nature of technology. The excerpts were selected to describe how intersubjectivity is either established or not established around the technology knowledge emerging in the activity and to exemplify how toddlers' and preschool teachers' initiatives bring new directions into the interaction so that intersubjectivity can be negotiated and re-established.

Analytical Procedures Study III

Socioculturally informed perspectives on concept formation as interrelated everyday and scientific ways of conceptualising (Vygotsky, 2016) were adopted in the analytical process. Three excerpts were systematically selected from the transcribed body of empirical data to illustrate how toddlers and preschool teachers conceptualise technology in everyday and scientific ways and how these conceptualisations are interrelated in their interactions. Two selection criteria guided this process: (i) sequences in which the interactions entailed conceptualising technology in everyday or scientific ways and (ii) instances in which the interactions involved everyday concepts and/or scientific concepts regarding technology.

Analytical Procedures Study IV

Leaning on socioculturally informed perspectives on toddlers' exercised agency (Pramling et al., 2024; Vygotsky, 2016; Wertsch et al., 1993; Wertsch & Rupert, 1993), this study focused on instances when toddlers exercised agency in interactions. Three excerpts from two separate activities were selected from the extensive corpus of transcribed empirical data to illustrate how toddlers exercise agency in preschool technology activities. These examples illustrate various ways in which toddlers exercised agency and thereby contributed to the technology activity, either in terms of shaping or challenging the technology focus or the technology knowledge of the activity. This, in turn, is argued to have changed the toddlers' participation and influenced the teacher's approach or the organisation of the activity.

Considerations Regarding Ecological Validity

To meet the requirements for ecological validity (Moschkowitz, 2019; Wallerstedt et al., 2022), a holistic approach was applied in terms of studying toddlers' and preschool teachers' interactions in technology activities within their everyday preschool settings and by considering the interactions within their wider social and cultural contexts (c.f. Cohen et al., 2007; Moschkovich, 2019; Wallerstedt et al., 2022). However, the strategic choices regarding the participating preschools entailed aspects with possible significance for the results as to the extent to which this study can be inferred as representative of Swedish preschools in general. One example of these aspects is the likely higher number of preschool teachers with an explicit interest in and/or subject specific training for teachers at preschools with a pronounced technology focus. In relation to this, the teachers were asked to choose, plan, and implement the activities themselves within their everyday familiar educational practices of each preschool group. In general, these practices were characterised by a general thematic preschool pedagogical approach, and preschool teachers and toddlers could be understood as owning the activities and the setting. In this way, the activities can be regarded as representational for technology activities in Swedish preschools. The possible implications for generating empirical data were continuously discussed with the teachers. This included, for example, the question of whether the teachers should plan the activities in relation to the planned visits for data generation or in relation to their pedagogical plans. In this way, ongoing reflections between the researcher and the participating preschool teachers formed an important basis for interpretive validity.

In this thesis, validity aspects were further approached by sustaining a systematic and explicit research process. The research field and research questions were appropriately designed and defined to align with the overarching aim of this thesis as a point of departure. Various choices regarding methodological aspects when generating, analysing, and interpreting empirical data were explicitly explained and grounded in theoretical argumentation, thus increasing access to the research process and enabling assessments of appropriate methodological aspects for relevant and plausible conclusions that could be transferred to other research contexts (Cohen et al., 2007). During the research process, video observations, transcripts and analyses were frequently reviewed and discussed by

established researchers both within various seminar groups at the university, various national networks on technology education and in the reviewing processes of publishing the four articles in accredited research journals. In this regard, the risk of errors concerning analytical and interpretive aspects was lessened (Cohen et al., 2007).

Aspects regarding the risks of nonresponse (Cohen et al., 2007) can be related to, for example, obtaining parental consent. By informing teachers, parents and children about the aims and implementation of the study, by meeting up with the teachers beforehand to build a trusting relationship with them and by generating empirical data within familiar surroundings for both teachers and children, the risk for nonresponse was reduced. In the three preschool groups, some of the children's parents did not hand in the signed written consent forms. However, because of the small number of participants that did not hand in written consent forms, the reasons for this were not investigated further. Another consideration was the choice to let the preschool teachers decide which children should participate, since this limited the number of participating children and could have affected the depth and richness of the data. The interactions and shared conceptualisations related to technology among the excluded children might have offered additional significant perspectives essential for a holistic understanding of early childhood technology education, thus potentially influencing the results. However, including more children at a time would have undermined the activity as a learning activity, and it would have been difficult to study the interactions, since too many would have been occurring at once. In this sense, a selection of participating children was necessary at some point in the process, and a sustainable and ecologically valid selection was made in relation to the everyday group activity organisation specific to each preschool. From an ethical perspective, it was also appropriate to delegate this decision to the preschool teachers, since they know the children well and are therefore best placed to make a context-sensitive assessment of who could participate on a given occasion without undue pressure or disadvantage to any child.

Furthermore, the participants' right to withdraw their participation at any stage in the research process included a nonresponse aspect. At one point, one of the children chose not to continue his participation in that activity. In relation to this, the familiar setting and the child's secure relationship with his teacher helped him to express his resistance to participating, and the same

reasons aided the teacher in perceiving his signals for resistance and allowed the teacher to recognise and respect that decision. Finally, the risk of technology activities being cancelled due to practical reasons, such as teachers' illnesses or resignations, was considered, but this did not occur.

Ethical Considerations

The ethical aspects adhered to the current ethical considerations of the Swedish Research Council (2017; 2024) and were in accordance with Swedish law and the UN Convention on the Rights of the Child (SFS 2018:1197). Ethical considerations were assessed continuously by reflexive means during the entire research process, both as a rule and when needed in spontaneously occurring situations. Written information about the aims and design of the study was handed out to parents, and parental approval was obtained by written consent. The participating children were verbally informed repeatedly by both their teachers and the researcher about the study and their right to participate and terminate their participation at any time.

In the process of gaining access to the field, extra thought was given to attaining the teachers' trust and making them feel comfortable. I experienced that my background as a preschool teacher was beneficial for this process and felt that the teachers were comfortable sharing their educational thoughts and insecurities with me since I 'know what teaching children can be like'. My impression is that this aspect also made it easier for the teachers to ask me to stop filming on a few occasions in response to the children's signals. The benefits of my background as a preschool teacher have been addressed here and previously in this thesis. However, this preunderstanding of the preschool context and children's interactions can also be understood as obscuring significant occurrences from the researcher's observant eye (c.f. Cohen et al., 2007). One weakness in this regard is the risk of interpreting children's and teachers' interactions as intentional since my focus as a preschool teacher is to organise interactions with the intention of teaching and to respond to the children's interactions as intentional and meaning-making responses to my initiatives. To meet this possible shortcoming, distinct research foci grounded in relevant theoretical and methodological conceptual frameworks have been central throughout the research process in an open-minded attempt to look beyond what I sense is happening and instead focus on the empirical data that was actually observed.

When conducting research involving toddlers, extra care and attention must be given to their often subtle signals of reluctance to participate (Lindgren & Sparrman, 2003). Recognising and interpreting toddlers' perspectives can prove to be an intricate process (Punch, 2002), especially since a researcher has an external motive that differs from the children's motive to participate. The preschool context and its imbalance between teachers and children is another factor affecting children's optional participation. In preschool, children are often supposed to follow teachers' instructions, and a 'correct' answer is often implicitly expected. In contrast, a Swedish preschool context entails the notion of fostering secure and confident children, and in this way, the safe and familiar surroundings of the preschool context can be understood as providing an ethically sound place for conducting research (Punch, 2002). When conducting research in a preschool context, the researcher is responsible for providing a safe space that secures children's rights (Williams et al., 2018). I am convinced that my professional experience and knowledge as a preschool teacher contributed to strengthening such ethical aspects during the generation of data, on account of my ability to recognise and interpret the children's interactions and detect any possible reluctance to participate.

To visually clarify the researcher's documentary role, I wore a signal vest when filming. This increased the children's possibilities for making their own choices in relation to participating in the data production (Larsson et al., 2019) and increasing the opportunities for the children to participate in and influence the activities. Throughout the entire research process, the children were closely supervised for any signs of unwillingness to participate (Punch, 2002; Quennerstedt et al., 2014). The teachers showed sensitivity regarding the children's engagement as well as recurring flexibility that allowed for spontaneous and new directions within the framework of the planned technology activities. One example is the occasion when one of the children showed signs of reluctance to participate in the activity. The teacher acknowledged this and asked me to stop filming, and the child was given the choice to leave the activity based on their own decision.

In this research process, the aspect of young children's perspective of time and their still-emerging ability to acknowledge the long-term consequences of their participation in research studies has been considered (Graham & Fitzgerald, 2010; Quennerstedt et al., 2014). Throughout the whole research process, the child's perspectives and the best interests of the

child here and now, as well as the child as a future adult, have been close at heart. In the initial research process, an ethical review by the Swedish Ethical Review Authority was considered, especially with respect to the vulnerability related to the young ages of the participating children. However, since the focus of this thesis has been on the interactions between the participants and not on the individuals as such, and since the methods adopted do not aim to affect or harm the participating individuals in any way, an ethical review was deemed unnecessary. This decision was based on an assessment of the study in relation to the Swedish regulations for ethical review, the nature of the empirical material and the absence of interventions intended to physically or psychologically affect the participants. Nevertheless, because the study involved very young children and video-recorded interactions, the research process was organised according to heightened ethical caution, repeated verbal information to the children and sensitivity to the children's ongoing assent. In this respect, the teachers' choices were considered ethically grounded and in the best interests of the children, since they were the ones who knew the children best. To ensure protection of the participants, the children, preschool teachers, and settings were given pseudonyms and general descriptions when reporting findings. Empirical data (including video films, transcriptions, written consent, still images from films and drawings) have been handled in accordance with the data managing plan and filed in the official research database of the University of Gothenburg. Participating teachers and parents of participating children were informed by written consent (Appendices 3 and 4) that the results of the research study would only be used in future research and teaching contexts.

Chapter 5 Results – Summary of the Studies

This chapter presents a summary of the four sub-studies, focusing on their results. Together, these four studies form the basis for the aggregated and comprehensive results of this thesis. As established earlier, the present thesis and its four separate studies explore the field of early childhood technology education. An initial literature review mapped the field, after which my research focus shifted towards understanding the various aspects of how toddlers develop knowledge about technology. Consequently, subsequent empirical studies have focused on toddlers' interactions as a prerequisite for learning about technology. Underpinned by sociocultural perspectives, the unit of analysis is the interaction between toddlers and teachers, including their use and appropriation of cultural tools related to technology (Vygotsky, 2016; Wertsch, 1998).

Initially, two studies were conducted as part of a licentiate thesis: Study I, the literature review, and Study II, the first empirical study. The literature review revealed a scarcity of research addressing the historical dimension of technology. This generated further inquiries that formed the basis for the research questions in Study II, which concerned the dimensions of the nature of technology that emerged in interactions with toddlers during technology activities in ECE. As in Study I, DiGironimo's (2011) framework of the nature of technology was applied. However, Study II served to conceptualise technology as the knowledge that emerged in toddlers' and preschool teachers' interactions. For the doctoral thesis, Studies III and IV were added to further explore the same body of data – specifically, toddlers' contributions to early childhood technology education – in greater depth. While conducting Study II, numerous occasions were noted when toddlers' initiatives contributed technology knowledge or redirected the focus towards different dimensions of the nature of technology. These observations prompted the research interests of Studies III and IV. In Study III,

interrelations between the everyday and scientific conceptualisations of technology in the interactions were explored, and in Study IV, toddlers' exercised agency and its significance for early childhood technology education were explored.

The aggregated results of the four studies identify early childhood technology education as both a broad and multi-dimensional research field and a curricular subject area in which four out of five dimensions of the nature of technology (DiGironimo, 2011) are well represented. The significance of the teacher's approach, the playful organisation of technology activities, as well as the significance of promoting toddlers' initiatives, contributions, and possibilities to exercise agency by means of non-verbal and verbal conceptual or tangible cultural tools, both in relation to the technology content and the organisation of the activity, is recognised and discussed in the thesis.

In the following section, all four studies are summarised, followed by illustrations from the technology activities included in the excerpts in each of the empirical studies.

Study I

Eliasson, S., Peterson, L., & Lantz-Andersson, A. (2023). A systematic literature review of empirical research on technology education in early childhood education. *International Journal of Technology and Design Education*, 33(3), 793–818.

<https://doi.org/10.1007/s10798-022-09764-z>

To address the research gap within the research field of early childhood technology education related to the nature of technology and what technology education in ECE can entail, the aim of Study I is to systematically synthesise and present an overview of the existing empirical research within the research field, focusing on how technology is characterised in relation to the five dimensions of the nature of technology, as presented by DiGironimo (2011). This study is guided by the following research questions:

- 1) What aligned outcomes of technology education in ECE can be drawn from the findings?

2) What conceptual dimensions of the nature of technology (DiGironimo, 2011) emerge in technology education studies in ECE?

In this study, previous research was examined to highlight and discuss the different aims, perspectives and, specifically in this review, categorisations of the nature of technology that emerged in the studies, leaning on the strategy for systematic literature review suggested by Gough (2007). Empirical data were generated through a literature search encompassing technology education in ECE within three major databases: (i) Scopus, (ii) a joint search of the Online Education Database and Education Resources Information Center (ERIC) databases (Proquest) and (iii) Education Research Complete (EBSCO). A systematic and thorough review process resulted in a final corpus of 23 articles, forming the basis for the literature review.

In the analytical process, the aims, perspectives, methods and categorisations of the technology education that underpin them were systematically reviewed and discussed (cf. Gough, 2007; Gough et al., 2012). Deductive qualitative content analyses (Cohen et al., 2007) were conducted to identify the conceptual dimensions of the nature of technology (DiGironimo, 2011) emerging in the corpus. The dimensions represent five merging dimensions of an ever-changing human technology enterprise (see Figure 1 in chapter 3), where technology is understood as (1) artefacts, (2) creation processes and (3) human practices, and conceptualised as the *shape and structure of technology*. These three dimensions are directly related to the *enterprise of technology*, consisting of the prism base as (4) the history of technology and the top of the prism as (5) the current role of technology in society (DiGironimo, 2011).

The aligned outcomes, along with the possibilities, challenges and implications for the current field of research on technology education in ECE, are discussed in relation to the shape, structure and enterprise of technology. The results show that the five dimensions of the nature of technology (DiGironimo, 2011) are represented in the objects of knowledge and/or objects of inquiry. In studies that focus on the *in situ* exploration of technology education, technology is characterised in relation to its shape and structure. By contrast, studies of preschool teachers' and pre-service preschool teachers' understanding of technology and technology education relate technology to its shape and structure to a lesser extent.

In answer to the first research question of this study – What aligned outcomes of technology education in ECE can be drawn from the results? – four broad themes were identified. Two of these themes consist of studies focusing on preschool teachers and preservice teachers, and these are divided into two sub-themes: studies that focus on preschool teachers' and preservice teachers' content-specific technology competence (4 studies) and studies that focus on preschool teachers' and preservice preschool teachers' professional development regarding didactic knowledge for technology education (5 studies). The remaining two themes address studies that focus on technology activities with children and are divided into two sub-themes: studies that examine the relationship between teaching and learning (10 studies) and studies that explore children's previous technology experiences and knowledge (4 studies).

The second research question of this study relates to what conceptual dimensions of the nature of technology (DiGironimo, 2011) emerge in technology education studies in ECE, and the results show a salient understanding of the nature of *technology as artefacts and technology systems* (16 studies) and as *creative processes* (14 studies). The most prominent dimensions in the studies are *technology as human practice* (23 studies) and the *role of technology in society* (22 studies). However, the dimension concerning the *history of technology* is addressed in only one of the previous studies.

In relation to the enterprise of technology (DiGironimo, 2011), it can be argued that the historical dimension includes an understanding of technology as an evolving phenomenon, which is essential for toddlers to develop a broad understanding of technology that encompasses all five dimensions of the nature of technology. The prism illustrating the five dimensions of technology education (DiGironimo, 2011) can therefore be used to visualise the research field as having a metaphorically weak base, given the lack of attention given to the historical dimension. To conceptualise technology as a human enterprise, the historical dimension is indispensable. Consequently, when the historical dimension is not included, the understanding of modern technology advances, as well as the understanding of technology as a fundamental part of all civilisations and humanity itself, becomes diminished.

Study II

Eliasson, S., Peterson, L., & Lantz-Andersson, A. (2024). You don't have to re-invent the wheel to implement technology activities in early childhood education. *Early Childhood Education Journal*.
<https://doi.org/10.1007/s10643-022-01441-z>

Study II is an empirical study on technology education conducted in a Swedish preschool group with a pronounced technology focus. It aims to explore how technology activities in early childhood education are enacted and what knowledge emerges about the five dimensions of the nature of technology when intersubjectivity is established in interactions between toddlers and preschool teachers. The study is guided by the following research questions:

- 1) How is technology education enacted in the interaction between a teacher and children in technology activities in preschool?
- 2) What knowledge related to the five dimensions of the nature of technology is made possible for the children to learn when intersubjectivity is established in the interaction between the participants?

The empirical data consist of three video-documented technology activities carried out in one of the participating preschool groups, involving five toddlers (aged 2–3 years) and one preschool teacher. Underpinned by sociocultural perspectives (Säljö, 2009; Vygotsky, 2016) and drawing on the five dimensions of the nature of technology derived from the framework of DiGironimo (2011), the toddlers' and preschool teachers' interactions were analysed. In line with sociocultural theoretical perspectives, the units of analysis consisted of interactions between toddlers and preschool teachers. The transcripts were submitted to interactional analysis (Derry et al., 2010; Jordan & Henderson, 1995) to examine if, and if so how, intersubjectivity (Linell, 2014; Rommetveit, 1974) – in terms of whether mutual, temporary and sufficient understandings of technology – had been established and negotiated among the participants in the technology activities. These analyses resulted in various sequences of the toddlers' and preschool teachers' non-verbal and verbal interactions, during which intersubjectivity on any of the dimensions of the nature of technology was shown to have been established, negotiated, and re-established.

The results illustrate situations in which toddlers' focus was directed towards technology knowledge in hands-on technology activities that were simultaneously goal-oriented and play-based. Technology knowledge related to four of the five dimensions of the nature of technology (DiGironimo, 2011) emerged and was illustrated with three examples.

In the first example, toddlers' and preschool teachers' interactions around actual wheels and their properties and functions were analytically related to the dimension of *technology as artefacts* and *creation processes*. The toddlers' interactions were exemplified by verbal interactions, such as 'biky' (bike) and 'sokes' (spokes) in response to the teacher's verbal interactions, which included the names of the parts and functions of the wheel, everyday concepts and questions about the wheel and non-verbal interactions like making gestures and spinning the wheel in response to the toddlers' initiatives. The toddlers' interactions were also exemplified by non-verbal interactions, such as touching the various parts of the wheel. One child, Carl, stopped his motor pretend play and turned silent, turning his head and body towards the teacher and the wheel, while pushing the spokes of the wheel as if to spin it.

The second example shows the toddlers' and preschool teachers' engagement in *creation processes* (DiGironimo, 2011) in terms of designing their own wheel model and how cultural artefacts, such as an actual wheel and wheel-shaped gestures, as well as drawing circles, mediate technology knowledge. In this activity, the children engaged in non-verbal interactions, such as making circular gestures and drawing a circular shape to create the design of a wheel. The teacher engaged in non-verbal interactions, such as making circular gestures and showing the children how to draw the design of a wheel. She verbally offered various terms related to the shape of a wheel and designing a wheel, including 'design', 'round' and 'shape of a circle'. By participating in the activity of drawing a circle as a design for the wheel and by using artefacts, verbal technological concepts, gestures and the actual drawing of a representation of the wheel, the toddlers and preschool teacher were analytically shown to engage in initial *creation processes* involving technology.

The third example illustrates how the dimensions of *technology related to human practice* and its *current role in society* (DiGironimo, 2011) emerged in non-verbal and verbal interactions as they handled artefacts and talked about the purpose of garbage bins on wheels. The toddlers engaged in non-verbal

interactions when finding and pointing out the wheels on the garbage bin and by taking the initiative to push the bin by grabbing its handle. In response, the preschool teacher verbally directed the toddlers' attention to the role and functions of the bin's wheels by telling them that wheels are good for moving heavy objects and non-verbally by inviting them to push the bin tilted on its wheels and try to push it when it is standing upright. She combined this by commenting on how the wheels help ease tasks related to garbage disposal. In this activity, toddlers are thus offered technology knowledge related to *technology as a human practice* and to *the current role of technology in society*.

In relation to the first research question concerning how technology education is enacted in the interactions between a teacher and toddlers during technology activities, the results of this study highlight the significance of toddlers' contributions and tangible artefacts. In turn, tangible artefacts offer further possibilities for toddlers to contribute non-verbal and verbal initiatives that support and enable temporarily shared, established, negotiated and re-established intersubjectivity. The results also suggest that establishing intersubjectivity on technology can be deterred by toddlers' play frame and that teachers, by ignoring or responding to toddlers' interactions, can re-direct the focus and actions towards the technology content of the activity. A combination of teacher-led activities, well-defined technology content and a sensitive and responsive teacher approach that allows and supports toddlers' initiatives related to technology to shape the activity as it unfolds is suggested as critical for advantageous early childhood technology education.

The second research question concerns the knowledge that is related to the five dimensions of the nature of technology that is made possible for toddlers to learn when intersubjectivity is established, and the results illustrate how intersubjectivity is established, negotiated and re-established around four of the five dimensions of technology (DiGironimo, 2011). However, the absence of the dimension of the history of technology is prominent. In the study, the historical aspect of mechanical technology is acknowledged as critical for toddlers to develop a broad understanding of how technology is, has been and will be intertwined with human development and societies throughout history.

To sum up, this study indicates that even very young children can communicate and contribute new directions related to the various dimensions of the nature of technology through the use of technology

artefacts in non-verbal and/or verbal interactions. Concluding reflections suggest that the weak presence of the historical dimension of technology implies that technology education lacks a knowledge base that includes the accumulated knowledge of humanity. This is a valuable finding for both the educational practice and for the field of research to continue exploring.

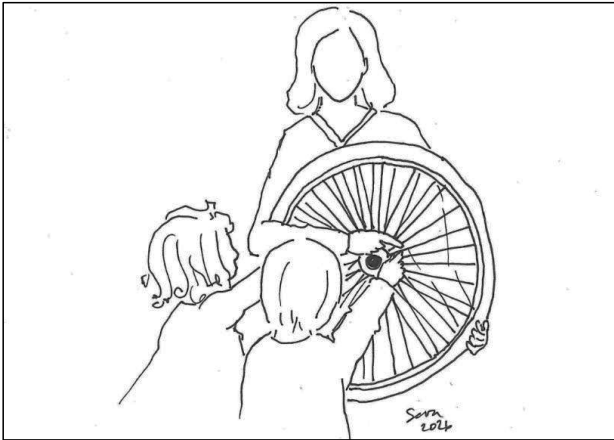


Figure 13. Illustration Excerpt 1, Study II.

Source: Frame from video observation WG:1. Illustration by Sara Eliasson.

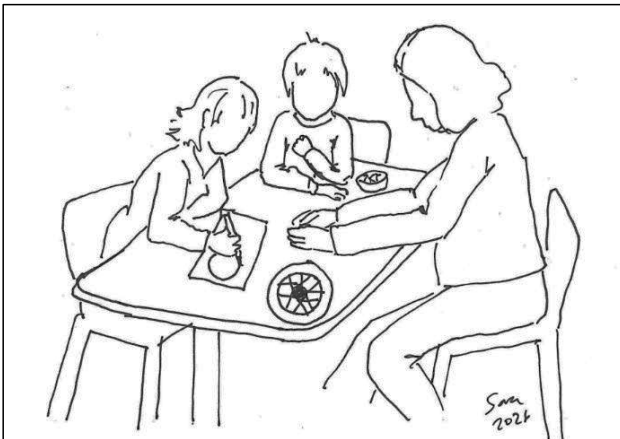


Figure 14. Illustration Excerpt 2, Study II.

Source: Frame from video observation WG:3. Illustration by Sara Eliasson.



Figure 15. Illustration Excerpt 3, Study II.

Source: Frame from video observation WG:1. Illustration by Sara Eliasson.

Study III

Eliasson, S., Peterson, L., & Lantz-Andersson, A. (2026). The Interrelation Between Everyday and Scientific Conceptualization in Preschool Technology Activities. *Journal of Research in Childhood Education*, 40(2), 209–223.

<https://doi.org/10.1080/02568543.2024.2425374>

In Study III, toddlers' and preschool teachers' interactions related to mechanical technology and, more specifically, the wheel, were explored from a sociocultural perspective on concept formation as twofold: conceptualising the world in an everyday and a scientific way (Vygotsky, 2016). Everyday concepts involve direct interactions with tangible objects and an intuitive understanding of the functions of technology. A scientific way of conceptualising involves a more abstract structuring of everyday conceptualisations. While everyday conceptualisations are context dependent, scientific conceptualisations are disembedded and generalised. The dialectical and interdependent interrelation between these ways of conceptualising is emphasised as critical for toddlers' emerging scientific conceptualisations. The study is guided by the following research question:

How are everyday and scientific conceptualisations of technology enacted and interrelated in the interactions among the participants in technology activities?

Underpinned by sociocultural perspectives (Vygotsky, 2016), the focus of this study was on toddlers' and preschool teachers' interactions. Given the young age of the children (2–3 years), these interactions include non-verbal communication, such as gestures, sounds and facial expressions, as well as verbal interactions. Empirical data were therefore generated by video observations and were analysed in an iterative process using SIA (Wallerstedt et al., 2022). Three excerpts were systematically selected from the transcribed data to illustrate how toddlers and preschool teachers conceptualise technology in everyday and/or scientific ways and how these are interrelated. Two selection criteria guided this process: (i) sequences in which the interactions convey conceptualising of technology in everyday and scientific ways and (ii) instances in which the interactions involve everyday concepts and/or scientific concepts related to technology.

The first example illustrates how everyday and scientific conceptualisations of the wheel are interrelated in toddlers' and preschool teachers' interactions when exploring various wheels. By non-verbally conceptualising an actual tape roll, conceptualising technology in an everyday way, as a wheel by rolling it like a wheel, technology knowledge is embodied and enacted in interactions mediated by cultural tools in terms of both non-verbal and verbal language, as well as physical interactions with tangible artefacts. Verbally conceptualising the tape roll by the abstract concepts of 'wheel' interrelated with the actual rolling of the tape roll and the wheels, together with the teachers' verbal interactions about the properties of and similarities to the wheel, 'it looks like a wheel' and 'a tape roll that became a wheel', offers possibilities to conceptualise wheels in an emerging scientific way. Everyday and emerging scientific ways of conceptualising wheels were interrelated in the toddlers' and preschool teacher's interactions, supporting a generalised and expanded understanding of the wheel. The teacher's verbal interactions also supported scientific principles, such as hypothesising, experimenting and testing, when she encouraged the toddlers to roll the tape roll and wheels on the floor.

In the second example, the teacher's and toddlers' combination of non-verbal and verbal interactions in designing a model of a wheel supported

them in conceptualising the hammer as an appropriate tool for nails and as technology artefacts in an abstract and scientific way. In their interactions, actual nails, gestures, sounds, and verbal interactions related to tools for creating a model of a wheel were examples of cultural tools. Their non-verbal interactions were exemplified by one toddler's non-verbal gestures imitating a hammering movement while verbally expressing 'drill' and making the sound 'pooff!' and by the teacher's hammering movements in response to his initiative and what tool was appropriate for nailing the actual nails she had brought to the activity. The toddler responded to the teacher's interactions non-verbally by making hammering movements and verbally by answering 'hammer'. The interrelation of the everyday and emerging scientific conceptualisations of technology related to tools and creating a model of a wheel was supported by the toddlers' and teacher's non-verbal and verbal interactions.

In the third example, toddlers' interactions after a technology story retelling activity reflected a shift from distinguishing the technology objects solely as characters in a story to viewing them as technology objects with specific properties and functions. The toddlers engaged in exploratory play with the wooden characters from the story *The Wheel*, *The Inclined Plane* and *The Wedge*. In their interactions, the two toddlers were analytically shown to conceptualise the wooden artefacts in everyday ways when they referred to them as their characters and in emerging scientific ways when they examined the artefacts and recognised that the inclined plane and the wedge differed from each other in terms of their properties and functions. The toddlers were analytically shown to conceptualise the technological objects in emerging scientific ways verbally by referring to them using technological concepts. They conceptualised them non-verbally in emerging scientific ways by actually placing the wedge so that it functioned as an inclined plane and when they rolled the wheels down the wedge as if it were an inclined plane. In other words, everyday and emerging scientific conceptualisations of the technology objects were interrelated in the toddlers' and preschool teachers' non-verbal and verbal interactions.

The results illustrate how a dialectical movement between everyday and scientific conceptualisations emerged in the interactions. These dynamics occurred primarily in hands-on, teacher-mediated, play-framed activities that facilitated toddlers' exploration through non-verbal and verbal interactions.

Toddlers' contributions to these interactions and how both their everyday and emerging scientific conceptualisations of technology knowledge are recognised to contribute to and support the dialectical movement between these two ways of conceptualising technology. The results also highlight the significance of tangible objects to support toddlers' everyday and emerging scientific conceptualisations of technology. In addition, the teachers' role is highlighted as central to facilitating toddlers' everyday and emerging scientific conceptualisations of technology. This is conducted by means of verbal and non-verbal interactions that mediate both hands-on and implicit technology knowledge, relating everyday conceptualisations of the properties and functions of the technology artefacts to scientific conceptualisations that structure toddlers' everyday conceptualisations of technology. Here, preschool teachers' subject-specific knowledge is significant for how technology principles can be communicated through bodily enactment and verbal interactions to support toddlers' development of conceptualising technology in both everyday and emerging scientific ways. The teacher's sensitive approach and didactic knowledge are also emphasised as critical for acknowledging, interpreting, and responding to the technology knowledge mediated in toddlers' non-verbal interactions, particularly given their young age.

To summarise, the results emphasise both the initiatives and contributions of the toddlers and the role of hands-on exploration of tangible objects as significant aspects when conceptualising technology in everyday and scientific ways. In addition, the role of artefacts when conceptualising technology through non-verbal interactions is highlighted. By means of these non-verbal interactions, toddlers appear to form abstract connections between tangible objects and the scientific principles governing their use and purpose.

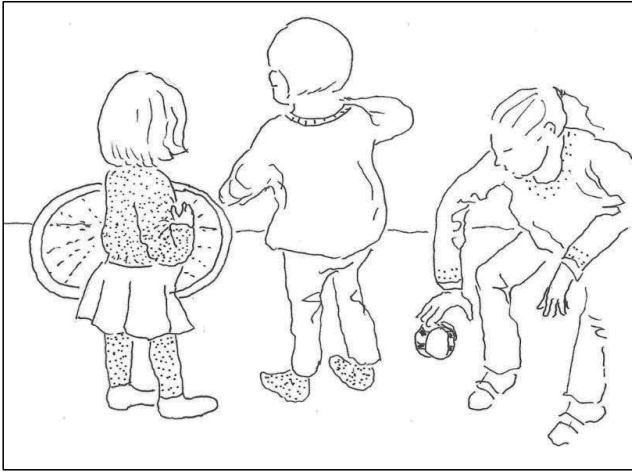


Figure 16. Illustration Excerpt 1, Study III.

Source: Frame from video observation WG:1. Illustration by Anne Marie Eliasson.

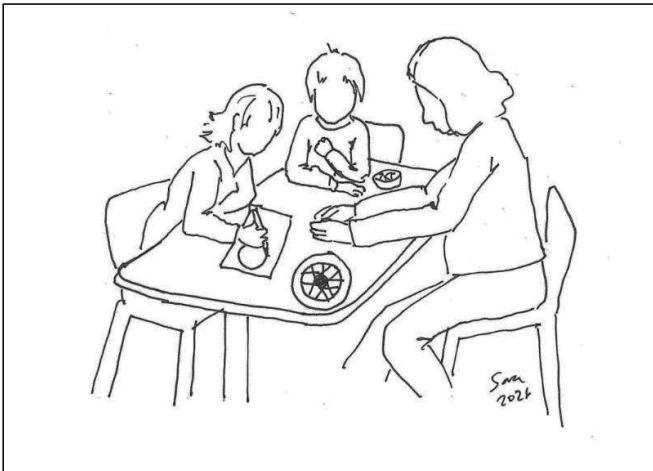


Figure 17. Illustration Excerpt 2, Study III.

Source: Frame from video observation WG:3. Illustration by Sara Eliasson.



Figure 18. Illustration Excerpt 3, Study III.

Source: Frame from video observation LG:4. Illustration by Sara Eliasson.

Study IV

Eliasson, S. (under review). Exploring toddlers' agency in preschool technology activities.

Prompted by the results of the previous studies in this thesis that point to toddlers' contributions to interactions in technology activities, and underpinned by sociocultural perspectives (Säljö, 2009; Vygotsky, 2016; Wertsch et al., 1993), empirical study IV primarily explores the role of toddlers as agents in early childhood technology activities.

The aim of this study was to contribute knowledge to both the fields of technology education and sustainable education by exploring the role of preschoolers' initiatives when interacting in hands-on technology activities. The study was guided by the following research question:

How do preschoolers exercise agency in the studied hands-on technology activities, and what significance does this have for the unfolding activity?

The study's empirical data comprised two video-documented technology activities in two Swedish preschool groups with a pronounced technology

focus. In the activities, six children aged 2–3 years and two preschool teachers participated as part of their everyday education activities. The body of empirical data was analysed by means of SIA (Wallerstedt et al., 2022) and three excerpts were systematically selected to represent the various ways in which toddlers' initiatives were found to contribute to the technology activity. For more detailed information about the methodological aspects of the study, please see Eliasson et al. (2024) and Eliasson et al. (2026). The activities were planned and organised by the teachers as part of the preschools' everyday curriculum and were conducted in smaller groups of 2–4 children of the teachers' choice. Empirical data were categorised by participants, activities, artefacts and non-verbal as well as verbal actions, and transcriptions were then scrutinised by means of SIA (Wallerstedt et al., 2022) in an iterative process that entailed numerous analyses moving between video observations, transcripts and critical theoretical concepts.

The results comprise a larger corpus of data from which three examples have been systematically selected to illustrate how toddlers exercise agency in preschool technology activities. The analysis focuses on instances in which toddlers initiate interactions. Three excerpts from two separate activities are presented to illustrate the various ways in which toddlers' initiatives contribute to technology activity in terms of toddlers' exercised agency.

In the first example, toddlers' exercised agency was illustrated by one of the toddlers, who adopted an authoritative role, sharing technology knowledge regarding the lowering gates at a train station. Kurt does this through non-verbal interactions, such as using sounds and gestures to describe the warning sound and the upward and downward movements of the lowering gates, and through verbal interactions, such as naming and describing the functions and properties of the lowering gates. His initiatives were analytically interpreted as prompted by physical cultural tools in terms of photos and conceptual cultural tools in terms of the teacher's question. In addition, the participatory approach was found to support toddlers and teachers in contributing to the interaction on equal terms.

The second example illustrates how toddlers exercise agency and how their initiatives contribute to expanding technology knowledge in their interactions during pretend play by creating a vehicle using a large cardboard box and four stroller wheels. This interaction included such aspects as the pretend-play approach, the teacher's responsiveness, tangible cultural tools like actual wheels, the box, and a book with pictures of vehicles as well as

intellectual cultural tools stemming from the toddlers' previous technology knowledge. The cultural tools were analytically shown to present opportunities for them to exercise agency through non-verbal interactions, for example, when one toddler leaves the room to get a toy toolbox and then engages in pretend play, using the various toy tools to fasten the wheels to the box combined with tool sounds. The teacher supported the interactions involving technology knowledge by naming the toolbox and incorporating the tools into the narrative of the pretend play. Here, the toddler's exercised agency contributed new technology knowledge to the activity and shifted the focus in their pretend play towards an increased focus on the technology knowledge of creating a vehicle and also on using the toy tools.

In the third example, the analysis illustrates how toddlers exercise agency by challenging the technology focus of the activity and demonstrates the significance of how technology knowledge is elaborated on in parallel strands by the teacher and the child. Toddlers' exercised agency was shown to be simultaneously confined and supported by the teacher's goal-oriented approach and by the available physical cultural tools. The available cultural tools – the four wheels and the box – appear to restrict the teacher's focus on only creating a vehicle with four wheels and the toddlers' possibilities to exercise agency. At the same time, these same cultural tools, in combination with the playful approach and freedom within the activity, appear to support toddlers' agency. This is exemplified by the toddlers' perspective, which challenged that of the teacher's perspective, and by how the play frame allowed the participants to exercise differing and parallel intentions and understandings regarding the technology focus of the activity. In this way, opportunities were supported for the toddlers to contribute technology knowledge that engaged both them and their teachers in creative processes on equal terms.

The preschool teacher's use of open-ended questions (Houen et al., 2016) was found to generate changes in the role of authority that supported the toddlers' opportunities to exercise agency through active and meaningfully informed contributions (cf. Borg & Pramling Samuelsson, 2022). Regarding the research questions addressing how preschoolers exercise agency in hands-on technology activities and what significance this has for the unfolding activity, the results suggest that toddlers' initiatives to exercise agency can contribute to and expand the technology focus and/or the technology content of the activity. Depending on the teacher's

responsiveness, the artefacts available and the interactions, this can, in turn, further expand the technology content, promote toddlers' participation, change the teacher's approach and impact the organisation of the activity. The significance of a holistic perspective and supporting toddlers' contributions to and possibilities for exercising agency in early childhood technology education are highlighted. Supporting toddlers' participation in educational activities is emphasised as a prerequisite for participation in sustainable democratic practices in the future.

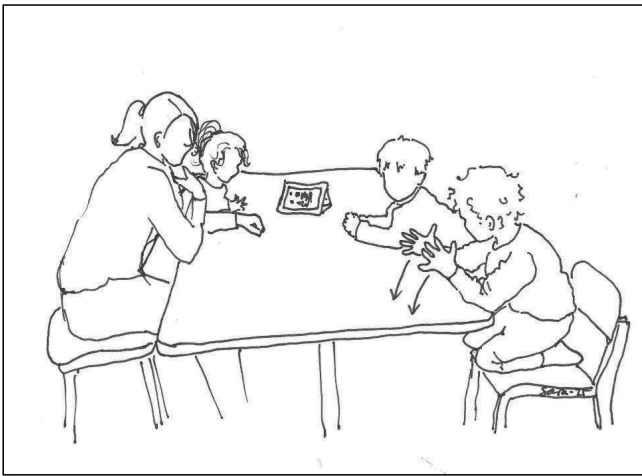


Figure 19. Illustration Excerpt 1, Study IV.

Source: Frame from video observation BG:2. Illustration by Sara Eliasson.

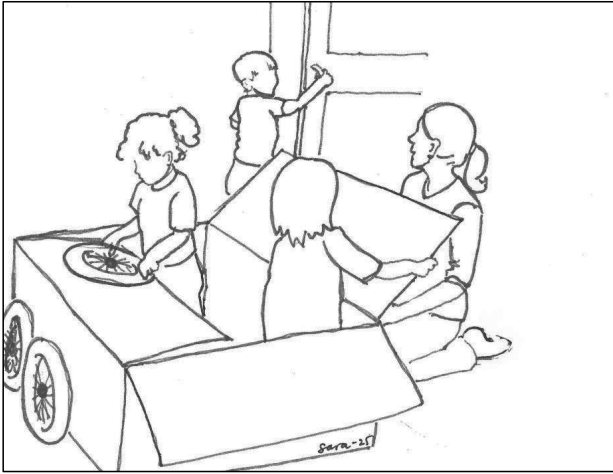


Figure 20. Illustration Excerpt 2, Study IV.

Source: Frame from video observation WG:2. Illustration by Sara Eliasson.

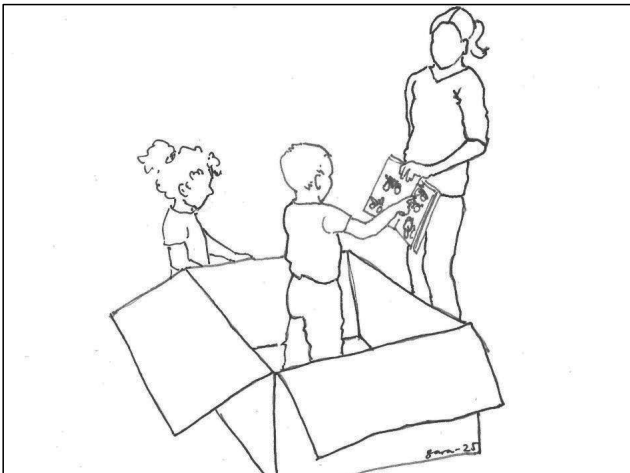


Figure 21. Illustration Excerpt 3a, Study IV.

Source: Frame from video observation WG:2. Illustration by Sara Eliasson.

Chapter 6 Discussion and Conclusion

The overarching aim of this doctoral thesis is to contribute knowledge to the field of early childhood technology education involving mechanical technology. This is pursued through a systematic literature review and synthesis of the existing research, alongside empirical explorations of toddlers' and preschool teachers' interactions in early childhood hands-on mechanical technology activities. The results are further discussed in this chapter and should be understood within the Swedish preschool context.

I start this chapter by accounting for how the integrated results of the thesis answer each research question. This is followed by more in-depth discussions of how preschool teachers' and toddlers' interactions can be analytically related to DiGironimo's five dimensions of the nature of technology and its implications. I continue by addressing the opportunities for and implications of toddlers' everyday and scientific conceptualisations of technology. Next, I address the significance of toddlers' exercised agency in technology activities. Finally, I discuss the instructional challenges and implications of implementing a holistic and equitable approach to supporting toddlers' initiatives to interact in early childhood technology activities.

Contribution to Early Childhood Mechanical Technology Education

While there are several common aspects of interest across the studies in this thesis that each answer various aspects of all the research questions, research question 1 is primarily answered by Studies I and II. Research question 2 is primarily answered by Studies II and III, and research question 3 is answered by Studies II, III, and IV. Three overarching research questions frame this extended summary:

RQ1: How is technology education in early childhood education conceptualised in recent research and enacted in hands-on preschool activities when analysed through a framework of the nature of technology?

RQ2: How is technology mediated when intersubjectivity is established, and how are everyday and scientific conceptualisations related to the technology negotiated and interrelated in teacher–child interactions in preschool technology activities?

RQ3: How do teacher–child interactions and toddlers' agency shape the enactment and development of technology knowledge in preschool technology activities?

RQ1 – Conceptualisations of Technology and Technology Education

Addressing the first research question, the results of the thesis clarify that early childhood technology education emerges in recent empirical research as a broad, multidimensional, and still-evolving subject field, both in terms of technology education as a research field and as emerging in technology activities in ECE. Technology and technology education are conceptualised in various ways, which in Study I are categorised into four separate and overlapping themes. Two of these themes focus on preschool teachers and preservice teachers and concern their subject-specific technology knowledge and understanding as well as their professional development related to technology and technology education. These themes relate to how technology activities are organised and, in this context, preschool teachers' subject knowledge and didactic abilities when orchestrating technology activities. Framing technology activities as collaborative and problem-solving was shown to be successful, as were the somewhat contradictory approaches of organising them as structured and teacher-led or as exploratory play involving children's free choice. The other two themes focus on technology activities involving children in preschool settings. In these themes, children's previous experiences and knowledge were acknowledged as significant for the content and process of technology activities and for their learning about technology.

Similarly, the data from the empirical studies in this thesis illustrate a wide span of technology knowledge, ranging from exploring wheels in hands-on activities, searching for wheels outside and studying photos of various trains

to using tools to create a model of a wheel, and retelling a story about mechanical technology. The results show how toddlers non-verbally and verbally conceptualise technology involving various technological artefacts. These conceptualisations encompass everyday and specific technological concepts, including rolling various wheels and spinning them, creating designs using pen and paper, making gestures indicating the shape of a wheel, and exploring the function of wheels on bins by engaging in pushing the bins. In this way, toddlers contribute to joint understandings of technology as artefacts, creative processes, human practices and the role of technology in current society. However, the historical dimension of technology does not emerge as prominent, either in previous research or in the empirical data of this thesis.

RQ2 – Toddlers’ Interactions and Everyday and Scientific Conceptualisations

In reference to the second research question of this thesis, the combined results of the empirical studies of this thesis draw attention to how toddlers’ initiatives and active participation contribute to how intersubjectivity is established, challenged and negotiated in technology activities. The results show that preschool teachers’ orchestration of technology activities as goal directed and at the same time play oriented activities create opportunities for meaningful interactions related to technology between teachers and toddlers. These findings align with previous research highlighting the significance of goal-directed approaches (Looijenga et al., 2015; Thorshag & Holmqvist, 2019) and play-oriented approaches (Fox-Turnbull, 2018; Hallström et al., 2015; Johansson, 2021; Looijenga et al., 2016; Milne, 2013) in preschool technology education. The toddlers’ numerous contributions to interactions related to technology observed in the activities relate to the teachers’ redirection of their joint focus of attention on the technology knowledge combined with the often open-ended explorations, the play frame and the teachers’ responsiveness. In these interactions, intersubjectivity is established, creating a temporary and sufficiently shared understanding of the shape and structure of the nature of technology in ways that are comprehensible and meaningful for toddlers. In addition, toddlers’ non-verbal and verbal initiatives are emphasised as contributions to interactions

that shape, expand, and deepen both the technology knowledge and the technology focus of the activity.

The results also illuminate how various conceptualisations of technology emerge in toddlers' and preschool teachers' interactions when handling tangible artefacts. In these dynamic activities, preschool teachers and toddlers conceptualise technology in everyday and scientific ways through verbal interactions. These include naming the technology artefacts, describing their shapes and functions and linking general and abstract technological principles between various wheels and a tape roll. Their non-verbal interactions, such as gestures, gazes and manipulation of artefacts, encompass gestures that indicate the shape of a wheel and a hammer, rolling the Wheel characters down the Wedge character as if it were an inclined plane, as well as engaging in simultaneous hands-on rolling of various wheels and a tape roll. This implies that toddlers are offered opportunities to conceptualise technology in everyday ways, as well as generalised and emerging scientific ways. It also suggests that they are active contributors to interrelating everyday and emerging scientific ways of conceptualising technology.

RQ3 – Toddlers' Exercised Agency in Technology Activities

Answering the third research question of this thesis, the integrated results of Studies II, III and IV show that the toddlers' exercised agency contributed to the technology activities in terms of how toddlers' initiatives add and expand the technology focus and the technology knowledge in the activity and in terms of how toddlers resist and negotiate the technology content. The results of the thesis emphasise these toddlers' contributions to responsive and meaningful interactions as supporting interactions in technology activities. These interactions involve tangible objects, such as a book of vehicles, tangible wheels and a toy toolbox. Conceptual technology knowledge, such as how to fasten objects to something, the concept for and gesturing the movement of the lowering gates and take the form of contributing to or challenging technology knowledge.

Overarching Aspects Across the Studies

The following sections present in-depth discussions of the results related to various aspects identified across the four separate studies. These aspects comprise the emerging patterns of technology education in toddlers' interactions related to DiGironimo's (2011) five dimensions, opportunities for and implications of interrelating everyday and scientific conceptualisations of technology and implications related to toddlers' initiatives to interactions and exercised agency.

The Nature of Technology in the Literature and in Toddlers' Interactions

The literature review was informed by the framework of DiGironimo (2011) and its five dimensions of the nature of technology, with the aim of exploring which dimensions of technology are made available for preschool children. As established previously, the results of Study I showed that while four out of five dimensions are well represented in previous research studies within the field of early childhood technology education, the historical dimension is notably scarce, emerging in only one of the scrutinised studies.

This motivated the application of DiGironimo's (2011) framework to the empirical data, resulting in Study II, which largely mirrored the results of the literature review: no instances were identified in which technology was conceptualised in explicitly historical terms. In this respect, the results resonate with earlier work using the same framework, such as Boström et al. (2022), who explored preschool teachers' didactic actions in construction tasks in collaborative preschool settings. The results showed that the teachers primarily focused on process, product, and concepts, thereby aligning with the dimension of technology as a creation process (DiGironimo, 2011). Whereas Boström et al. (2022) reported an absence of the other four dimensions in preschool teachers' didactic actions, the results of this thesis showed a broader representation of dimensions in the preschool teachers' and toddlers' interactions.

The results provided numerous examples of interactions in which the other four dimensions of DiGironimo's theoretical framework of the nature of technology became salient. One plausible explanation is contextual: The preschool teachers in the present thesis worked in technology-profiled

preschools and were offered recurring professional development related to technology. This may account for the many dimensions of technology that emerge in the empirical data and is in line with previous research (Sundqvist et al., 2025). Importantly, however, this does not explain the continued lack of the historical dimension of technology in the empirical data. In line with Sundqvist et al. (2025), preschool teachers' professional development in technology does not necessarily correlate with an explicit and broad conception of technology that includes its history. However, we can take it as a given that preschool teachers often provide young children with technology artefacts but avoid spontaneous technology teaching situations and that technology knowledge is seldom verbalised (e.g. Hultén & Björkholm, 2016; Öqvist & Högström, 2018; Sundqvist & Nilsson, 2018). As a result, opportunities for addressing the historical dimension of the nature of technology are less likely to be made visible.

The Absent Historical Dimension of Technology

From a sociocultural perspective, it can be argued that the historical dimension of technology is embedded in the technology artefacts themselves. This implies that toddlers may encounter the artefacts' historical dimensions simply by handling them, thereby developing know-how knowledge about properties and functions that have evolved over time and are embodied in contemporary artefacts. However, a sociocultural perspective also emphasises the significance of conceptualising such knowledge, since the technology knowledge embedded in artefacts may otherwise remain unnoticed and incomprehensible to the learner. Consequently, not only the history of technology but also the everyday and scientific conceptualisations of technology knowledge may remain concealed.

This thesis shows that toddlers are active contributors to externalising and conceptualising various forms of technology knowledge (Vygotsky, 2016). In addition, preschool teachers are shown to play a significant role in creating opportunities for interactions, acknowledging and responding to toddlers' initiatives and supporting movement between everyday and emerging scientific conceptualisations, thus making multiple dimensions of the nature of technology accessible in early childhood technology activities.

The absence of a historical dimension may be explained by the abstract nature of time and toddlers' still-emerging understanding of temporality, which may restrict their contributions to this dimension of the nature of technology. Hence, with regard to toddlers' contributions to technology activities and how they add to and shape the technology knowledge involved, the historical dimension appears to constitute an overlooked aspect of their initiatives. Therefore, it is suggested that opportunities to address the historical dimension depend on teachers' active mediation in interactions. This also motivates a more distinct focus on the historical dimension of technology in early childhood technology education.

Although toddlers are only just starting to develop emerging understandings of technology, society, and temporal aspects, they are simultaneously active participants in democratic practices within their locally situated context of Swedish preschools (Edmonds, 2019). This pattern, in which technology is predominantly represented as *artefacts*, as *creation processes*, as *human practices* and as *technology in contemporary society*, yet with a weak *historical foundation* (DiGironimo, 2011) points to a knowledge gap. This gap may constrain toddlers' emerging holistic and broad understanding of technology as part of humanity's knowledge heritage. A historical perspective, combined with knowledge of technology principles, may support toddlers' innovative and creative resourcefulness.

The results of this thesis thus point to the significance of toddlers' contributions related to the various dimensions of the nature of technology and to the importance of recognising their knowledge as meaningful for appropriating technology knowledge. Just as toddlers are involved in other learning activities, such as managing emotions or developing social skills as prerequisites for future learning and participation in democratic practices, they can also be introduced to technology as embedded in its historical and societal context. Given the absence of the historical dimension of the nature of technology in the empirical data, the results of this study do not provide any empirical examples of how this can be accomplished. However, this thesis contributes knowledge about toddlers' initiatives in interactions related to the other four dimensions and how preschool teachers can support toddlers in developing knowledge about these aspects. Such knowledge may be fruitful for organising technology activities, with a stronger focus on the historical dimension of technology.

Interrelating Everyday and Scientific Conceptualisations of Technology

The results of this thesis draw attention to toddlers' contributions to the emergence of the everyday and scientific conceptualisations of technology in interactions between toddlers and preschool teachers when handling tangible artefacts. For example, toddlers express generalised understandings of the shape and functions of wheels non-verbally by rolling wheels and tape rolls and verbally by comparing their functions. This resonates with research by Lindahl and Samuelsson (2002), which shows how toddlers' embodied science knowledge enacted in their actions supports their concept formation about science. The toddlers in this thesis also conceptualise technology in emerging scientific ways through abstract and structured concepts, such as *spokes* and *vehicles* and by conceptualising a tape roll as a wheel. In addition, subject-specific concepts such as *design* are conceptualised in interactions and the toddlers and the teachers refer to artefacts that are not present. Teachers' use of artefacts, open-ended questions and responsiveness to toddlers' initiatives guide the interactions towards everyday as well as more generalised and emerging scientific conceptualisations. Similar to research by Fragkiadaki et al. (2024), the toddlers' non-verbal interactions in this thesis can be understood as real forms of knowledge grounded in their everyday experiences. Their verbal interactions, by contrast, can be understood as more abstract, ideal forms of knowledge. These various ways of conceptualising technology are bridged and brought together in hands-on interactions and supported by teachers' responsiveness and use of subject-specific language, enabling an interrelation between everyday and emerging scientific conceptualisations of technology. Svensson et al. (2023) reported the significance of preschool teachers' enhanced awareness of how technology is expressed as children's embodied knowledge. This is reflected in the empirical data of this thesis in terms of how teachers can support toddlers' nuanced and advanced understandings of technology by recognising toddlers' embodied knowledge expressed in interactions, such as the initiative to start pushing the garbage bins (Study II), and link these to technology knowledge and principles.

Initially, my interest in the research field of early childhood technology education involved curiosity about how toddlers learn about technology and what aspects emerge as significant in these activities. How intersubjectivity

is established, challenged, and negotiated in the interactions is thoroughly accounted for in the separate studies and previously in this chapter, as are the implications for and contributions to the unfolding technology activity regarding non-verbal and verbal interactions involving technology. In relation to toddlers' ways of expressing themselves non-verbally, their explorative manipulation can be understood to mediate their emerging technology knowledge. In the three empirical studies (Studies II, III, and IV) in this thesis, this is shown to be of great significance for the negotiation and establishment of intersubjectivity, for sharing everyday and scientific conceptualisations, and for the ways in which toddlers exercise agency.

Toddlers' Conceptualisations of Tangible Cultural Tools

As noted earlier in this discussion, it may be questioned whether toddlers conceptualise the tangible world around them in any way other than in an everyday manner, since they may be experiencing various technological artefacts for the first time ever. Their handling and exploration of objects and developing know-how knowledge on how to use them may suggest that toddlers conceptualise these objects in an everyday way. However, the results of this thesis illustrate how toddlers and their preschool teachers engage in interactions in which technology knowledge is conceptualised in both everyday and scientific ways and how these conceptualisations are interrelated. This resonates with the study of toddlers' science activities by Henriksson et al. (2025), who argued that toddlers' non-verbal initiatives related to science, such as enacting the behaviour of scared turtles, provide opportunities for both play and the further exploration of science content. Similarly, Myklebust and Fagerbakke (2024) concluded that toddlers' non-verbal exploration and interest related to tangible objects can support toddlers' agency by enabling a shift from participation to actively guiding others in interactions. They argued that, combined with preschool teachers' verbal conceptualisations related to science, toddlers' exploration of tangible objects can support their concept development. As mentioned, the empirical data in this thesis illustrate how toddlers' everyday and emerging scientific conceptualisations of technology knowledge are expressed through the handling of artefacts and by gestures and the non-verbal and verbal use of abstract and structured concepts. These concepts express generalised

understandings of technology principles or refer to artefacts that are not present. The dialectical movement between toddlers' and teachers' everyday and scientific ways of conceptualising technology is therefore understood to support toddlers' emerging scientific conceptualisations of technology.

Previous research repeatedly emphasises the role of preschool teachers, as well as their subject-specific knowledge, in early childhood technology education (e.g. Boström et al., 2022, 2023; Henriksson et al., 2025; Sundqvist, 2025; Svensson et al., 2023). The role of preschool teachers is also specifically recognised in this thesis as critical for acknowledging and interpreting toddlers' non-verbal gestures, explorations, and handling of tangible technology artefacts and for recognising the technology knowledge embedded in these interactions. Henriksson et al. (2025) emphasised the significance of teachers' support and responsiveness to toddlers' initiatives related to science, thereby enhancing and supporting the subject content of the activity. In this thesis, such recognition and responsiveness are viewed as essential for supporting the unfolding of the activity and its various interactions involving technology knowledge.

The significant role of preschool teachers and peers is highlighted in sociocultural perspectives on children's agency (Wertsch & Rupert, 1993; Wertsch et al., 1993). This role is also recognised by Sevón and Alasuutari (2026), who understand children's agency as relationally constructed and linked to children's participation and intentionality in interactions. This resonates with the results of this thesis in terms of the toddlers' and preschool teachers' negotiations, the teachers' responsiveness and the way in which toddlers' initiatives are related to technology knowledge. This is also reflected in how the activities are adapted to encompass toddlers' initiatives. Toddlers' opportunities to conceptualise technology in everyday as well as generalised and emerging scientific ways and their role as active contributors to interrelating everyday and emerging scientific ways of conceptualising technology are illustrated and stressed as significant for their appropriation of and participation in shaping and recreating technology knowledge.

Toddlers' Exercised Agency as Negotiating and Expanding

Empirically, this thesis demonstrates the active participation of toddlers in technology activities engaging in interactions with conceptual and tangible

cultural tools related to technology. Previous research acknowledges the significance of organising learning activities that support interaction, active participation, and children's exercised agency (Myklebust & Fagerbakke, 2024; Sairanen et al., 2022). This aligns with the results of this thesis, in which toddlers' initiatives contribute new technology knowledge and an enhanced focus on various dimensions of technology. In the technology activities, the toddlers exercise agency by communicating and acting on what is interpreted here as their prior and emerging technology knowledge, thereby negotiating, influencing and changing the activity or their participation in it (Houen et al., 2016; Lagerlöf et al., 2023; Magnusson & Bäckman, 2023; Myklebust & Fagerbakke, 2024).

Toddlers' exercised agency as *contributing* to technology knowledge is highlighted in the results. Toddlers' initiatives in collaborative interactions support their opportunities to *contribute* to technology activities. They exercise agency that in various ways contributes to technology knowledge through tangible cultural tools, such as the toolbox, and conceptual cultural tools, such as technology knowledge related to fastening wheels with a screwdriver, and the mediation of this knowledge through the use of the toy tools. The toddlers' contributions shape and expand the technology knowledge and the organisation of the activity, and they also change the other toddlers' participation by creating a more pronounced focus on the technology knowledge, shifting the activity from exploring the cardboard box to using the toy tools to create a vehicle (Borg & Pramling Samuelsson, 2022; Arthur, 2009).

Toddlers are analytically shown to exercise agency by positioning themselves in an authoritative role (Pramling et al., 2024), as in the example of the lowering gates. This is understood as an opportunity to make a shift towards actively guiding the interactions (Myklebust & Fagerbakke, 2024) in terms of sharing previous knowledge and experiences related to how the gates function. Toddlers are thus understood as active participants in evolving interactions characterised by initiatives, negotiations, and changes in democratic practices within their preschool context. The results emphasise how toddlers' initiatives are supported by the teachers' approach and, thus, resonate with research by Sairanen et al. (2022).

Toddlers' exercised agency as *challenging* technology knowledge is highlighted in the results. Toddlers' initiatives in collaborative interactions relate to their opportunities to challenge technology knowledge in the activity

in terms of maintaining their own perspective and resisting change, which is analytically understood as toddlers exercising agency (Pramling et al., 2024; Sairanen et al., 2022). The teachers' responses vary, and in some instances, they accept (cf. Sairanen et al., 2022) the toddlers' authoritative and guiding role and the tangible and conceptual tools related to technology that they bring into the activity, as in the examples of the lowering gates and the toolbox (Study IV). Furthermore, teachers adapt and expand these additions in further interactions, thus supporting toddlers' agency (cf. Sairanen et al., 2022). In the case of the motorcycle (Study IV), the toddler exercises agency by non-verbally and verbally challenging the technology knowledge, as shaped by the teacher and resists her request to create a vehicle with four wheels (cf. Pramling et al., 2024; Sairanen et al., 2022). The teacher declines the toddler's initiative to create a motorcycle. However, contrasting the results with those of Sairanen et al. (2022), the teacher's response did not appear to undermine the toddler's opportunities to exercise agency. Instead, the teacher's rather weak rejections in the shape of doubtful non-verbal interactions and verbal questions appeared to create space for the toddler to sustain his initiative and follow it through the whole activity. Analytically, the teacher's responses relate to the minimal response described in Myklebust and Fagerbakke (2024), as well as to the open-ended questions highlighted by Houen et al. (2016) and are understood to support toddlers' agency. However, contrary to Houen et al. (2016), the results of the thesis show that toddlers' exercised agency is not dependent on whether the teacher accepts their initiatives or not.

The cultural tools, in the shape of the book of vehicles, the tangible wheels and the teacher's goal-directed approach and responses are therefore understood to simultaneously constrain and support the toddler's opportunities to exercise agency, engage critically in creative processes and communicate his intentions.

Regarding how preschool teachers can organise technology activities that support toddlers' opportunities to exercise agency, similarly to previous research, this thesis shows how toddlers' exercised agency is supported by teachers' legitimising (cf. Boström et al., 2023) toddlers' initiatives and making the connections to the underlying technological principles more visible. Consequently, toddlers' exercised agency becomes both a resource for generating and enhancing technology knowledge and a democratic practice aligned with preschool educational principles. Preschool teachers'

technology knowledge and approach to toddlers' initiatives can be assumed to determine if and how toddlers' initiatives are recognised, responded to, and linked to technological principles.

In addition, the results show the significance of open-ended questions, similar to the 'I wonder...' approach noted in the study by Houen et al. (2016). In Study II, this is exemplified by questions such as 'Do you remember?' and 'What do you mean?'. The questions differ slightly from the 'I wonder...' strategy of inviting the toddlers to take the role of agents and instead indicate that, in this situation, either the toddlers' previous experiences matter or they are invited to develop their train of thought. Nevertheless, these questions appear to shift authority relations and create opportunities for toddlers to exercise agency through meaningful participation (cf. Borg & Pramling Samuelsson, 2022). Toddlers' responses to these questions draw on their previous technology knowledge, allowing them to contribute by using physical and conceptual cultural tools that extend and enhance technology knowledge. This is analytically accounted for in Study IV when the preschool teacher asks the toddler standing by the door with his hand on the door handle, 'What do you mean?' This appears to prompt the toddler to open the door and follow through on his initiative to get the toolbox. In this way, the teacher's questions are suggested to support toddlers' opportunities to exercise agency to actively make meaningful and informed contributions related to technology. The toolbox enables further elaboration related to technology knowledge and the use of tools. Specifically, it sparks the toddlers' renewed focus on technology knowledge and shifts their participation in the activity to become more engaged in technology-related play.

Framing technology activities as play-based interactions during which collaboration is supported is recognised as favourable for children's participation in technology activities (e.g. Hultén & Björkholm, 2016; Magnusson & Bäckman, 2023; Thorshag & Holmqvist, 2019; Yliverronen et al., 2018). Hence, play can be understood as encouraging toddlers' exploration and engagement in technology activities and fostering creativity and opportunities to exercise agency. In this thesis, the play frame of technology activities is analytically acknowledged to support toddlers' participation and their possibilities to contribute non-verbally by rolling various wheel-shaped artefacts and spinning the wheel and verbally by suggesting that the tape roll is a wheel and that the wedge can be used as an

inclined plane. The play-frame can be understood to support toddlers' initiatives to add tangible artefacts, such as the toolbox, since play engages children in creative and imaginative activities on their own terms. Moreover, in reference to how preschool teachers more often legitimise the ideas and suggestions made by children who appear confident in technology activities (Boström et al., 2023), such a play frame can be of significance. Although not a prerequisite, a play frame indicates toddlers' increased possibilities to exercise agency in terms of how their initiatives may be legitimised and supported as pretend play creativity (Magnusson & Bäckman, 2023). Henriksson et al. (2025) acknowledge preschool teachers' responses to toddlers' initiatives and simultaneous focus on the subject knowledge as a favourable balancing act for supporting toddlers' learning about science. Similar patterns are identified in this thesis in relation to the significance of preschool teachers' sensitive and permissive approach in combination with a play frame and sustained focus on technology knowledge in the activity.

The Significance of Technology Artefacts as Cultural Tools

As noted previously, the results of this thesis underscore the significance of cultural tools and technology artefacts in hands-on activities in terms of how they enable and support a shared focus on various aspects of technology knowledge. Tangible cultural tools, such as the toolbox or various wheels, are analytically shown to be important for how the activity unfolds and for how they support toddlers' participation and opportunities to exercise agency by adding technology knowledge and expanding technology activities. In this sense, technology artefacts are not merely present as physical objects in the activities, but function as mediating cultural tools through which toddlers and preschool teachers can establish, negotiate, and transform a shared focus on technology. The results of this thesis thus align with previous research by Myklebust and Fagerbakke (2024), in which toddlers' interest and agency related to tangible objects, namely slugs, and how this proved critical for maintaining a shared focus and for transforming their non-verbal interactions into opportunities to verbally conceptualise scientific knowledge about slugs.

In contrast, as noted in Study IV, it can be argued that physical cultural tools may pose limitations for toddlers' possibilities to exercise agency (cf.

Wertsch and Rupert, 1993). In this case, their presence appeared to have influenced the teacher's approach of ignoring and questioning the toddler's suggestions to construct a motorbike with only two wheels. However, cultural tools are also analytically understood to create opportunities for the toddler to actively contribute technology knowledge, exercise agency and maintain his perspective throughout the activity, resisting the teacher's view of what they are creating. This illustrates how the same artefacts may simultaneously constrain and support toddlers' agency depending on how they are taken up in the interaction. The situation can therefore be understood as involving two different foci, but both focus on technology knowledge in creative and parallel processes on equal terms (Pavlova & de Vries, 2018; de Vries, 2006).

Furthermore, tangible cultural tools are recognised as prerequisites for conceptualising technology in both everyday and scientific ways by interrelating them with conceptual cultural tools in non-verbal and verbal interactions. It can be questioned whether tangible wheels are conceptualised by toddlers as merely objects encompassing everyday conceptualisations of their functions and properties. Grounded in the results of this thesis, as illustrated in the toddlers' interactions, I argue that toddlers always encounter wheels as human cultural tools and technology artefacts as encompassing historical and contemporary knowledge involving everyday conceptualisations related to their functions and properties, as well as scientific conceptualisations. However, these historical as well as their contemporary, societal, and cultural dimensions related to humankind embedded within the wheels must be conceptualised in meaningful interactions to become noticeable and comprehensible to the toddlers.

The results of this thesis extend a sociocultural understanding of conceptual cultural tools by illustrating how these tools emerge in toddlers' situated interactions with preschool teachers, peers and tangible technology artefacts. Rather than functioning as concepts that are simply transmitted to children, conceptual cultural tools are shown to be collectively shaped through toddlers' embodied actions, previous experiences, verbal contributions, and explorations of artefacts. This contributes to theory by focusing on toddlers as active participants in the formation of technology knowledge. Thus, the educational significance of technology artefacts lies not only in their material presence, but in how they become part of shared meaning-making processes where toddlers' previous experiences, embodied

actions, verbal contributions, and emerging technology knowledge are made visible and further developed.

Theoretical and Methodological Considerations, Limitations and Future Research

In this section, I discuss some of the results in relation to the methodological choices made in the thesis. This is followed by methodological reflections regarding possible theoretical perspectives and the relevance of applying Vygotsky's (2016) notion of everyday and scientific concepts to toddlers' concept formation.

Possible limitations of this thesis have been discussed earlier in the methodological section and include its scope and possibilities for suggesting general knowledge that can be applied in similar situations. However, video data generated in small groups are essential for studying the simultaneous and varied interactions between toddlers, and the generalisability of these kinds of in-depth analyses is therefore often limited. At the same time, empirically studying technology activities recognises toddlers' interactions and exercised agency as socioculturally grounded within their locally and culturally situated premises.

The unit of analysis in this thesis is the non-verbal and verbal interactions of toddlers and their teachers with the intention of studying concept formation and exercised agency related to technology. In this regard, there are no other equally favourable alternatives for conducting this kind of research. Crucially, the chosen method enables fine-grained, in-situ observation and analyses of non-verbal interactions, concept formation and exercised agency in real time, including gestures, gazes and embodied orientations that precede or accompany speech (Ochs, 1979; Wallerstedt et al., 2022). With children this young, such micro-sequential interactions would not be accessible through alternative methods, such as interviews, surveys or solely product-focused assessments. Thus, methodologically, the thesis contributes by showing how toddlers' agency can be studied through detailed analyses of non-verbal and verbal interactions, including gazes, gestures, bodily orientation, handling of artefacts, and responses to teachers' initiatives. This approach makes it possible to analyse agency not as an

individual trait but as something interactionally accomplished and situated within preschool technology activities. This methodological affordance can therefore be seen as a strength rather than merely a limitation.

In addition, video observation can be adopted by preschool staff as a tool for quality and development strategies in general and for technology education specifically to study what children actually do in interactions related to technology. Adopting the framework of DiGironimo (2011), although not completely covering all aspects of technology education (for example, it does not cover the interdisciplinary nature of technology in relation to various other educational subjects, such as science, arts, and mathematics), is suggested as a meaningful tool for analysing young children's interactions related to technology. Thus, this thesis contributes significant aspects of how toddlers' interactions in preschool technology activities can be taken into consideration and transformed to organise sustainable and fruitful technology learning activities.

Initially, this thesis approached early childhood technology education by inquiring about what technology education is and how it can be enacted in preschools. The results demonstrate that early childhood technology education involving toddlers and various dimensions of technology is not only possible, but that toddlers are active contributors to these activities. One focus of this thesis has been toddlers' initiatives in interactions. The results do not allow conclusions to be drawn about the intentionality of these initiatives, nor is this the aim of the thesis. Instead, the results show how the activities and the technology focus of the interactions change in various ways. Both toddlers and preschool teachers are active contributors and the teachers' role in responding to toddlers' initiatives and their approaches that embrace toddlers' initiatives and support their exercised agency has already been discussed.

It can be discussed whether there is a difference between toddlers' initiatives and toddlers' exercised agency and whether they can be understood as consciously taking initiatives to change or contribute to technology activities. From a sociocultural perspective, toddlers' agency does not necessarily presuppose explicit or verbally expressed intentions but can be understood as emerging through their participation in social, material, and cultural practices and through the ways their actions are taken up by others. This thesis recognises that any toddler's initiative can be understood as exercising agency and, adopting a sociocultural perspective on agency, their

individual initiatives in interactions are understood as contributions to the dialectic appropriation of knowledge related to technology. In addition, the participants' mutual and dynamic interactions embedded within their social and cultural contexts are understood to be important for the ways in which toddlers' exercised agency contributes to or changes the unfolding activity. By engaging in meaningful interactions, toddlers gain experience and knowledge about their abilities, rights and ways of exercising agency to contribute to, change and influence their everyday lives and their own learning about technology. Moreover, when toddlers exercise agency, they experience themselves as capable of doing so and of contributing to activities that support their future participation and opportunities to exercise agency. The young age of the children participating in this thesis therefore demands ways of understanding and studying agency that attend to how intersubjectivity is established through embodied, verbal and relational forms of participation.

It can be questioned whether Vygotsky's (2016) notion of *schooling* and the introduction of scientific concepts are applicable to toddlers in a preschool context. However, Swedish preschool policy texts emphasise play, learning, care and nurturing as equally important, while also emphasising teaching as a core aspect that should be offered to all children from the first day of preschool. In this light, systematic schooling can be understood to encompass toddlers within a preschool context. Within such a framework, preschool teachers' practices of responding to toddlers' initiatives and explicitly identifying and conceptualising technology knowledge in everyday and scientific ways as part of the subject of mechanical technology provide a principled basis for emerging concept formation. In addition, preschool teachers' subject-specific knowledge in terms of recognising and adapting technology knowledge in toddlers' interactions with the activity is recognised as supporting toddlers' broad understanding of technology, including all five dimensions of the nature of technology (DiGironimo, 2011).

While various other perspectives are acknowledged for taking into account the field of early childhood technology education, the relevance of a philosophical perspective of technology and technology education framing this thesis is suggested to encompass its interdependence with humankind and society. Other frameworks, such as Mitcham's (1994), contribute with their focus on the contextual and embodied conceptualisations of technology, as does de Vries' (2016, 2018) framework, with valuable insights

on the educational dimensions of technology. Adopting a set framework, such as the one proposed by DiGironimo (2011), can in itself be understood as a limitation, since it involves classification, which can delimit a broad understanding of technology. However, in this thesis, DiGironimo's (2011) conceptual framework is argued to have demonstrated its relevance by providing analytical tools that make it possible to identify emerging dimensions of technology incorporated in their human, cultural and societal aspects. Regarding educational perspectives and toddlers' understanding of the nature of technology, the framework has been useful in identifying toddlers' contributions to technology. The significance of separating the five dimensions for analytical purposes has been discussed. This distinction can also contribute to educational and practical insights into how technology activities can be organised and how toddlers' initiatives can be supported in ways that enhance a broad understanding of the nature of technology.

How a historical dimension of technology can be included and supported in interactions during planned preschool technology activities and in everyday interactions related to technology is suggested as a focus for future research. From an educational perspective in the Swedish context, children start preschool from the age of 12 months, which underscores the need for further empirical investigation of toddlers' engagement and conceptualisations of the various dimensions and aspects of technology grounded in understandings of toddlers' agency as situated and realised within its cultural premises.

Implications for the Research Field and Practice

This thesis has explored toddlers' and preschool teachers' mediated knowledge and conceptualisations of foundational principles related to mechanical technology. Thus, it addresses research gaps in empirical research involving mechanical technology, as well as research involving toddlers, who typically are underrepresented in the research field of early childhood education. By clearly distinguishing interactions related to mechanical technology activities from those related to digital technology activities, this thesis has clarified key distinctions in the field of early childhood technology education.

Understanding and studying how intersubjectivity is established in interactions involving toddlers is of analytical interest to the research field. Empirically, uncertainties can occur regarding the extent to which toddlers' interactions are initiatives or responses, since they often do not immediately respond and sometimes respond by initiating non-verbal interactions or by becoming silent. One example is from Study II, when one toddler stops making motor sounds and becomes silent, turns around to look at the preschool teacher and the wheel, then grabs the wheel and eventually pushes the spokes sideways as if to spin the wheel. Keeping these aspects in mind, I have scrutinised video observations and transcripts to determine whether, and when, the interactions are directed towards the same technology focus, when alterity occurs and when intersubjectivity is re-established in non-verbal interactions such as gestures, gazes and the handling of objects, as well as verbal interactions (Linell, 2014; Vygotsky, 2016). In this thesis, I identify various occasions and dimensions of technology knowledge that emerge in interactions and are thereby made available for toddlers' appropriation.

Toddlers' everyday and scientific conceptualisations related to technology are illustrated and the results specifically highlight the significant role of non-verbal interactions and the use of hands-on cultural tools in play-framed technology activities. Analytically grounded, I argue that these support meaningful interactions involving various dimensions of the nature of technology as well as the interrelation between everyday and scientific conceptualisations. As already highlighted, teachers' sensitive and responsive approaches are essential to recognise and support toddlers' spontaneous interactions, bringing together toddlers' previous and new technology knowledge in the activity. Thus, preschool teachers' knowledge of how toddlers conceptualise technology in everyday and scientific ways and of how these conceptualisations can be interrelated in non-verbal and verbal interactions have significant implications for how they are able to organise appropriate technology activities for toddlers. Successfully combining teaching and play in playful interactions depends on how preschool teachers respond to toddlers' initiatives and relate these initiatives to their previous experiences and technology knowledge while directing their focus towards relevant technology knowledge. This also includes organising activities that enable toddlers to exercise agency grounded in their locally situated context and to have opportunities to realise their initiatives. Success in this effort depends on recognising toddlers' ability to add, change, challenge, and

expand tangible and conceptual cultural tools as critical aspects of technology knowledge.

As initially highlighted in the introduction of this thesis, the significance of a holistic perspective for supporting toddlers' participation in educational activities is also supported by the overarching results of this thesis as a prerequisite for sustainable and democratic participation here and now and in future practices. Toddlers' interactions are emphasised as contributions to the conceptualisation of technology, the technology content, and the way in which the activity evolves. This can best be achieved when the activity is organised to support non-verbal and verbal interactions in which toddlers' initiatives and contributions are recognised and legitimised (cf. Boström et al., 2023) and the preschool teacher asks open-ended questions that create spaces for the toddlers to exercise agency (cf. Houen et al., 2016). By accepting the toddlers' decisions and developing them in interaction, the preschool teacher playfully directs the toddlers' interactions and handling of objects towards technology principles. Various dimensions of the nature of technology are embedded in each artefact, and it is through interactions that these dimensions, together with the aggregated human knowledge embedded in each artefact, must be conceptualised and externalised if toddlers are to develop knowledge about them.

As stated in Swedish preschool policies (Swedish National Education Agency, 2025), analogue learning tools should provide didactic value, and this thesis recognises that almost any technology artefact can constitute such a learning tool. In an educational context, this implies that even old wheels and garbage bins can function as analogue learning tools in preschools, depending on how they are addressed in interactions between preschool teachers and toddlers. From a Swedish educational perspective in a Swedish context, preschool technology subject knowledge can therefore be understood as encompassing toddlers' hands-on exploration of everyday mechanical technology artefacts in interactions through which principles related to human, societal, cultural, and historical contexts are conceptualised during technology activities.

Based on the findings of this thesis, I recommend incorporating a historical dimension of technology into toddlers' activities in preschool by reflecting on how things were done before certain artefacts were invented. This can be done in close relation to handling and exploring these tangible artefacts. In this interaction, the interrelation between tangible know-how

knowledge and everyday knowledge about the technology principles that have evolved over time and are embodied in the artefacts with emerging scientific conceptualisations of technology can be emphasised. Based on the results of this thesis, combining technology and play in technology activities as well as everyday activities is argued as a fruitful way of sustaining the Swedish *educare* model involving learning, development, teaching, care, and play. For example, at lunchtime, we could talk about how hot food was handled before forks were invented and when dressing for outdoor play, we could reflect on how we kept our jackets closed before zippers were invented. It could also involve everyday conceptualisations of technology in terms of practical activities, such as trying to push heavy objects without or with wheels and exploring how to use logs (or something similar, like pipes) to move these heavy objects and reflect on how objects were moved before the invention of the wheel.

Conclusion

In this thesis, toddlers' initiatives and exercised agency are emphasised as prerequisites for shifts in how various dimensions of technology knowledge emerge and how everyday and emerging scientific conceptualisations of technology are communicated and interrelated in interactions. In addition, toddlers' initiatives and exercised agency are shown to expand and add technology knowledge as well as influence how the activity is organised and evolves. In this interaction, preschool teachers' technology knowledge, their sensitive and play-oriented approach and their simultaneous responsiveness and goal directedness have significance for how toddlers' initiatives and knowledge related to technology are responded to, legitimised and linked to technological principles, as well as for how everyday and scientific ways of conceptualising technology become interrelated. Thus, the social, cultural, and educational situatedness of toddlers' exercised agency and contributions in meaningful interaction are recognised.

This implies that toddlers are not only offered opportunities to learn about various aspects of technology and its relationships with humans at a young age. It also stresses that toddlers actively contribute to creating opportunities to address various dimensions of technology. This creative and transformative notion resonates with sociocultural theoretical perspectives of toddlers as actively engaged in appropriating, negotiating and shaping their

own knowledge. In addition, toddlers' exercised agency in terms of creative initiatives and active participation in innovative technology activities is highlighted as a sustainable contribution that interrelates technology with human practices and toddlers' democratic participation in their locally situated contexts.

The significance of supporting toddlers to exercise agency to expand the technology content, strengthen their participation, and create opportunities for them to voice and display their knowledge is stressed in this thesis. In this way, toddlers' exercise of agency can be viewed as a driving force for negotiating and expanding both the technology content and the technology focus of the activity. This may occur either by adding tangible and conceptual technology content to the activities or through forms of resistance that redirect, challenge or transform the unfolding activity. In addition, toddlers' exercised agency can be understood as being related to technology knowledge in itself, particularly in terms of its creative dimension, which is critical for the ever-expanding enterprise of technology (DiGironimo, 2011). The results of this thesis, therefore, emphasise a holistic and democratic approach to technology activities in early childhood education, in which toddlers' and preschool teachers' interactions are both significant for the unfolding activity.

Toddlers' exercised agency is understood to contribute to and expand the technology content of technology activities and to promote toddlers' participation. Correspondingly, this can contribute to preschool teachers' approach to and organisation of technology activities and represent a critical move away from reducing the learner to merely a receiver of knowledge and instead promoting even the youngest children's participation and agency. On the same note, the preschool teachers' role is specifically emphasised in this thesis as critical for acknowledging and interpreting toddlers' non-verbal interactions. This involves recognising the technology knowledge embedded in toddlers' non-verbal interactions and using this recognition to support the unfolding of the activity and its technology-related exchanges.

A holistic view of early childhood technology education includes understanding these intertwined interactions as part of toddlers' locally situated contexts (Edmonds, 2019) and, from a wider perspective, as including various dimensions of technology and its interdependence with the development of human knowledge and societies. This is especially the case regarding the innovative and creative dimensions that technology

encompasses. This implies that technology, as a subject in its own right, encompasses interactions related to technology objects and principles that both enable, invite and, in some respects, require agency, innovation, creativity, and learning in terms of sharing and gradually appropriating new knowledge (Wertsch, 1998), thereby contributing to collectively developed and structured human knowledge (Säljö, 2009). Against this background, the results of this thesis offer theoretical contributions to the field of early childhood technology education.

A philosophical perspective broadens what can count as technology knowledge in the analysis by making it possible to attend to artefacts, creation processes, human practices, historical dimensions and the current role of technology in society. Based on the results of this thesis, I argue for introducing technology education from the earliest years in preschool, so that even the youngest children are offered opportunities to develop a broad understanding of technology and its relationships to humankind, society and, not least, its historical dimension. Philosophical and sociocultural perspectives on technology recognise the historical dimension as critical for technology as a subject and as human knowledge aggregated over time and closely linked to societal development. Technology education itself is ever-evolving and continually changing since it is intertwined with the development of technology in human societies. The two crucial temporal aspects of this evolving interplay are the two dynamic aspects related to the enterprise of technology: the history of technology and the current role of technology in society (DiGironimo, 2011). Accordingly, the curriculum and education should give toddlers clear, age-appropriate ways to engage with hands-on explorative activities that are interrelated with conceptual knowledge of how technology has changed over time. Such an approach can support toddlers in connecting present-day artefacts and practices with the technology knowledge accumulated over time.

Combining a philosophical perspective on technology with a sociocultural perspective and a holistic view of toddlers' learning offers a deep understanding of how their technology knowledge recurrently shapes and is shaped by each other in educational practices. It provides critical notions of the social, creative and innovative aspects embedded in technology. A holistic approach views toddlers' emerging technology knowledge related to mechanical technology as a prerequisite for engaging in meaningful, democratic, and socially sustainable educational practices in

which technology, society, humankind and toddlers' learning are addressed as interrelated and mutually dependent. Theoretical contributions to the field of early childhood technology education involve empirically grounded arguments for understanding technology as encompassing toddlers' agency as part of innovative and creative interactions through which technology knowledge is generated, negotiated and connected to the collective knowledge of humankind. In this thesis, toddlers' initiatives and exercised agency related to technology are therefore understood as both prerequisites for developing knowledge about technology, generating technology knowledge, as well as constituting a democratic practice in line with the relational, holistic, and sustainable principles guiding Swedish preschools.

Chapter 7 Summary in Swedish

Kapitel 1: Inledning

I denna avhandling studerar jag förskolans teknikundervisning med fokus på interaktionen mellan barn i ett till treårsåldern (toddlare) och förskollärare i aktiviteter som involverar mekanisk teknik. Inledningsvis analyseras forskningsfältet i en systematisk forskningsöversikt. Därefter studeras olika aspekter av toddlers och förskollärares interaktion i tre empiriska studier. Avhandlingens första två studier har tidigare publicerats inom ramen för min licentiatuppsats.

Barn växer idag upp i digitalt präglade och högteknologiska samhällen, omgivna av olika tekniska artefakter, tekniska system och digitala verktyg som bygger på grundläggande mekaniska principer som under flera århundraden har utvecklats (de Vries, 2016). Det är teknik som barn kan använda, men vars bakomliggande tekniska principer de ofta inte har kunskap om. Toddlars begynnande teknikkunskap kan förstås som betydelsefull för deras möjligheter att kritiskt samtala om teknik (de Vries, 2016; Williams, 2009), som en stabil grund för framtida lärande om teknik (Sundqvist, 2020) och för att utveckla en förståelse av hur mänskliga samhällen och teknik är ömsesidigt sammanflätade.

Syftet med avhandlingen är att bidra med kunskap till forskningsfältet om mekanisk teknikundervisning i förskolan, med särskilt fokus på interaktionen mellan toddler och förskollärare i teknikaktiviteter.

Följande forskningsfrågor guidar det samlade resultatet från avhandlingens fyra delstudier:

Forskningsfråga 1: Hur konceptualiseras teknikundervisning i early childhood education i aktuell forskning och genomförs i praktiska teknikaktiviteter i förskolan, analyserat utifrån ett ramverk om teknikens natur?

Forskningsfråga 2: Hur medieras teknik när intersubjektivitet etableras och hur förhandlas och interrelateras vardagliga och vetenskapliga begrepp

relaterade till teknik i interaktion mellan förskollärare och toddlare i förskolans teknikaktiviteter?

Forskningsfråga 3: Hur formar interaktionen mellan förskollärare och toddlare liksom toddlares agens hur teknikkunskap uttrycks i handling och utvecklas i förskolans teknikaktiviteter?

Kapitel 2: Teoretiska perspektiv

Förskollärares och toddlares interaktion i de studerade teknikaktiviteterna förstås utifrån sociokulturella perspektiv (Vygotsky, 1943/1987/2016; Säljö, 2009). Kunskap ses därmed som *situerad* inom sin kulturella och historiska kontext och som att den *medieras* genom de kulturella verktyg som finns tillgängliga (Vygotsky, 2016; Wertsch et al., 1993). Lärande handlar då om att *appropriera* (Wertsch et al., 1993) kunskap, det vill säga att i meningsfulla samspel tillägna sig ny kunskap. Detta sker genom att deltagarna, med hjälp av kulturella verktyg, delar, förhandlar och koordinerar sina olika perspektiv och förståelser, så att en gemensam förståelse, *intersubjektivitet* (Linell, 2014; Rommetveit, 1985), kan etableras mellan dem.

Utifrån ett sociokulturellt perspektiv (Vygotsky, 2016) beskrivs interrelationen mellan *vardagliga* och *vetenskapliga begrepp* som en förutsättning för att utveckla begreppsförståelse. Vardagliga begrepp definieras som begreppsliggörande relaterad till konkreta föremål och aktiviteter och utgör förutsättning för att utveckla vetenskapliga begrepp. Vetenskapliga begrepp omfattar abstrakt och generell förståelse av fenomen utifrån deras vetenskapliga principer. De kan användas i olika situationer utan att innebörden förändras och de strukturerar vardagliga begrepp.

I avhandlingen konceptualiseras *toddlares agens* utifrån sociokulturella perspektiv (Wertsch et al., 1993; Wertsch & Rupert, 1993) som deras delaktighet i meningsfulla aktiviteter. I samspel med andra delar, förhandlar och återskapar toddlarna kunskap om teknik, som medieras genom de kulturella redskap som finns tillgängliga. På så sätt är de delaktiga i och påverkar sin egen kunskapsutveckling. Toddlares agens förstås som att de *utövar agens* (Pramling et al., 2024; Sairanen et al., 2022) vilket understryker deras roll som aktiva medskapare av kunskap genom medvetna och meningsfulla bidrag.

Kapitel 3: Bakgrund och tidigare forskning

Avhandlingen vilar på ett filosofiskt perspektiv där teknik och teknikundervisning förstås som inbäddade i sociala, kulturella och historiska kontexter, i enlighet med DiGironomos (2011) ramverk. Ramverket fokuserar utbildningsvetenskapliga och historiska aspekter av teknik och teknikundervisning och omfattar fem dimensioner av teknikens natur. Tre dimensioner utgör 'the shape and structure of technology' (DiGironimo, 2011, p. 1341) och omfattar teknik som (i) *artefakter*; (ii) teknikkunskap för att kunna delta i *skapande processer*; och (iii) teknik som *mänsklig praktik*, vilket inbegriper sociala, samhälleliga, kulturella, ekologiska, miljömässiga, etiska och genusrelaterade aspekter. De sista två dimensionerna av teknikens natur: (iv) teknikens *historiska dimension*; och (v) *teknikens roll i dagens samhälle* utgör 'the enterprise of technology' (DiGironimo, 2011, p1341).

Den svenska termen 'teknik' kan syfta dels på teknik som kunskap och ämne, dels på olika tekniker för att utföra något. Detta tillsammans med teknikämnets ämnesöverskridande natur kan bidra till vaga förståelser av vad teknik och teknikundervisning kan omfatta, både generellt i vardagen och i utbildningssammanhang (se tex. Sundqvist & Nilsson, 2018). Begreppet 'mekanisk teknik' används därför i avhandlingen för att beskriva de observerade konkreta föremål och aktiviteter som involverar grundläggande principer inom mekanisk teknik.

Tidigare forskning visar att svensk förskola erbjuder olika teknikaktiviteter och att flera olika slags teknikkunskap behandlas. Teknikaktiviteter omfattar oftast kunskap om tekniska artefakter, vardagsteknik, konstruktion, design och kreativa processer där barnen tillverkar olika saker i skapandeaktiviteter (se tex. Boström et al., 2022; Sundqvist, 2019, 2022; Sundqvist et al., 2025). Betydelsefulla aspekter när det gäller förskollärares roll är deras ämnesspecifika kunskap (se tex. Hallström et al., 2015; Hedlin & Gunnarsson, 2014; Öqvist & Högström, 2018; Sundqvist et al., 2025; Svensson et al., 2023), liksom deras pedagogiska kompetens (Sundqvist, 2019) och organisatoriska kompetens att rama in teknikaktiviteter som lek- och samarbetsaktiviteter (Hultén & Björkholm, 2016; Thorshag & Holmqvist, 2019; Yliveronen et al., 2018). Teknikens olika dimensioner uppmärksammas i ett par studier. I den ena studeras teknikens historiska dimension i teknikaktiviteter med sexåringar (Johansson, 2021) och i den andra jämförs förskollärares förståelser av teknikens olika

dimensioner med deras ämnesspecifika utbildning (Sundqvist et al., 2025). Studier som granskat organisatoriska aspekter av förskolans teknikundervisning visar olika och ibland motsägelsefulla resultat. Teknikaktiviteter kan gynnas både av en välstrukturerad och lärarledd inramning (Looijenga et al., 2015; Thorshag & Holmqvist, 2019) och av fri och utforskande lek (Fox-Turnbull, 2016; Hallström et al., 2015; Johansson, 2021; Looijenga et al., 2016).

Tidigare forskning visar också att konkret utforskande av artefakter som kopplas till tekniska begrepp och principer i meningsfullt samspel är avgörande för barns utveckling av kunskap och begreppsförståelse relaterade till teknik (Åkerblom & Thorshag, 2021; Sundqvist, 2022; Yliveronen, 2018). Detta stöds av studier om barns och toddlares kunskapsutveckling och begreppsförståelse av naturvetenskapliga fenomen (Fleer, 2009; Fragkiadaki et al., 2024; Lewis et al., 2019; Lindahl & Samuelsson, 2002). Dessutom betonas betydelsen av förskollärares förmåga att identifiera tekniska principer i barns icke-verbala interaktion och att koppla dessa till tekniska begrepp och principer (Svensson et al., 2023).

Barns agens konceptualiseras i tidigare forskning som deras möjligheter till samspel och delaktighet (Lagerlöf et al., 2023; Sairanen, 2022), som barns röster, initiativ och egna val (Lagerlöf et al., 2023; Magnusson and Bäckman, 2023) samt som möjligheter att påverka och förändra aktiviteter (se tex. Houen et al., 2016; Lagerlöf et al., 2023; Magnusson & Bäckman, 2023; Sairanen et al., 2022). Barns *utövade agens* förstås som pågående förhandlingar och som barns motstånd till förändring (Pramling et al., 2024).

Kapitel 4: Metodologiska aspekter

Syftet med avhandlingens systematiska forskningsöversikt (Gough, 2007) var att kartlägga aktuell empirisk forskning om teknikundervisning med barn i åldern 0 – 8 år och specifikt hur teknik framträder utifrån DiGironimos (2011) konceptuella ramverk med olika dimensioner av teknikens natur. Studien guidades av följande forskningsfrågor: 1. Vilka samlade resultat av teknikundervisning i de tidiga åren kan identifieras i tidigare empirisk forskning? 2. Vilka begreppsliga dimensioner av teknikens natur (enligt DiGironimo, 2011) framträder i empiriska studier om teknikundervisning i förskolan? En systematisk litteratursökning genomfördes och urvalet begränsades till vetenskapligt granskade empiriska studier på engelska som

studerat teknikundervisning med barn i åldern 0 – 8 år och som hade publicerats mellan 2013 och 2020. Snöbollsmetoden (Biernacki & Waldorf, 1981) tillämpades för att inkludera studier som ofta refererades till, i enlighet med samma systematiska urvalsförfarande. Efter upprepade och fördjupade granskningar och analyser inkluderades slutligen 23 studier. Studierna granskades utifrån deras syfte, teoretiska perspektiv, metod och form av teknikundervisning (Gough, 2007; Gough et al., 2012). Därutöver noterades citeringar, utgivningsår, författare, titel, tidskrift, nyckelord och geografisk kontext. Deduktiva kvalitativa innehållsanalyser (Cohen et al., 2007) användes för att identifiera hur olika dimensioner av teknikens natur, såsom de beskrivs i DiGironimos (2011) konceptuella ramverk, framträder i studierna.

I avhandlingens tre empiriska delstudier genereras data med fokus på toddlares och förskollärares interaktion i teknikaktiviteter. Urvalet var strategiskt och inkluderade förskolor med uttalat teknikfokus, med hänsyn även till deras geografiska tillgänglighet. För att få tillgång till fältet i den initiala fasen ingick personliga möten med förskollärarna för att informera om studiens syfte och metod, skapa tillitsfulla relationer och diskutera praktiska aspekter. Empiriska data genererades i tre förskolegrupper på två förskolor där fyra förskollärare och tolv barn (2 – 5 år) deltog (se tabell 1). Aktiviteterna valdes, planerades och genomfördes av förskollärarna som en del av deras pågående pedagogiska aktiviteter (se tabeller 2 – 5). Totalt genomfördes tio videoobservationer omfattande 237 minuter. Praktiska och metodologiska aspekter (Derry et al., 2010; Ivarsson, 2003; Jordan & Henderson, 1995; Lantz-Andersson, 2009; Lindgren & Sparrman, 2003; Lindwall, 2008) liksom etiska aspekter av videoobservationer med små barn (Ochs, 1979; Punch, 2002; Quennerstedt et al., 2014) har diskuterats och beaktats i avhandlingen.

Transkriptioner och översättningar av videoobservationer förstås som delar av avhandlingens analysprocesser (Jordan och Henderson, 1995; Ochs, 1979) och avser att synliggöra hur toddlare och förskollärare initierar interaktion om teknik och svarar på varandras initiativ. För att betona likvärdigheten mellan icke-verbal och verbal interaktion, liksom betydelsen av icke-verbal interaktion, har den icke-verbala interaktionen placerats till vänster, det vill säga först i västerländsk läsriktning.

Initiala transkriptioner och efterföljande analyser gjordes på svenska och översattes därefter till engelska. Översättningarna är anpassade till sin

kontext och till engelska språkets grammatiska struktur i syfte att göra transkriptionerna lättlästa utan att innehållet förändras. Transkriptionerna analyserades med modifierade versioner av interaktionsanalys (Jordan & Henderson, 1995) och sociokulturell interaktionsanalys, SIA (Wallerstedt et al., 2022). Initiala, öppna och utforskande analyser följdes av näranalyser i iterativa processer mellan transkriptioner, videofilmer och centrala teoretiska begrepp. Den empiriska datan kategoriserades utifrån avhandlingens övergripande syfte och olika teoretiska nyckelbegrepp (Derry et al., 2010; Pramling, 2023). Olika mönster i empirin utforskades med hjälp av tematiska analyser (Derry et al., 2010; Jordan & Henderson, 1995; Wallerstedt et al., 2022). I analysprocessen har toddlares specifika samspelsmönster (Ochs, 1979) särskilt beaktats.

Ekologisk validitet (Moschkovich, 2019; Wallerstedt et al., 2022) och en holistisk ansats tillämpades i avhandlingen och teknikaktiviteterna studerades i sina sociala och kulturella kontexter i en vardaglig förskolemiljö. Avhandlingen vilar på en systematisk och teoretiskt förankrad forskningsprocess med tydliga metodologiska val utifrån avhandlingens syfte. En övervägande del av texten har granskats i seminariegrupper, nationella nätverk och i samband med publiceringen av de fyra delstudierna, vilket stärker avhandlingens trovärdighet. Risker för bortfall hanterades genom detaljerad information.

Avhandlingen följer Vetenskapsrådets etiska riktlinjer (2017), svensk lagstiftning samt FN:s barnkonvention (SFS 2018:1197). Etiska överväganden gjordes kontinuerligt och reflexivt under hela forskningsprocessen. Vårdnadshavare informerades skriftligen och deras skriftliga samtycke inhämtades för barnens deltagande liksom för framtida användning av den empiriska datan i forsknings- och undervisningssammanhang. Det empiriska materialet har hanterats i enlighet med Göteborgs universitets dataskyddsplan. Barnen informerades muntligt vid upprepade tillfällen om sin rätt att delta eller avstå och om när kameran var i gång. Barns perspektiv och bästa intresse, både i stunden och med hänsyn till framtida konsekvenser, har varit centrala i alla forskningsetiska överväganden. Alla deltagare har avidentifierats med hjälp av pseudonymer och generella beskrivningar av de deltagande förskolorna.

Kapitel 5: Resultat och sammanfattningar av studierna

Avhandlingens övergripande resultat visar att fyra av de fem dimensionerna i DiGironimos (2011) ramverk för teknikens natur är väl representerade i både tidigare empirisk forskning och i interaktionen mellan toddlare och förskollärare i avhandlingens empiriska studier. I resultatet framträder även toddlares icke-verbala och verbala initiativ som betydelsefulla för teknikrelaterad kunskap, begreppsutveckling och deras utövade av agens.

Studie I

Eliasson, S., Peterson, L., & Lantz-Andersson, A. (2023). A systematic literature review of empirical research on technology education in early childhood education. *International Journal of Technology and Design Education*, 33(3), 793–818.

<https://doi.org/10.1007/s10798-022-09764-z>

Syftet med Studie I var att bidra med kunskap inom fältet teknikundervisning i förskolan, särskilt gällande teknikens natur och vad teknikundervisning kan innebära för de yngre åldrarna (0 – 8 år). Studien utgörs av en systematisk översikt av befintlig empirisk forskning inom området, med fokus på hur teknik begreppsliggörs i relation till DiGironimos (2011) fem dimensioner av teknikens natur. Följande forskningsfrågor guidade studien: 1. Vilka samlade resultat av teknikundervisning i de tidigare åren kan identifieras i tidigare empirisk forskning? 2. Vilka begreppsliga dimensioner av teknikens natur (enligt DiGironimo, 2011) framträder i empiriska studier om teknikundervisning i förskolan?

Fyra övergripande teman identifieras i studiens resultat: (i) lärares och lärarstudenters ämneskunskaper inom teknik (4 studier), (ii) deras didaktiska och ämnesspecifika kompetensutveckling (5 studier), (iii) undervisning och lärande i teknikaktiviteter med barn (10 studier) och (iv) barns tidigare erfarenheter och kunskaper om teknik (4 studier). Studiens resultat visar att alla fem dimensioner förekommer i tidigare studier, men i varierande grad. Dimensionerna *teknik som mänsklig praktik* (23 studier) och *teknikens roll i samhället* (22 studier) är mest framträdande. Däremot adresseras teknikens *historiska dimension* endast i en av studierna, vilket indikerar att denna dimension är svagt representerad inom forskningsfältet. Slutligen

argumenteras för att teknikens historiska dimension är betydelsefull även för förskolans yngre barn, för att möjliggöra en helhetsförståelse av teknik som mänskligt meningsskapande i sociala och kulturella praktiker. Att osynliggöra teknikens historiska dimension riskerar att begränsa barns förståelse av teknikens utveckling och dess interrelation med och fundamentala betydelse för människans och samhällets utveckling.

Studie II

Eliasson, S., Peterson, L., & Lantz-Andersson, A. (2024). You Don't Have to Re-invent the Wheel to Implement Technology Activities in Early Childhood Education. *Early Childhood Education Journal*, 52(2), 387–399.

<https://doi.org/10.1007/s10643-022-01441-z>

Syftet med Studie II var att empiriskt utforska hur teknikaktiviteter iscensätts i förskolan samt vilken teknikkunskap som blir tillgänglig för barnen när intersubjektivitet etableras i interaktionen mellan barn och förskollärare. Studien guidades av följande forskningsfrågor: 1. Hur iscensätts teknikundervisning i interaktionen mellan förskollärare och barn i teknikaktiviteter i förskolan? 2. Vilken kunskap relaterad till de fem dimensionerna av teknikens natur blir möjlig för barnen att tillägna sig när intersubjektivitet etableras i dessa interaktioner?

Studiens empiriska data genererades genom tre videodokumenterade teknikaktiviteter i en förskolegrupp med fem barn (2 – 3 år) och en förskollärare. Analysen guidades av sociokulturella perspektiv (Säljö, 2009; Vygotsky, 2016) och DiGironimos (2011) ramverk för teknikens natur. Studiens resultat visar att teknikaktiviteterna är målstyrda och samtidigt lekbaserade där barn initierar och upprätthåller både verbala och icke-verbala interaktioner, vilket möjliggör att intersubjektivitet etableras. I detta samspel är konkreta artefakter betydelsefulla för barnens interaktion runt teknik. Samtidigt visar studien att barnens lekinramning kan avleda fokus från teknikkunskap och att förskollärares lyhörda och responsiva förhållningssätt kan fänga upp och rikta deras fokus tillbaka till teknikkunskapen.

I interaktionen framträder fyra av de fem dimensionerna av teknikens natur (DiGironimo, 2011). Hantering och utforskande av hjul kopplas till teknik som *artefakt* och *skapande process*. Barnens delaktighet i att designa en hjulmodell visar hur kulturella redskap, som fysiska hjul och ritningar, liksom deltagarnas användning av begrepp och gester, medierar kunskap om teknik

som *skapande processer*. Barnens och förskollärarens interaktion kring och hantering av soptunnor på hjul medierar kunskap om teknik som *mänsklig praktik* och om dess *roll i samhället*. Däremot synliggörs att dimensionen *teknikens historia* är frånvarande, vilket i studien problematiseras som begränsande för barns möjligheter att utveckla en bred begynnande förståelse av teknik.

Studie III

Eliasson, S., Peterson, L., & Lantz-Andersson, A. (2026). The Interrelation Between Everyday and Scientific Conceptualization in Preschool Technology Activities. *Journal of Research in Childhood Education*, 40(2), 209–223.

<https://doi.org/10.1080/02568543.2024.2425374>

I Studie III studerades interaktionen mellan barn och förskollärare i teknikaktiviteter med fokus på mekanisk teknik. Ett sociokulturellt perspektiv på begreppsutveckling användes, där teknik konceptualiseras på både vardagliga och vetenskapliga sätt (Vygotsky, 2016). Studien besvarar följande forskningsfråga: Hur iscensätts och interrelateras vardagliga och vetenskapliga konceptualiseringar av teknik i interaktionen mellan barn och förskollärare i teknikaktiviteter?

Den empiriska datan utgörs av videodokumenterade teknikaktiviteter med yngre förskolebarn (2 – 5 år), där både icke-verbal och verbal interaktion (gester, kroppsspråk, ljud) analyserats med sociokulturell interaktionsanalys - SIA (Wallerstedt et al., 2022). I resultatet synliggörs analytiskt hur barns och förskollärares interaktion växlar mellan vardagliga och vetenskapliga sätt att begreppsliggöra teknik. Exempelvis konceptualiseras en tejprulle och olika hjul på ett vardagligt sätt genom handling och på ett mer abstrakt och vetenskapligt sätt genom att tejprullens egenskaper och funktion jämförs med hjulet som en teknisk artefakt. Liknande mönster framträder i studiens andra exempel, där deltagarnas gester och ljud bidrar till att en hammare konceptualiseras på ett mer abstrakt och vetenskapligt sätt. Det tredje exemplet synliggör komplexiteten i barns konceptualiseringar av teknik där växlingen mellan vardagliga och vetenskapliga sätt att konceptualisera teknik är beroende av kontexten. I studiens resultat understryks barns bidrag i form av både vardagliga och begynnande vetenskapliga konceptualiseringar av teknik som centrala. Förskollärares lyhördhet och ämneskunskap betonas

när det gäller att erbjuda konkreta artefakter samt att tolka och stötta interrelationen mellan barns vardagliga och vetenskapliga konceptualiseringar av teknik.

Studie IV

Eliasson, S. (submittd) Exploring toddlers' agency in preschool technology activities.

Med utgångspunkt i sociokulturella perspektiv undersöktes i Studie IV hur toddlare utövar agens i teknikaktiviteter genom att studera toddlares och förskollärares interaktion med konkreta tekniska artefakter. Studien besvarar följande forskningsfråga: Hur utövar toddlare agens i de studerade teknikaktiviteterna, och vilken betydelse har detta för hur aktiviteten utvecklas?

Studiens empiriska data utgörs av två videodokumenterade aktiviteter i där sex toddlare (2 – 3 år) och två förskollärare från två olika förskolegrupper med ett uttalat teknikfokus deltar. Analysen genomfördes med hjälp av SIA – sociokulturell interaktionsanalys (Wallerstedt et al., 2022). I studiens resultat identifieras hur toddlare utövar agens genom sina initiativ till interaktion. Dessa initiativ innebär att de bidrar med konkret och abstrakt teknikkunskap till aktiviteten, vilket utvecklar och fördjupar teknikkunskapen och deltagarnas fokus på teknikkunskapen i aktiviteten. Dessutom visar studien att toddlare utövar agens genom att utmana eller göra motstånd mot förskollärarens målorienterade arbetssätt, och att detta möjliggörs av aktivitetens lekinramning, lärarens lyhördhet och responser, olika tillgängliga artefakter och toddlares tidigare kunskap och erfarenheter. Slutligen understryks vikten av att förstå toddlares utövade agens som en teknikkunskap i sig och som en förutsättning för och möjlighet till deras aktiva delaktighet i hållbara och demokratiska praktiker i förskolan och i samhället, nu och i framtiden.

Kapitel 6: Diskussion och slutsatser

I relation till avhandlingens första forskningsfråga visar resultatet på en bredd och variation i fråga om hur teknik och förskolans teknikundervisning förstås. Detta gäller både forskningsfältet och i avhandlingens empiriska studier och omfattar variationen av aktiviteter och hur de organiseras, liksom

den teknikkunskap som framträder i aktiviteterna. I Studie I kategoriserades tidigare forskning i fyra teman: två som fokuserar på förskollärares och blivande förskollärares ämnesspecifika kunskap och förståelse av teknik och förskolans teknikundervisning, samt två som fokuserar på förskolans teknikaktiviteter. Studier visar att både strukturerade och lärarledda aktiviteter samt utforskande och fri lek som ger utrymme för barns fria val har betydelse för barns lärande om teknik. Barns tidigare erfarenheter och kunskaper samt deras samarbete och problemlösning betonas som betydelsefullt, liksom förskollärares ämneskunskap och didaktiska förmågor. Resultatet av Studie I och II, där DiGironimos (2011) ramverk applicerats på empiriska data, visar att fyra av de fem dimensionerna av teknikens natur är väl representerade i tidigare forskning och i avhandlingens empiri. Däremot framträder den historiska dimensionen av teknikens natur endast i begränsad omfattning, vilket diskuteras nedan.

I relation till hur teknikens natur framträder i interaktionen visar avhandlingens resultat att barn i förskolan erbjuds flera olika sätt att konceptualisera teknik, nämligen som *artefakter*, *kreativa processer*, *mänsklig aktivitet* och *teknikens roll i dagens samhälle* (DiGironimo, 2011). I likhet med tidigare forskning (Boström et al., 2022) saknas däremot den historiska dimensionen av teknikens natur, vilket i avhandlingen inte kan förklaras utifrån förskollärares utbildning och kompetensutveckling eller förskolans teknikfokuserade kontext. I avhandlingen lyfts därför betydelsen av att den historiskt ackumulerade teknikkunskap, som är inbäddad i kulturella verktyg, synliggörs och externaliseras i teknikaktiviteter i förskolans teknikundervisning. Detta är betydelsefullt för att även den historiska dimensionen av teknikkunskap ska kunna uppmärksammas och för att vardagliga och vetenskapliga konceptualiseringar skall kunna interrelateras. Teknikens historiska dimension betonas som betydelsefull för toddlarnas kunskap om teknikens innovativa aspekter och för deras möjligheter att utveckla en bred och holistisk förståelse av teknik och dess nära samband med människan och samhället.

Som svar på avhandlingens andra forskningsfråga illustreras i avhandlingen hur toddlare konceptualiserar teknik på både vardagliga och begynnande vetenskapliga sätt i teknikaktiviteter med konkreta artefakter genom icke-verbal och verbal interaktion. I Studie II och III framhålls även hur förskollärares organisering av teknikaktiviteter som samtidigt målstyrda och lekinramade, med utrymme för barns initiativ, skapar tillfällen för

meningsfull interaktion kring teknik. Förskolans toddlare konceptualiserar teknik på vardagliga sätt och på generaliserade, begynnande vetenskapliga sätt. Toddllarna bidrar också aktivt till att dessa olika sätt att konceptualisera teknik interrelateras i meningsfulla samspel. I de empiriska studiernas resultat synliggörs hur vardagliga och vetenskapliga konceptualiseringar av teknik interrelateras. Toddlares icke-verbala och verbala interaktion tillsammans med användning av artefakter, förskollärares ämnesspecifika språk, öppna frågor liksom responsiva förhållningssätt, bidrar till att vardagliga konceptualiseringar av teknik interrelateras med mer generaliserade och begynnande vetenskapliga konceptualiseringar av teknik.

Som svar på den tredje forskningsfrågan visar det sammanlagda resultatet från Studie II, III och IV att toddlares icke-verbala och verbala interaktion bidrar till teknikaktiviteterna genom att rikta fokus mot olika dimensioner av teknikkunskap samt genom hur intersubjektivitet om teknik etableras, förhandlas och återetableras. När toddlare ger uttryck för teknikkunskap i interaktionen i teknikaktiviteterna, liksom när de visar motstånd mot och förhandlar om teknikinnehållet i aktiviteten, bidrar båda formerna av deltagande till att aktivitetens teknikfokus och teknikkunskap utvecklas och fördjupas. Toddlares utövade agens, som tar sig uttryck genom att de ställer frågor, föreslår och tar en guidande roll (Sairanen et al., 2022) liksom deras motstånd och utmanande initiativ i form av icke-verbal och verbal interaktion kring konkreta föremål understryks som betydelsefulla för hur förskolans teknikaktiviteter utvecklas och för hur teknikkunskap fokuseras, utvecklas och förtydligas. Förskollärare kan stötta toddlares delaktighet och utövade agens genom att legitimera (Boström et al., 2023) och svara på deras initiativ samt genom att konceptualisera den teknikkunskap som involveras i interaktionen. På detta sätt blir toddlares utövade agens både ett sätt att generera och utveckla teknikkunskap och en betydelsefull del av en demokratisk praktik så som den uttrycks i svenska förskolans läroplan.

I avhandlingen problematiseras toddlares konceptualisering av kulturella verktyg i form av konkreta föremål problematiseras. De konkreta föremålens betydelse för toddlares utövade agens och för toddlares och förskollärares vardagliga och begynnande vetenskapliga konceptualiseringar av teknik betonas, liksom hur de interrelateras i interaktion. Betydelsen av att använda konkreta föremål i teknikaktiviteter understryks framför allt när det gäller toddlares icke-verbala interaktion. Toddlares aktiva roll som medskapare av att konceptualisera teknik på både vardagliga och begynnande vetenskapliga

sätt betonas som betydelsefullt för deras delaktighet i att forma och appropriera teknikkunskap. Konceptuella kulturella verktyg understryks som kritiska för hur toddlare strukturerar och organiserar kollektiv teknikkunskap samt för toddlares gemensamma meningsskapande om teknik.

Avhandlingens didaktiska bidrag omfattar kunskap om hur toddlares icke-verbala och verbala konceptualiseringar av teknik kan ta sig uttryck i teknikaktiviteter, liksom om på vilka sätt vardagliga och vetenskapliga konceptualiseringar av teknik uttrycks och kombineras i interaktionen. Dessutom betonas toddlares utövade agens som betydelsefull för hur teknikaktiviteterna formas och för hur teknikkunskapen fokuseras och fördjupas. Här synliggörs även förskollärares betydelse för barns delaktighet i teknikaktiviteter, bland annat genom deras lyhörda responser, ämneskunskap och förmåga att uppmärksamma den teknikkunskap som barn uttrycker och att koppla den till både vardagliga och vetenskapliga konceptualiseringar av teknik.

Förslag på fortsatt forskning omfattar teknikens historiska dimension och hur den kan inkluderas och stöttas i förskolans teknikaktiviteter. I en svensk förskolekontext börjar toddlare i förskolan redan från tolv månaders ålder, vilket understryker vikten av fortsatt empiriskt utforskande av toddlares delaktighet och begreppsbyggande av olika dimensioner och aspekter av teknik.

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INSTITUTIONEN FÖR PEDAGOGIK, KOMMUNIKATION OCH LÄRANDE

Vill du och ditt arbetslag delta i en forskningsstudie om teknik?

Jag heter Sara Eliasson, och jag är licentiand i ReCEC forskarskola vid Göteborgs universitet. Jag är förskollärare och har arbetat i mer än 20 år inom förskolan, och sedan september 2018 forskar jag på deltid parallellt med mitt arbete som förskollärare vid Göteborg Högre Samskola.

Jag planerar att genomföra en studie om teknikundervisningen i förskolan. Teknik har ju fått en mer framskjuten plats i förskolans läroplan, men samtidigt finns det inte så mycket forskning om teknikundervisningen i svenska förskolor, så det är ett nytt spännande område att studera. Jag tycker det vore jättespännande att studera hur man kan jobba med teknik exempelvis utifrån barnlitteratur, och hoppas få komma och följa just er teknikundervisning med barnen. Min studie är inte inriktad på Läslýftet i sig, utan jag är nyfiken på era erfarenheter och tankar om teknikundervisning inom ramen för förskolans verksamhet. Baserat på detta är jag intresserad av att ta tillvara på er kunskap och erfarenhet och vilka möjligheter ni ser med att arbeta med teknik i er pedagogiska verksamhet i förskolan.

Min tanke är att följa det arbete ni gör i den vanliga verksamheten, och följa er planerade pedagogiska verksamhet under några samlingar eller er projekttid, beroende på hur ni vanligen lägger upp ert arbete. Det innebär alltså inga extrauppgifter för er som arbetslag, utan bara att ni ger mig möjligheten att följa er teknikundervisning, och jag är öppen för era förslag och idéer. Det är ni som jobbar ute i verksamheterna som kan visa mig detta, och med er hjälp hoppas jag att studien skall kunna bidra till att utveckla förståelse av förskolans teknikundervisning!

Aktiviteterna är tänkta att dokumenteras med hjälp av videokamera. Etiska aspekter kommer givetvis att beaktas, som exempelvis att endast de förskollärare och de barn vars föräldrar som skriftligen samtycker till deltagande kommer att delta, att alla som väljer att delta kommer informeras, att resultatet enbart kommer att användas i forskningssammanhang, och genom aidentifiering av deltagarna.

Studien ingår i min licentiatuppsats som jag skriver inom ramen för ReCEC forskarskola vid Göteborgs universitet, och mina handledare är Annika Lantz Andersson och Louise Peterson vid Institutionen för pedagogik, kommunikation och lärande.

Jag kommer gärna och har ett förutsättningslöst möte med er och berättar mer om hur jag tänkt mig upplägget med studien, och självfallet är jag också intresserad av era synpunkter.

Ta gärna kontakt med mig redan nu, så kan vi boka in ett möte efter jul!

Vänliga hälsningar Sara

Sara Eliasson, licentiand
ReCEC forskarskola

Institutionen för pedagogik, kommunikation och lärande, Göteborgs universitet

Kontakt Sara: sara.eliasson.2@gu.se tel: 0734-331302

Kontakt handledare: Annika Lantz Andersson: annika.lantz-andersson@ped.gu.se
Louise Peterson: louise.peterson@ped.gu.se

För information om forskarskolan ReCEC:
se <https://ipkl.gu.se/utbildning/forskarutbildning/forskarskolor/recec> eller kontakta vetenskaplig ledare
Niklas Pramling niklas.pramling@ped.gu.se tel. 031-7862563

Hej alla föräldrar och barn på xxx!

Jag heter Sara Eliasson och är doktorand vid Göteborgs universitet. Jag deltar i ReCEC forskarskola, samtidigt som jag arbetar med 1-3åringar på en förskola i Göteborg.

Jag är förskollärare och har arbetat inom förskolan sedan 1994, och nu har jag förmånen att få forska inom mitt eget yrke- jättekul!



Under hösten 2019 kommer jag att besöka xxx vid ca 4 tillfällen, för att studera teknikaktiviteter som lärarna gör med barnen. Det finns ganska lite forskning om teknikundervisning i förskolan, så det ska bli jättespännande att få se vad som händer under dessa aktiviteter.

Ni kanske kommer se mig bärandes på videokamera, och det är för att jag kommer att videofilma aktiviteterna. Det är **bara** de barn vars föräldrar **skriftligt har godkänt deltagande**, som kommer att filmas. Och såklart bara om barnen själva vill!

Jag ser verkligen fram emot att få inblick i hur era barn undervisas i teknik här på xxx!

Hälsningar Sara



SAMTYCKESBLANKETT (för vårdnadshavare till barn under 15 år)

Sidan 1(2)
2019-08-13

Till dig som är förälder till barn på xxx förskola

Samtycke till ert barns medverkan i forskningsstudie om teknikundervisning i förskolan

Vid några tillfällen under höstterminen 2019 kommer forskarstuderande Sara Eliasson vid Göteborgs universitet att genomföra en studie på xxx förskola. För detta behövs förskollärares, samt föräldrars/vårdnadshavares samtycke. Studien ingår i den licentiatuppsats som Sara skriver inom ramen för ReCEC forskarskola vid Göteborgs universitet. Handedare för uppsatsen är Annika Lantz Andersson och Louise Peterson vid Institutionen för pedagogik, kommunikation och lärande.

Kort presentation av studien

Studien kommer att undersöka hur teknikundervisning iscensätts i förskolan.

Studiens design innebär att förskollärares och barnens interaktion i förskolans teknikaktivitet kommer att videodokumenteras. Forskningsmaterialet kommer att användas för analys av interaktionen i teknikundervisningen. Vi vill betona att det är undervisning i relation till teknikaktiviteter som intressant för studien, och att enskilda förskollärares eller barns prestationer inte kommer fokuseras.

Förskolan och alla deltagarna i studien kommer att avidentifieras, för att skydda deltagarnas identitet. Namn kommer att ändras till fiktiva namn i alla texter som publiceras om studien. Eventuella videoinspelningar som används vid rapporteringar kommer att avidentifieras, så att barnen inte är möjliga att känna igen. Allt arbete inom studien kommer att ske i enlighet med Personuppgiftslagen (1998:204). Inspelningar kommer att förvaras på sätt som innebär att obehöriga inte kan få tillgång till dem. Videofilmer kommer enbart att användas i forsknings- och utbildningssammanhang.

De barn som själva inte vill delta, eller vars vårdnadshavare inte givit sitt samtycke till att låta sina barn delta i studien, kommer inte att videofilmas.

Deltagande barn, liksom barnens vårdnadshavare, kan under hela studiens gång välja att ångra eller avbryta deltagandet.

Kontaktpersoner vid frågor eller funderingar

Forskarstuderande: Sara Eliasson

sara.eliasson.2@gu.se

Handledare: Annika Lantz-Andersson

annika.lantz-andersson@ped.gu.se

Handledare: Louise Peterson

louise.peterson@ped.gu.se

Postadress
Box 300
SE 405 30 GÖTEBORG
SWEDEN

Besöksadress
Läroverksgatan 15
GÖTEBORG

Telefon
[Sara Eliasson](tel:0734-331302)
0734-331 302

Emailadress:
sara.eliasson.2@gu.se

Underskrift av vårdnadshavare

Eftersom denna typ av datainsamling kräver vårdnadshavares samtycke ber vi därför er föräldrar att meddela nedan om ert barn får delta i denna studie.

Medverkan i undersökningen är frivillig. Endast de barn som själva vill delta, och vars vårdnadshavare givit sitt samtycke att låta sina barn delta i studien, kommer att videofilmas.

Deltagande barn, liksom barnens vårdnadshavare, kan under hela studiens gång välja att ångra eller avbryta deltagandet.

Lämnas till pedagogerna på xxx senast den 20 september 2019

Informerat samtycke till mitt barns medverkan i forskningsstudie om teknikundervisning i förskolan

☐ Ja, jag ger tillstånd till att mitt barn medverkar i studien och tillåter dokumentation med hjälp av videoinspelning. Forskningsmaterialet får användas i forsknings- och utbildningssammanhang.

Datum: _____

Barnets namn: _____

Målsmans underskrift: _____

Namnförtydligande: _____

*Målsmans underskrift: _____

*Namnförtydligande: _____

* Vid delad vårdnad krävs båda föräldrars medgivande



MEDGIVANDEBLANKETT (för förskolans förskollärare)

Sidan 1(2)
2019-08-13

Till dig som arbetar på xxx förskola

Medgivande till medverkan i forskningsstudie om teknikundervisning i förskolan

Vid några tillfällen under höstterminen 2019 kommer forskarstuderande Sara Eliasson vid Göteborgs universitet att genomföra en studie på xxx förskola. För detta behövs förskollärares, samt föräldrars/vårdnadshavares medgivande. Studien ingår i den licentiatuppsats som Sara skriver inom ramen för ReCEC forskarskola vid Göteborgs universitet. Handledare för uppsatsen är Annika Lantz Andersson och Louise Peterson vid Institutionen för pedagogik, kommunikation och lärande.

Kort presentation av studien

Studien kommer att undersöka hur teknikundervisning kan iscensättas i förskolan.

Studiens design innebär att förskollärarnas och barnens interaktion i förskolans teknikaktivitet kommer att videodokumenteras. Forskningsmaterialet kommer att användas för analys av interaktionen i teknikundervisningen. Vi vill betona att det är undervisning i relation till teknikaktiviteter som intressant för studien, och att enskilda förskollärares eller barns prestationer kommer inte att fokuseras eller bedömas.

Förskolan och alla deltagarna i studien kommer att avidentifieras, för att skydda deltagarnas identitet. Namn kommer att ändras till fiktiva namn i alla texter som publiceras om studien. Eventuella videoinspelningar som används vid rapporteringar kommer att avidentifieras, så att barnen inte är möjliga att känna igen. Allt arbete inom studien kommer att ske i enlighet med Personuppgiftslagen (1998:204). Inspelningar kommer att förvaras på sätt som innebär att obehöriga inte kan få tillgång till dem. Videofilmerna kommer enbart att användas i forskningssammanhang.

De förskollärare eller de barn som själva inte vill delta, eller vars vårdnadshavare inte givit sitt medgivande att låta sina barn delta i studien, kommer inte att videofilmas.

Deltagande förskollärare och barn, liksom barnens vårdnadshavare, kan under hela studiens gång välja att ångra eller avbryta deltagandet.

Kontaktpersoner vid frågor eller funderingar

Forskarstuderande: Sara Eliasson

sara.eliasson.2@gu.se

Handledare: Annika Lantz-Andersson

annika.lantz-andersson@ped.gu.se

Handledare: Louise Peterson

louise.peterson@ped.gu.se

Underskrift av förskolans förskollärare

Eftersom denna typ av datainsamling kräver deltagande förskollärares medgivande ber vi därför er meddela nedan om ni vill delta i denna studie.

Medverkan i undersökningen är frivillig. Endast de förskollärare och de barn som själva vill delta, och vars vårdnadshavare givit sitt medgivande att låta sina barn delta i studien, kommer att videofilmas. Deltagande förskollärare och barn, liksom barnens vårdnadshavare, kan under hela studiens gång välja att ångra eller avbryta sitt deltagande.

Medgivande till medverkan i forskningsstudie om teknikundervisning i förskolan

☐ Ja, jag vill medverka i studien och tillåter att den dokumenteras med hjälp av videoinspelning. Forskningsmaterialet får användas i forskningssammanhang.

Datum: _____

Personalens underskrift: _____

Appendix 5 Chronological timeline for the conducted videoobservations

Date	191001	191003	191010	191016	191016	191024	191031	191105	191205	191205
	BG:1	LG:1	LG:2	WG:1	BG:2	LG:3	LG:4	WG:2	WG:3	BG:3
Preschool group	The Block Group	The Lever Group	The Lever Group	The Wedge Group	The Block Group	The Lever Group	The Lever Group	The Wedge Group	The Wedge Group	The Block Group
Activity	Glueing small objects to a model of a train coach.	Analogue programming each other. Sequence.	Creating patterns using Ozmo application on digital tablet	Exploring wheels, tape roll. Wheel hunt outside.	Exploring various trains and parts of a train station.	Coding routes for mini robots using analogue and digital tools.	A literacy activity about the wheel using small wooden characters.	Pretend play creating a vehicle.	Designing and creating a model of a wheel.	Creating a train coach model, glueing wheels to wheel axle.
Participants	FRIDA Kurt Jon Klara	FATIMA Hector Ayia Hilda	FELICIA Ayia Hilda	FIONA Carl Martha Philip	FRIDA Kurt Jon Klara	FATIMA Hector Hilda	FELICIA Ayia Hilda	FIONA Carl Martha David Kerstin	FIONA David Kerstin	FRIDA Kurt Jon

Previous publications:

Editors: Kjell Härnqvist and Karl-Gustaf Stukát

1. KARL-GUSTAF STUKÁT *Lekskolans inverkan på barns utveckling*. Stockholm 1966
2. URBAN DAHLÖF *Skoldifferentiering och undervisningsförlopp*. Stockholm 1967
3. ERIK WALLIN *Spelling. Factorial and experimental studies*. Stockholm 1967
4. BENGT-ERIK ANDERSSON *Studies in adolescent behaviour. Project Yg, Youth in Göteborg*. Stockholm 1969
5. FERENCE MARTON *Structural dynamics of learning*. Stockholm 1970
6. ALLAN SVENSSON *Relative achievement. School performance in relation to intelligence, sex and home environment*. Stockholm 1971
7. GUNNI KÄRRBY *Child rearing and the development of moral structure*. Stockholm 1971

Editors: Urban Dahllöf, Kjell Härnqvist and Karl-Gustaf Stukát

8. ULF P. LUNDGREN *Frame factors and the teaching process. A contribution to curriculum theory and theory on teaching*. Stockholm 1972
9. LENNART LEVIN *Comparative studies in foreign-language teaching*. Stockholm 1972
10. RODNEY ÅSBERG *Primary education and national development*. Stockholm 1973
11. BJÖRN SANDGREN *Kreativ utveckling*. Stockholm 1974
12. CHRISTER BRUSLING *Microteaching - A concept in development*. Stockholm 1974
13. KJELL RUBENSON *Rekrytering till vuxenutbildning. En studie av kortutbildade yngre män*. Göteborg 1975
14. ROGER SÄLJÖ *Qualitative differences in learning as a function of the learner's conception of the task*. Göteborg 1975
15. LARS OWE DAHLGREN *Qualitative differences in learning as a function of content-oriented guidance*. Göteborg 1975
16. MARIE MÅNSSON *Samarbete och samarbetsförmåga. En kritisk granskning*. Lund 1975
17. JAN-ERIC GUSTAFSSON *Verbal and figural aptitudes in relation to instructional methods. Studies in aptitude - treatment interactions*. Göteborg 1976
18. MATS EKHOLM *Social utveckling i skolan. Studier och diskussion*. Göteborg 1976

19. LENNART SVENSSON *Study skill and learning*. Göteborg 1976

20. BJÖRN ANDERSSON *Science teaching and the development of thinking*. Göteborg 1976

21. JAN-ERIK PERNEMAN *Medvetenhet genom utbildning*. Göteborg 1977

Editors: Kjell Härnqvist, Ference Marton and Karl-Gustaf Stukát

22. INGA WERNERSSON *Könsdifferentiering i grundskolan*. Göteborg 1977
23. BERT AGGESTEDT & ULLA TEBELIUS *Barns upplevelser av idrott*. Göteborg 1977
24. ANDERS FRANSSON *Att rädas prov och att vilja veta*. Göteborg 1978
25. ROLAND BJÖRKBERG *Föreställningar om arbete, utveckling och livsrytm*. Göteborg 1978
26. GUNILLA SVINGBY *Läroplaner som styrmedel för svensk obligatorisk skola. Teoretisk analys och ett empiriskt bidrag*. Göteborg 1978
27. INGA ANDERSSON *Tankestilar och hemmiljö*. Göteborg 1979
28. GUNNAR STANGVIK *Self-concept and school segregation*. Göteborg 1979
29. MARGARETA KRISTIANSSON *Matematikenskaper Lgr 62, Lgr 69*. Göteborg 1979
30. BRITT JOHANSSON *Kunskapsbehov i omvårdnadsarbete och kunskapskrav i vårdutbildning*. Göteborg 1979
31. GÖRAN PATRIKSSON *Socialisation och involvering i idrott*. Göteborg 1979
32. PETER GILL *Moral judgments of violence among Irish and Swedish adolescents*. Göteborg 1979
33. TAGE LJUNGBLAD *Förskola - grundskola i samverkan. Försättningar och binder*. Göteborg 1980
34. BERNER LINDSTRÖM *Forms of representation, content and learning*. Göteborg 1980
35. CLAES-GÖRAN WENESTAM *Qualitative differences in retention*. Göteborg 1980
36. BRITT JOHANSSON *Pedagogiska samtal i vårdutbildning. Innehåll och språkbruk*. Göteborg 1981
37. LEIF LYBECK *Arkimedes i klassen. En ämnespedagogisk berättelse*. Göteborg 1981
38. BJÖRN HASSELGREN *Ways of apprehending children at play. A study of pre-school student teachers' development*. Göteborg 1981

39. LENNART NILSSON *Yrkesutbildning i nutidshistoriskt perspektiv. Yrkesutbildningens utveckling från skräväsandets uppbörande 1846 till 1980-talet samt tankar om framtida inriktning*. Göteborg 1981

40. GUDRUN BALKE-AURELL *Changes in ability as related to educational and occupational experience*. Göteborg 1982

41. ROGER SÄLJÖ *Learning and understanding. A study of differences in constructing meaning from a text*. Göteborg 1982

42. ULLA MARKLUND *Droger och påverkan. Elevanalys som utgångspunkt för drogundervisning*. Göteborg 1983

43. SVEN SETTERLIND *Avslappningsträning i skolan. Forskningsöversikt och empiriska studier*. Göteborg 1983

44. EGIL ANDERSSON & MARIA LAWENIUS *Lärares uppfattning av undervisning*. Göteborg 1983

45. JAN THEMAN *Uppfattningar av politisk makt*. Göteborg 1983

46. INGRID PRAMLING *The child's conception of learning*. Göteborg 1983

47. PER OLOF THÅNG *Vuxenlärares förhållningsätt till deltagarerbefar. En studie inom AMU*. Göteborg 1984

48. INGE JOHANSSON *Fritidspedagog på fritidsbem. En yrkesgrupps syn på sitt arbete*. Göteborg 1984

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Toddlers encounter technology long before they enter educational contexts, yet little is known about how they develop technology knowledge in everyday interactions. This thesis explores toddlers' and preschool teachers' interactions involving mechanical technology. Informed by sociocultural perspectives on learning, concept formation, and agency, the thesis draws on video observations of technology activities in Swedish preschools. The results demonstrate how toddlers' initiatives, interactions, and agency contribute to and shape technology activities in preschool. The results specifically highlight the significance of toddlers' initiatives and active contributions in preschool technology activities, specifically regarding how various dimensions of technology knowledge emerge in interactions, how everyday and emerging scientific conceptualisations of technology are interrelated, and how toddlers exercise agency involving non-verbal and verbal conceptual and tangible cultural tools that change and expand the technology knowledge or the organisation of the activity.

Toddlers' initiatives and exercised agency related to technology are understood as important for developing technology knowledge and supporting democratic practices in accordance with the relational, holistic, and sustainable principles guiding Swedish preschools. The thesis also provides empirically grounded arguments for understanding technology as encompassing toddlers' agency as part of innovative and creative interactions through which technology knowledge is generated, negotiated and connected to the collective knowledge of humankind.



Sara Eliasson has a background as a preschool teacher. Her research interests focus on toddlers' learning as social and collaborative practices in which toddlers' non-verbal interactions specifically are recognised as significant for their participation and contributions to technology activities.

