MAKING AND MAKER-ORIENTED ACTIVITIES WITH DIGITAL TOOLS IN EARLY CHILDHOOD EDUCATION: A QUALITATIVE RESEARCH SYNTHESIS

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Thesis submitted to the University of Ottawa
in partial Fulfillment of the requirements for the degree of
Master of Arts - Education in Studies in Teaching and Learning

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Abstract

This qualitative research synthesis examines the design of existing studies on making and maker-oriented activities with digital tools (Digital Making) in early childhood settings. This synthesis also provides an overview of teachers' understanding of Digital Making, and how teachers implement Digital Making in their teaching practice. To be included in this synthesis, studies needed to (a) focus on Digital Making, (b) include evidence of early childhood teachers' perspectives on Digital Making, (c) include children aged three to eight as Digital Makers, and (d) be situated in a formal educational setting. Given that young children's making activities with digital tools are limited by children's exposure to digital materials, I also considered studies in which children manipulated digital devices in ways that enabled them to develop foundational maker orientations and skills. Although 274 studies were considered, only seven studies met these criteria. Analyses show that the seven selected studies are grounded in the theoretical perspectives of constructivism, embodiment, and empowerment as an essential part of early childhood learning. These seven studies were conducted in a range of contexts with many different kinds of digital tools such as programable robots, remote toys, iPads, and 3D printers. Teachers viewed Digital Making as child-centred and engaging. They also reported using making and maker-oriented activities to support children's learning of problem-solving skills, social skills, and digital literacies. To better integrate Digital Making at scale, however, more training and support for teachers is likely needed.

Acknowledgement

I want to express my gratefulness to the Faculty of Education of the University of Ottawa for admitting me, accepting my transition to this program, and supporting me in many ways. I especially want to thank my supervisor Dr. Michelle Schira Hagerman. Thank you for leading me into research about making activities. Thank you for teaching me how to do research and how to write a paper. You have given me the energy to support me in finishing this project and surviving through the "lostness" I felt during the COVID-19 pandemic. I also want to thank the members of my committee, Dr. John Richardson and Dr. Christine Tippett, for their comments, insights, and encouragement. Thank you all for teaching me how to be a researcher. I want to thank Haixuan Zhang, Chuan Liu, and Xiaoling Luo, my friends and research buddies, for giving me advice and making progress together during this journey. I learned so much from this exceptional group of people.

I would like to thank my mother, Yijun Li, my husband, Weijia Yu, and my parents in law, Rongning Yu and Hong Wang, for supporting me and taking away my life stress. Last but not least, to my dogs, Pidan and Bijou, and my cats, Pumbaa, Elsa, Momo, and Timon: thank you for comforting me and keeping me accompanied.

Introduction

More than a century ago, Dewey (1906) wrote about the importance of hands-on, experiential learning activities for young children.

> The fundamental point in the psychology of an occupation is that it maintains a balance between the intellectual and the practical phases of experience. As an occupation, it is active or motor; it finds expression through the physical organs—the eyes, hands, etc. (p. 133).

A modern take on Dewey's ideas, making and maker-oriented activities for young children include manipulating both physical and digital materials to create things (Marsh, 2018; Wohlwend, 2017).

In formal contexts of early childhood education such as preschool and kindergarten classrooms, children may make handicrafts with paper and scissors, and make physical products with digital tools such as 3D printers during maker-oriented activities (Peppler et al., 2019). Both of the making activities with physical tools and digital tools require children to use their hands to manipulate materials, and use tools that enable them to create something new. What differentiates digital making from traditional handicrafts, however, is the use of digital tools to design and/or produce objects. Wolhwend (2017) defined maker-oriented activities in early childhood contexts as a combination of design and technology, in which children explore things like "textile crafts, robotics, electronics, digital fabrication, mechanical repair of everyday appliances, digital storytelling, arts and crafts" (p. 445). As identified by Blikstein (2013), making, or maker-oriented activities may be pedagogically useful because they include foundational aspects of multiple theories that explain how meaningful learning happens: constructionism (Papert, 1980), experiential education (Dewey, 1906; Montessori, 1964), and critical pedagogy (Freire, 1974; Illich, 1970) (p. 4). Constructionism emphasizes the idea of producing and sharing personal products in the construction process based on theory of constructivism (Jonasson et al., 1996; Martinez & Stager, 2013). Constructivism asserts that learning takes place in activity, through processes of meaning making that build on prior knowledge and in ways that are supported by more knowledgeable others (Dewey, 1906; Jonassen, 2010; Vygotsky, 1978). For this thesis, I used constructivism instead of constructionism as one of my theoretical frameworks to open my analysis to children's process of constructing with a variety of materials and for a variety of purposes. While making, children practice problem-solving, social skills in collaboration with peers, and interact with a range of materials – all of which align with aspects of constructivist theories (Halverson & Sheridan, 2014; Wohlwend, 2017). For experiential learning, Blikstein (2013) cited from scholars such as Dewey (1906) and Montessori (1964) to support the idea of child-centred, experiential activities that were connected to real-world objects.

In the early education context, the theory of embodiment can be a practice of experiential education. While making, children engage multiple senses while interacting with various materials and their environment to learn knowledges and develop skills. These ideas are central to theories of embodiment, which emphasize that learning is situated in the interactions between human sensory systems and the materials people (children) use in their environment (Glenberg, 2010; Hagerman & Cotnam-Kappel, 2019; Rowsell & Shillitoe, 2019).

Freire's descriptions of critical pedagogy (1974) emphasize that education should develop people's critical consciousness. Although young children are not likely to understand power and its use in educational systems, Blikstein (2013) suggests that young children can learn to become critical thinkers and problem solvers through making, and that these foundational mindsets or dispositions are precursors to other skills needed to grow into agents for systemic change. Evidence suggests that making and maker-oriented activities can support children's development of agency when the activities let children take the lead in ways that empower them (Clapp et al., 2020). It is also beneficial in terms of attracting children's attention when the activities are based on their life experiences and their cultural contexts (Blikstein, 2013; McCausland-Hartman, 2017; Rowsell & Shillitoe, 2019; Wohlwend, 2017).

Evidence suggests that through making and maker-oriented activities, children can also practice important dimensions of digital literacy, which includes "information, media, and technology skills" (Hockly, 2012, p. 108). As conceptions of literacies have taken a "digital turn" (Mills, 2010, p. 246), it is now understood that children must learn to make meaning with digital texts and in a range of digital contexts using digital tools such as laptop computers and mobile phones (Mills, 2010). Therefore, one way for children to begin to understand the affordances of digital tools is for teachers to integrate these tools into children's creative and play-based learning activities. Making and maker-oriented activities with digital tools can be leveraged to support children's emergent digital literacy skills while also providing play opportunities, open creative exploration, and hands-on activity (Ritchhart et al., 2011).

To date, however, making and maker-oriented activities with digital tools are rarely reported in the academic scholarship on early childhood teaching and learning, according to Marsh et al. (2018), "the specific concerns of early childhood educators in the area are rarely addressed in the literature" (p. 2), while Forbes et al. (2021) mentioned the "potential of makerspaces in early years education to support young children's development … (with) new digital tools such as 3D technologies (apps and printers)" (p. 173). The paucity of research is surprising, given evidence of making as a developmentally appropriate method for open, creative play with digital and physical materials (Blikstein, 2013; Clapp et al., 2020; Glenberg, 2010; Hagerman & Cotnam-Kappel, 2019; Halverson & Sheridan, 2014; McCausland-Hartman, 2017; Ritchhart et al., 2011; Rowsell & Shillitoe, 2019; Wohlwend, 2017). One possible reason for the limited number of empirical studies could be a lack of digital tools and maker materials in early childhood classrooms, which means that it would be difficult to plan for and study digital making activities. Another reason may be that digital making is not broadly taught in pre-service teacher preparation programs or as part of in-service teacher professional learning. Without access to professional development opportunities, early childhood teachers may not know how to integrate making and maker-oriented activities with digital tools into their instructional programs. Teacher training for digital making would need to address a range of pedagogical and technological issues that inform teachers' work with young children in schools including how to (a) plan activities and prepare the learning environment to support children in their practices of motor skills, social skills, and emergent literacies in activity, (b) know what kinds of digital tools can be used to meet their students' needs, and how to use them for children's learning, and (c) have the knowledge of assessment and evaluation of the learning outcomes (Marsh et al., 2017; Sillat et al., 2017).

To these ends, it would be useful, however, to know about the perspectives of early childhood teachers who have taken the leap to use "making" in their classroom practices. A synthesis of their perspectives could support the development of targeted professional learning programs aimed at addressing the key barriers and opportunities identified by those who have actually worked with young children on making and maker-oriented activities with digital tools.

To address this need, this study examines the insights provided by early childhood educators who have used making and maker-oriented activities with digital tools as a teaching intervention with their young students. The study is centered on the following research questions:

1) How have studies of making and maker-oriented activities with digital tools in early childhood classroom settings been designed?
   a) What were the contexts of these studies?
   b) What digital tools have been used in these studies, and for what purposes?
   c) How, if at all, have these activities been designed to align theoretically with tenets of constructivism, embodiment, and empowerment pedagogy?
2) How do teachers understand making as a teaching method?
   a) Using documentation of teachers' lesson planning and retrospective interview data reported in studies of making in early childhood classroom contexts, what can we learn about how early childhood teachers' conceptualize and then implement Digital Making in their classroom practices?

To address these questions, I analyzed the design of studies and their findings about early childhood teachers' perspectives of making and maker-oriented activities in three ways.

First, I synthesized the types of activities and tools reported in these studies. Second, I conducted a top-down analysis of these studies using foundational tenets of constructivism, embodiment, and empowerment pedagogy. This analysis provides an overview of the ideas that undergird the design of these studies, and of teachers' perspectives of digital making which, in turn, enables us to see which ideas are most common, and which aspects of these theories are rare or absent. Third, I conducted a bottom-up analysis using data provided in the included studies. I analyzed the perspectives of teachers who had experience in practicing making and maker-oriented activities with digital tools so that I could come to understand how they conceptualize making, and how they plan for digital making pedagogically.

Definition of Making and Maker-oriented Activities with Digital Tools

Before discussing the definition of Digital Making, I will define making and maker-oriented activities.

Making and maker-oriented activities in education find their origins in the maker movement (Halverson & Sheridan, 2014). According to Halverson and Sheridan (2014), the maker movement drew people's attention to the production of artifacts and the production process in physical or digital form, which was the foundation of making in education. The work by Halverson and Sheridan (2014), now considered a seminal article in maker education, was the first to identify the potential of the maker movement in systems of schooling.

There are many definitions of making and maker-oriented activity in early childhood contexts. Wolhwend (2017), whose work focuses on making in early childhood classroom contexts, defined making as a combination of design and technology. In their making and maker-oriented activities, children could create almost anything, "textile crafts, robotics, electronics, digital fabrication, mechanical repair or everyday appliances, digital storytelling, arts and crafts" (p. 445). Wohlwend (2017) also valued the children's interaction with materials and peers in the making process. Moreover, Sheridan and colleagues (2014) emphasized that in making and maker-oriented activities, children not only create things, but also explore ideas, learn technical skills, and learn to become creative with physical and/or digital tools. Honey and Kanter (2013) also pointed out that making in early childhood settings can be viewed as "design-make-play learning methodologies" (p. 4). From a theoretical perspective, making has been conceptualized as a constructivist pedagogy (Halverson & Sheridan, 2014; Vossoughi et al., 2016) which, as

Spiro and DeSchryver (2009) describe, should provide learners with “full explanations and worked examples” in addition to opportunities to practice new skills rather than teaching general rules or “essential information” (p. 120). Taking this information together, I define making and maker-oriented activities in early childhood contexts as activities that involve the creation of physical and digital artifacts, and that include the exploration of new ideas, opportunities to develop making skills, and that include interactions with materials and peers.

Whereas making, generally, can include use of digital and physical tools and materials, Digital Making emphasizes use of digital tools. With digital technologies, children can explore scientific concepts like electrical circuits using tools such as Makey Makey (Hagerman, 2017) or squishy circuits that use conductive play dough, wires, and a battery power source (Peppler et al., 2019). Children can also design and make physical productions with 3D printers. Moreover, Digital Making in early childhood education can meet the educational objectives of digital literacy instruction, which includes teaching children how to use a range of digital tools, and how to make meaning with digital texts in a range of digital contexts using digital tools such as laptop computers and mobile phones (Mills, 2010). Considering the fact that young children have limited abilities for making physical products with digital tools, I include physical manipulation as making and maker-oriented activities. The idea of making and maker-oriented activities are to construct and produce or learn abstract knowledge though physical manipulation. In this study, Digital Making is therefore defined as activities that involve the creation or manipulation of physical and digital artifacts with *digital* tools, and that involve a process of exploration of new ideas, development of digital literacies components such as information, media, and technology skills, as well as digital making and meaning-making skills, along with interaction with materials and peers.

Theoretical Framework

I have opted to present the theoretical framework for this study before the literature review for three reasons. First, Digital Making for early childhood education is the pedagogy of making and maker-oriented activities with specific tools, digital tools. Therefore, the theoretical foundation of making and maker-oriented activities also applies to Digital Making. Second, I reviewed literature that supports how Digital Making met children's learning needs based on the theories. And third, in this qualitative research synthesis, I synthesised theoretical frameworks of studies about Digital Making and teachers' understanding of Digital Making based on the theories that supported Digital Making in early childhood education.

Making and maker-oriented activities in education have only developed in recent decades starting from the Maker Movement (Halverson & Sheridan, 2014). However, the ideas behind the Maker Movement and digital fabrication in education are over a century old and are based on the theories of experiential education – which includes elements of constructivism, embodiment, and empowerment pedagogy (Blikstein, 2013). In this study, I use the principles of these theories to inform my analyses.

The Theory of Constructivism

Constructivist pedagogy is different from direct instruction. Constructivist teaching is not teaching general rules or "essential information" but providing learners with "full explanations and worked examples" in addition to opportunities to practice new skills (Spiro & DeSchryver, 2009, p. 120). As a theoretical perspective, constructivism asserts that learning takes place in activity, through processes of meaning making that build on prior knowledge and are supported by more knowledgeable others (Dewey, 1906; Jonassen, 2010; Vygotsky, 1978).

Making, too, is a constructivist pedagogical approach when integrated in classrooms. In making and maker-oriented activities, the learning purpose or trigger can come from both teachers and students (Rowsell & Shillitoe, 2019), which means that it is important for teachers, who typically do all of the planning in classroom settings, to remain open to children's ideas and to be flexible in their approach to lesson planning. In early childhood contexts, making and maker-oriented activities not only emphasize child-centred learning but must also include the intentional design that scaffolds children's learning, and meets curriculum expectations. Teachers play a fundamental role because they create learning conditions and provide guidance to support children's problem-solving activities (Blikstein, 2013). For example, Hagerman's (2017) paper on teachers' planning of a STEM lesson with making activity indicated the importance of layering in supports for children's learning.

Some scholars have described learning through digital making as constructionist rather than constructivist (Martinez & Stager, 2013). Constructivism, however, expresses the notion that knowledge is built by the learner, while constructionism includes the further idea that the knowledge-building process happens more felicitously when the learner is engaged in an external and sharable construction, like "a sandcastle, a machine, a computer program, a book" (Papert. 1991, p. 3). Constructivism is the more generic concept, which supports that learning is through the production of external products, while constructionism emphasizes learners as constructors and producers of personal and shareable products (Jonasson et al., 1996). In this way, making and maker-oriented activities can certainly be viewed as constructionist. For the purposes of this paper, however, I used the broader constructivist theoretical framing so as not to constrain my analyses too narrowly. A focus on product may constrain important insights related to process, or children's interactions with a range of materials, and in collaboration, as part of their making and maker-oriented learning. This study focused on learning with digital devices to facilitate the process of producing digital and/or physical objects. Therefore, I use the educational theory of constructivism in my study, and position constructionism as informed by, or derivative of, constructivism.

Multiple aspects of constructivism support making as an appropriate pedagogy for young children. Dewey (1916) suggested that thinking "cannot be transferred causally from an individual to another" but can be reconstructed and interpreted in education (p. 186). The theory of constructivism suggests that learning happens in social activities as people exchange their ideas and experiences. Sutinen (2008) wrote that children "construct, modify and interpret the information they encounter in their relationships with the world" (p. 1). Martinez and Stager (2013) stated that the maker movement was based on constructivism and focused on developing learners' problem-solving skills and productive ability with digital or physical materials. I used the essential elements of constructivism as an analytical heuristic for understanding the extent to which Digital Making activities in early childhood classrooms have been designed according to constructivist principles. The elements are: (a) children's learning should come from social activities, (b) children's learning should come from interactions of relationships between children and materials, (c) learning activities should support children's development of productive skills, and (d) learning activities should support children's development of problem-solving skills.

The Theory of Embodiment

Embodiment is the understanding that "all physical processes are influenced by body morphology, sensory systems, motor systems, and emotions" (Glenberg, 2010, p. 586). Its application in education is the understanding that the meaning-making process comes from our senses, and our body gathers information so that thinking can happen. When considering making and maker-oriented activities as embodied learning, the theory of embodiment is situated in the process of students' sensory and physical interactions with materials and the environment. In Hagerman and Cotnam-Kappel's (2019) example, interactions with materials supported children's meaning-making as they first navigated information online and then used physical materials to construct musical instruments from recycled cardboard, plastic, wood, and other art materials. As Barsalou (2010) stated, the theory of embodiment also emphasizes the vital role of the environment in learning - that learning happens in the interaction between body and environment, and the environment works as a scaffolding for the brain thinking through the senses. Moreover, making and maker-oriented activities require students to use tools in new ways, for new purposes, and to make new things (Hagerman & Cotnam-Kappel, 2019). Applied to making and maker-oriented activities, an embodiment perspective situates learning in the child's interactions with materials and environment. What a child learns through making is inextricable from their sensory, emotional and physical experiences and must therefore be understood as such by the educators who plan for their learning each day. I used the essential elements of constructivism as an analytical heuristic framework for understanding the extent to which digital maker activities in early childhood classrooms have been designed according to constructivist principles. The elements are: (a) learning is a meaning-making process that comes from our senses, (b) environment provides interactions for learning, and (c) learning should include using tools for new purpose, in new way, to make new things.

Empowerment Pedagogy

I use empowerment pedagogy to describe learning activities that create the conditions through which young children can learn to think critically about a range of problems. Critical pedagogy scholar Paolo Freire (1974) wrote about the importance of “culturally meaningful curriculum construction” (p. 5), which Blikstein (2013) discussed in relation to making and maker-oriented activities. According to Blikstein (2013), cultural-based learning enabled children connect their learning projects with meaningful problems at a personal or community level, which made the process of making become both educational and empowering. Others have taken up these ideas in their scholarship on making too. For example, culturally situated learning, child-centred learning, and empowerment are key design features of scholarship by Clapp et al. (2020), Marsh et al (2018), and Wohlwend (2017). In the framework of maker-centered learning, presented by Clapp et al. (2020), maker empowerment is one of the two core concepts, representing “a sensitivity to the designed dimension of objects and systems along with the inclination and capacity to shape one’s world through building, tinkering, re/designing, and/or hacking” (p. 2).

Therefore, I use empowerment pedagogy as the third theoretical perspective that informs my analyses of making and maker-oriented activities with digital tools in early childhood contexts. Empowerment pedagogy, as practiced in early childhood education, should include learning informed by elements of the local culture. Children may construct products using themes informed by their understanding of their culture, or through interactions with members of the local community. Empowerment pedagogy also emphasizes that students’ learning should be deeply connected to real-world problems that relate to themselves or their living context and issues of power and justice. And thus, the process of finding solutions to those problems can fulfill the requirements of education and empower students’ agency and citizenship at the same time (Blikstein, 2013). The elements of empowerment pedagogy used in my analyses are: (a) learning should be based on meaningful problems related to culture, and (b) learning should contribute to children's agency development.

In the review of literature, I discuss how making and maker-oriented activities meet young children's learning needs based on these three theories.

Literature Review

The literature review is divided into several parts. Using constructivism, embodiment and empowerment pedagogy as my organizational heuristic, I describe studies that show how making and maker-oriented activities meet children's learning needs in the early childhood education context according to each of these theories. Next, I review studies that describe teachers' practices in making and maker-oriented activities. Given that Digital Making is a subcategory of Making – one that requires teachers' knowledge and ability to use digital tools, I then review studies about early childhood teachers' use of digital tools in their teaching as well. Informed by evidence from the studies I review, I finish this section with a description for why this study is needed and the statement of research questions.

How can Making and Maker-oriented Activities in Early Childhood Classroom Meet Children's Learning Needs? Theoretical Perspectives

In this section, I review what is understood about making and maker-oriented activities in early childhood teaching contexts and how these activities can be adapted to meet children's learning needs. I focus on evidence from studies that have shown how making and maker-oriented activities (including Digital Making) are beneficial for young children's learning in ways that align with tenets of constructivism, embodiment, and empowerment pedagogy.

Making and Maker-oriented Activities Meeting Children's Learning Needs from Constructivism Perspective

During the making process, children bring their life experiences into their work while building their social identity and developing social skills. Several studies have described the ways that young children practice social interactions through making. Marsh et al. (2018) researched how making activities can support children's social development. Through making and maker-oriented activities, children built a strong sense of social inclusion through interactions with people from different professions like academics, museum educators, librarians, makerspace staff, and artists. With support from adults, children participated in many different activities using many different materials such as LEGO, arts and crafts materials, programming, and robotics. For example, in one Finnish setting, children discussed their culture spirits in the forest that were protecting their nature and themselves. The project starts with joint reading of children and teacher of the *Whisper of the Spirit* literature. Then, children were introduced to the totem pole as an important cultural artifact of the Indigenous peoples of the Pacific Northwest (First Nations Studies Program, n.d.). After information-searching on iPad (the digital component of this Maker activity) children came up with the idea of spirits of the forest. They sketched their designs of spirits on paper, made plans of what materials they would like to use, and collected the materials from woods. They then made totem poles from cardboard and natural materials such as nuts with shapes of animals to protect the forest and people. The project was intended to "enhance the children's maker literacies and maker citizenship via the children's engagement in developing multimodal narratives on the Finnish forest through the construction of material artefacts and digital storying" (p. 8). The results of this study showed that making and maker-oriented activities could support young children in thinking about how they belong to a community, about their identities, and how they can engage in their community.

From the theory of constructivism, making and maker-oriented activities can be understood as ways to engage the whole child in hands-on, problem-solving processes of constructing that also situate the learning in children's lives, communities and cultures. Children develop social skills of communication and collaboration during making and maker-oriented activities. Other than connecting children with their living context, making and maker-oriented activities also enable children to interact with the materials and environment. I discuss how making and maker-oriented activities meet children's learning needs from the perspective of the theory of embodiment in the following section.

Making and Maker-oriented Activities Meeting Children's Learning Needs from Embodiment Perspective

In relation to Dewey's ideas, the essential concept of Digital Making in education is how children interact with materials (Marsh, 2018; Wohlwend, 2017). In some ways, making and maker-oriented activities create ideal conditions for children to learn in activity, and through their senses with new materials. Marsh et al. (2018) also proposed that learning through making could combine formal and informal learning. In their study, "projects are being undertaken in which makerspaces are offered in a range of formal and non-formal settings, such as nurseries, schools, community spaces, museums, and libraries" (p. 7). They suggested that the integration of making and maker-oriented learning objectives could disrupt top-down rules and constraints imposed by government educational policies. Ideas of child-centered and hands-on learning from making and maker-oriented activities may actually move systems toward more developmentally appropriate methods of instruction for young children. For example, Peppler et al. (2019) pointed out that young children from age three to five should have many different opportunities to learn and express their understanding of learning concepts through senses like "gesture and actions" before verbalizing it (p. 125). They also suggest that teachers should provide students with an open-ended environment for learning through trial and error. As mentioned in their study, "squishy circuits use non-insulated materials […] making short circuiting mistakes possible and productive" (p. 125). In this way, the learning that happens is situated in the child's manipulation of the materials which, in turn, can become a condition for the development of new understandings.

In terms of the impact of environment on children's literacy development, evidence from research by Wohlwend (2017) suggested that children from age three to five could benefit from opportunities to explore in open-ended activities, without any worry about evaluation or judgment of their "performance." The ultimate goal for creating the learning environment for making activities in early childhood classrooms is to "transform pedagogical environments into spaces of possibility through sensory and affective practices" (Rowsell & Shillitoe, 2019, p. 1544). This emphasis on open-ended learning environments in the studies by Wohlwend, Rowsell and Shillitoe means that children have to use multiple sensory systems through cycles of trial and error. This aligns with the theory of embodiment.

In the next section, I describe the third theoretical perspective, empowerment pedagogy.

Making and Maker-oriented Activities Meeting Children's Learning Needs from Empowerment Pedagogy Perspective

Children's interaction with materials brings up another discussion about children's identity development through the lens of empowerment pedagogy. The research team *Agency by Design* defined maker-oriented activities as a pedagogy that "fosters individual and collective agency and empowers young people to shape their worlds" (Clapp et al., 2020, p. 2). Children's agency is their ability to direct and regulate their own learning activities. During a making and maker-oriented activity, children take charge of their decision-making, actions, and meaning making. Children are empowered through the making activity when their sensitivity to design develops (Clapp et al., 2020). Through these experiences of making and designing, children build up their agency as independent learners. The development of agency in children's early years enables them to build up critical consciousness in future, which is one of the fundamental goals in education according to Freire (1974).

Making and maker-oriented activities are commonly situated in makerspaces that are outside classrooms (Martin, 2015). Makerspaces as learning environments can support child-centred learning because children can take the lead and make their decisions in the making process while acquiring hands-on making skills, cognitive understanding about materials, and social and emotional skills in a collaborative endeavour. Rowsell and Shillitoe (2019) investigated craftivism as a makerspace practice where learning is child-centred, and children's feelings and thinking were valued. The study showed the importance of valuation children's perspectives, which is another form of empowerment (Rowsell and Shillitoe, 2019). Moreover, they emphasized that the child-centred learning could not break away from teachers' direction and scaffold. Another survey research by Lahmar et al. (2017) found that educators in informal education settings, like makerspaces staff and library and museum staff, had more knowledge of making activities than early years practitioners in North America. The results indicated that curriculum constraints in the early childhood context of schooling could prevent the implementation of making and maker-oriented activities because of the limitation of teachers' training and the shortage of resources in school. While making and maker-oriented activities can benefit children from theoretical perspectives of constructivism, embodiment, and empowerment pedagogy, it can realize the development of digital literacies as information, media, and technology skills, as well as digital making and meaning-making skills with digital tools.

Making and Maker-oriented Activities Meeting Children's Learning Needs with Digital Tools

In this section, I reviewed studies about making activities with digital tools. Evidence suggests that children can develop digital literacies through making and maker-oriented activities

(Blikstein, 2013; Marsh et al., 2018; Rowsell & Shillitoe, 2019). Further, the integration of digital tools in making and maker-oriented activities can create opportunities that expand children's imagination and benefit their cognitive development (Blikstein, 2013; Peppler et al., 2019).

Digital literacies include "information, media and technology skills" (Hockly, 2012, p. 108). As summarized by Hockly (2012) whose definition is one of many (cf. Buckingham, 2010) digital literacies can be considered as a combination of four literacies: (1) language-based literacies such as decoding online text genres, (2) information-based literacies such as navigating digital information from the internet, (3) connection-based literacies such as managing personal digital identity in the virtual world, and (4) (Re)design-based literacies such as recreating or repurposing digital content. Results from studies of children K-12 using 3D printers (Blikstein, 2013; Marsh et al., 2018; Rowsell & Shillitoe, 2019), suggest that children can develop the third and the fourth aspects of digital literacies as mentioned above when they are exploring 3D printers. Further, the exploration of 3D design programs and 3D printers enables children to develop technical skills. When children design an object in a digital space and then print it into a physical object, the product of their imagination becomes tangible, and thus their competency of using digital tools develops (Blikstein, 2013; Marsh et al., 2018; Rowsell & Shillitoe, 2019).

Making also provides opportunities for children to learn abstract knowledge and skills. When designed well, making can create the conditions that enable children to explore on their own, in activity. Peppler et al. (2019) studied how making activities made abstract concepts tangible. When children (ages 3-5) learned electricity with squishy circuits, they figured out how to make an LED light with clear positive and negative terminals light up. Through this activity, the concepts of circuitry became visible, and children learned how electrons flowed by making mistakes and seeing the consequences. The results of this study indicated that giving children opportunities to explore digital devices through hands-on making activities could develop their disciplinary knowledges in science, but also their digital literacy.

Placing children in a makerspace can engage children's natural sense of curiosity. Blikstein's (2013) FabLab@School project brought "prototyping equipment such as laser cutters and 3D printers to a standardized low-cost lab at school" and combined digital fabrication with "making" (p. 4). The FabLab enabled students from K-12 to "safely make, build, and share their creations" (Blikstein, 2013, p. 6). This project made making more accessible for students, unlike other robot labs where engineering and invention existed only in highly gender-biased and private settings. The FabLab@School had the same intention as makerspaces in school, where students had equal rights regardless of their making skills.

Taken together, the evidence reviewed in this section suggests that children can benefit from making and maker-oriented activities in early childhood learning settings because these activities position children as leaders of their own learning, rather than as receivers or consumers. In the next section, I review studies about teachers using digital tools and their actions in making and maker-oriented activities. These studies suggest there is a shortage of teachers' training to perform making and maker-oriented activities with digital tools.

Shortage of Teachers' Training to Perform Making and Maker-oriented Activities with Digital Tools

When teachers apply digital making and maker-oriented activities in their teaching, both their understanding of digital technologies and of making and maker-oriented activities will affect their decision making. In this section, I discuss teachers' training in terms of (a) early childhood teachers using digital technologies based on the framework of technological pedagogical content knowledge (TPACK), and (b) early childhood teachers planning making and maker-oriented activities. I also discuss the importance of synthesizing studies' findings of teachers' perspectives.

Knowledges Required for Early Childhood Teachers to Use Digital Tools

Teaching with technologies requires teachers to leverage technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006). An integrated set of knowledges about teaching, learning and technologies and how they interact, teachers' decision making about how and when to use digital tools to support student learning depends on their "(a) content knowledge (subject matter that is to be taught), (b) technological knowledge (computers, the Internet, digital video, etc.), and (c) pedagogical knowledge (practices, processes, strategies, procedures, and methods of teaching and learning)" (Mishra & Koehler, 2006, p. 73). For early childhood teachers, however, concerns about young children's developmental needs, coupled with limited training in the use of digital tools in developmentally appropriate ways to teach foundational social skills, motor skills, emergent literacies, and numeracies, may limit teachers' understanding of how to plan for digital making.

Alazemi's (2017) research explored how willing pre-service kindergarten teachers were to use Web 2.0 in their classrooms. Web 2.0 referred to Wikis, Skype, social networking, and video sharing sites that enabled people to share their knowledge while learning and interacting. However, preservice teachers in this study were concerned about inappropriate content, which was due to preservice teachers limited knowledge of how to control children's access to inappropriate content on the internet. Moreover, for a successful integration of digital tools in curriculum, teachers should have choice of the materials and teaching content they would use – choice that allows them to integrate digital tools flexibly and for a range of purposes, including to teach content that they have also taught successfully using other methods, approaches, or materials (Jack & Higgins, 2019; Plowman et al., 2012).

Masoumi (2015) interviewed and observed teachers of a preschool in Sweden and found that most teachers used digital tools as display tools only. As a contrast, Samuelsson (2019) found that teachers were also using digital tools for display but with a concern for children's interaction with the digital tools. In Samuelsson's study, teachers used digital tools to display the photos of a previous activity to encourage children to review their experience and share their feelings. The digital tools in both studies were used as display tools but teachers' understanding of the tools and integrating strategies were different. This difference indicates the importance of teachers' comprehensive understanding of digital tools and being able to use them flexibly to provide protentional learning opportunities and supports for children.

Scholars have found that teachers' training in using digital technologies should concentrate on not only digital competencies but also the pedagogy with digital technologies so that teachers could acquire professional confidence in how to integrate digital technologies into their classrooms and apply theories into their teaching strategies (Myers & Halpin, 2002; Prestridge, 2012; Sillat et al., 2019). Alazemi's (2017) research also highlighted the importance of teachers' preparation, because teachers felt it challenging to use new digital technologies such as 3D printers, compared to the ones they used in their daily lives such as interactive whiteboard.

Early Childhood Teachers Planning for Making and Maker-oriented Activities

The use of making activities often requires teachers to shift their pedagogical priorities. Traditionally, schooling has emphasized evaluation of discrete skills, learned through direct instruction (Sawyer, 2010). Making and maker-oriented activities, however, disrupt this approach. In maker-oriented classrooms, students can regulate their own exploration of problems and use various materials and tools; teachers play a supportive role, and dynamically adjust to their students' needs in the moment (Ciocca, 2019; Godhe et al., 2019). Moreover, making activities create opportunities for teachers to closely observe their students as they collaborate, solve problems, and negotiate boundaries (Marsh et al., 2018). Novice teachers may find it particularly difficult to adopt a new maker approach, in part, because they may not have observed this approach in schools as students or during their certification programs.

Vartuli and Rohs (2009) found that although teachers were aware of the importance of having child-centred activities, new teachers relied on teacher-centred methods. In this study, it took about two years for new teachers to get used to and start using student-oriented activities. As new teachers learn to negotiate the balance of teacher-centred and child-centred instructional designs, they must learn to scaffold instruction that opens opportunities for student agency without overwhelming their young students who do, of course, need direct instructional cues at times (Espinoza & Vossoughi, 2014).

Hsiao (2003) studied teachers' attitudes toward children's arts making in Taiwan. Activities in the study included various physical materials. This study found that teachers with more teaching experience were more likely to agree with the relationships between children's physical growth and their visual development that appeared in the artwork. In this study, teachers did not have enough training to combine children's physical development with children's visual development in teachers' teaching.

To plan learning activities with Digital Making, teachers need to acquire knowledge of using digital tools and strategies of meeting children's learning needs with digital tools. To better prepare teachers with this knowledge, the perspectives of teachers who have experience of using

Digital Making in their teaching can be beneficial. Therefore, I discuss the importance of acknowledging teachers' conceptualization about Digital Making in the following section.

Importance of Acknowledging Teachers' Conceptualization about Making and Maker-oriented Activities with Digital Tools

When it comes to Digital Making as a pedagogical approach, we can look to other studies of teachers' pedagogical planning with digital tools to anticipate what may inform their decisions. It seems that the way that teachers conceptualize, or think about, a pedagogy includes (at least) their understanding of (a) the teaching content (Mishra & Koehler, 2006), (b) tools and technologies that enable them to use this method to teach this content (Mishra & Koehler, 2006), (c) their self-identity as teachers (Swallow & Olofson, 2017), and (d) their relationships and interactions with students (Swallow & Olofson, 2017). Evidence of these foundational elements may be visible in reports of teachers' planning, and in evidence from interview or observation fieldnotes.

In one example, Ciocca (2019) studied middle and high-school teachers' understanding of making activities in French-language schools in the Ottawa region using interview data and evidence from participants' planning documents. The study revealed three key aspects of conceptualizing for making activities: "(a) the creation of a Maker community mindset; (b) the implementation of a Maker mindset in activity; (c) the emergence of planning in the making" (p. iii). This study looked at teachers' perspectives as expressed through their planning for making activities and provided insights to guide middle-school and high-school teacher training. Given the potential for making to support young learners as well (Blikstein, 2013; Marsh et al., 2018; McCausland-Hartman, 2017; Peppler et al., 2019; Rowsell & Shillitoe, 2019; Smeet & Bus, 2012; Wohlwend, 2017), it is important to study the ways that early childhood teachers have thought about and planned making and maker-oriented activities.

Teachers’ conceptualization and planning of making and maker-oriented activities with digital tools may vary. Teachers likely build their conceptualizations as they reflect on their teaching practices (Vartuli & Rohs, 2009). Moreover, teachers’ decisions about integrating digital tools in classrooms are based on their understandings of the affordances and constraints of tools and their uses in relation to learning objectives (National Association for the Education of Young Children and the Fred Rogers Centre for Early Learning and Children’s Media, 2012; Mishra & Koehler, 2006). Plus, teachers’ decision-making in early childhood classrooms is a major determinant of children’s learning experience (Brito & Dias, 2018). Therefore, it is important for us to learn about early childhood teachers’ conceptualization of making and maker-oriented activities with digital tools to better develop theories for training, and, as indicated, to integrate these activities in early childhood education.

To better support teachers to integrate making and maker-oriented activities with digital tools in teaching and realize the above-mentioned learning benefits, we should learn from teachers who have had experience with these activities. Additionally, the gaps, differences, or even the variety of understandings that teachers hold about making and maker-oriented activities with digital tools, could point to the varied supports teachers may need or how school leaders may enter conversations about digital making with them. There are individual studies that have included teachers’ perspectives of making and maker-oriented activities, but there has been no systematic analysis of teachers’ perspectives from across studies of digital making in early childhood classrooms. In this qualitative research synthesis, I therefore analyze the studies on teachers’ perspectives of making and maker-oriented activities with digital tools in early childhood classrooms to provide much-needed evidence of what teachers know and do. The results of this study could inform professional development in Digital Making for early childhood teachers but perhaps most importantly, will provide much-needed evidence of how research on digital making in early childhood contexts has been designed, while centering the voices and experiences of teachers whose insights should lead future research priorities.

Conclusion of Literature Review

As argued in the review of literature, making and maker-oriented activities with digital tools can be beneficial for young learners. Evidence suggests that making – including Digital Making – can support literacies learning, social skills like communication and collaboration, as well as problem-solving skills (Clapp et al., 2020; Lahmar et al., 2017; Marsh et al., 2018; Peppler et al., 2019; Rowsell & Shillitoe, 2019; Wohlwend, 2017). Studies have also shown how making can prepare children to take initiative, collaborate with peers, and learn that their interests and ideas have value (Clapp et al., 2020; Marsh et al., 2018). And yet, maker-oriented approaches are not widely adopted in early childhood classroom settings in schools (Forbes et al., 2021; Marsh et al., 2019). There are likely many reasons for this, but without a synthesis of possible explanations, we are limited to individual accounts. A research synthesis that brings together the varied perspectives of early childhood educators who have actually planned for, and then used maker-oriented methods to support their students' learning for various purposes using various tools and materials would be useful, particularly if the synthesis also included descriptions of the contexts in which these studies have been conducted. This synthesis could provide teacher educators and policy makers with important evidence of the possibilities and limitations of making for the teaching of young children, as well as the limitations and challenges that teacher, at the vanguard of this pedagogical shift in early childhood education, have already experienced and discussed. This qualitative research synthesis aims to address this need. It therefore focuses on the following two questions with sub-questions designed to clarify the scope and sequence of the study's design.

Research Questions

As noted in the introduction, this study focuses on the following questions:

1) How have studies of Digital Making in early childhood classroom settings been designed?
    a) What were the context of these studies?
    b) What digital tools have been used in these studies, and for what purposes?
    c) How, if at all, have these activities been designed to align theoretically with tenets of constructivism, embodiment, and empowerment pedagogy?
2) How do teachers understand Digital Making as a teaching method?
    a) Using documentation of teachers' lesson planning and retrospective interview data reported in studies of making in early childhood classroom contexts, what can we learn about how early childhood teachers conceptualize and then implement making in their classroom practices?

Method

In this qualitative research synthesis, I reviewed what has already been researched in early childhood education with respect to making and maker-oriented activities with digital tools. In particular, I looked for studies that include teachers' perspectives on Digital Making. I analyzed these studies according to how teachers conceptualize the activity, and how they do or do not use these conceptualizations in their planning and teaching practices. As reported by Major and Savin-Baden (2010), a qualitative research synthesis can be used to "analyze, synthesize and interpret the results from qualitative studies" (p. 10). It can be used to answer the research question with a broad range of studies, which enables the researcher to make sense of themes and issues. Qualitative research synthesis can be used to surface patterns across qualitative studies and therefore, inferences and insights are stronger because they include evidence from multiple sources. Moreover, qualitative data can be well-grounded sources as the studies focus on the social context, participants' information, and authors' interpretation. Using the interview data and author fieldnotes reported in the selected studies, I investigated teachers' perspectives of digital making activities, while combining the researchers' primary descriptions of the setting in which the research was conducted. I used a qualitative research synthesis method following the steps outlined by Major and Savin-Baden (2010), which are: (a) formulate the research question, (b) identify relevant studies, known in this study as identify inclusion criteria, (c) select a sample of studies, (d) appraise studies and finalize the sample, (e) reflect upon the process, (f)analyzing and synthesizing the data, and (g) interpreting findings. The rest of the methods section is organized according to these steps. I describe, in detail, how I implemented each of these steps to complete this qualitative research synthesis. I put the step of *interpreting findings* as the *discussion* section after the *method* and *results* section in this thesis.

Formulating the Research Question

The research questions were formulated to address an identified need from my reading of research on the use of maker-oriented activities in formal contexts of early childhood teaching and learning. As presented already in the introduction and review of literature, this qualitative research synthesis is focused on two main questions: (a) how studies of making and maker-oriented activities with digital tools in early childhood classroom settings have been designed, and (b) how teachers understand making as a teaching method.

Identifying Inclusion Criteria

Reflecting on the rise of the maker movement in North America, the founding of *Make* magazine in 2005 and the first Maker Faire in the US in 2006 can be taken as milestones for making and maker-oriented activities emerging in education (Schad & Jones, 2020). Thus, I selected studies that have been published between 2005 and 2021. In terms of language, I reviewed English studies because of the possibility of mistranslating other languages. Another inclusion criterion of this study was whether the teaching and learning was happening for children aged 3-8 in a regulated pre-school program, or in a program offered in a publicly funded school. This criterion meant that I looked to include research on maker programs happening in formal contexts of schooling (e.g., Junior Kindergarten, Senior Kindergarten, Grades 1, 2, and 3) as well as state or provincially regulated early childhood education programs (e.g., HeadStart programs in the United States).

As noted in the introduction and review of literature sections, for the definition of making and maker-oriented activities with digital tools, I considered the definition of Godhe et al. (2019) as "(i) the use of digital technologies to facilitate the making of physical objects and/or (ii) the making of physical objects that incorporate some form of digital technology" (p. 317). Given the focus in this study on research with young children who, because they are very young are still developing gross motor and fine motor skills as well as the ability to manipulate digital products, I include physical manipulation as making and maker-oriented activities. The idea of making and maker-oriented activities are to construct and produce or learn abstract knowledge though physical manipulation. Therefore, in my qualitative research synthesis, I defined “Digital Making” as the learning process that includes using digital tools, with production or manipulation of physical objects.

Selecting Sample of Studies

I searched for studies to include in this qualitative synthesis by using the ProQuest database through the University of Ottawa library system. Through ProQuest, I was able to conduct a general search for relevant journal articles, dissertations and theses, and I was able to access a set of specific early childhood education journals which are outlined in Table 2. As outlined in Table 1, I used a common set of search strings to find relevant studies on ProQuest and to search through specific journals for relevant articles. I also used these same search strings to identify relevant research published by educational organizations using Google Search.

The topic of this qualitative research synthesis is Digital Making; however, some studies describe making activities with digital tools but do not label these activities as making. To ensure a broad search of studies, I also included “digital device” as a keyword and looked on the details of the study to see whether it included children’s production of projects.

Table 1
Search Strings

Variable of interest	Search strings
Making and maker-oriented activities with digital tools	“Digital making” OR "digital device"

Making and maker-oriented activities	"Arts-making" OR "making art" OR "studio-based STEM" OR "makerspace"
Teachers of young children (3-8)	("Young child*" OR kindergarten OR "early childhood" OR preschool OR "primary school" OR "elementary school") AND teacher*

In total, I searched for relevant research articles using three different search platforms: (1) the ProQuest database (for research articles, journals, thesis, and dissertations), (2) the search functions at the journals themselves, (3) Google search (for research published by educational organizations). From the three platforms, I have five steps in total for searching relevant studies and I elaborate on the specifics of each step in this process of selecting articles for inclusion below.

1. **ProQuest Database:** I began my search for relevant peer-reviewed studies using the PsycInfo data base in ProQuest. I searched using the search strings outlined in Table 1 with advanced search options that enabled me to search only titles and abstracts. I then read the abstracts of the searched studies to eliminate articles that do not align with my inclusion criteria. After identifying relevant research studies, I also looked through their reference lists to find additional relevant studies that may have been missed in the database search.
2. **Early Childhood Journals:** I searched for peer-reviewed scholarship in journals dedicated to early childhood learning (e.g., Child Development) and early childhood teaching (e.g., The Elementary School Journal). The list of journals that I identified a priori for this phase of searching is listed in Table 2.
3. **Educational Organizations:** I looked for reports of making and maker-oriented teaching methods published by educational organizations focused on early childhood

learning. I searched “education association” with countries and area’s names in Google and looked for related websites with peer reviewed research articles. I found five organization websites in total: The National Association for the Education of Young Children, The Canadian Education Association, The International Literacy Association, National Education Association, American Educational Research Association.

4. **Dissertations and Theses:** A sixth source of information was theses and dissertations which were available from the ProQuest database. As in my broad database search, I searched the theses and dissertations database using search strings that align with each variable of interest in the research questions shown in Table 1.
5. **Reference List**: After identifying relevant research studies, I also looked through their references lists to find additional relevant studies that may have been missed in the former four steps of searching.

Table 2

Journals

Journal	Areas of research or fields of study
Child Development	Topics in child development
Child Development Perspectives	Developmental science, policy, statistics and methods
Contemporary Issues in Early Childhood	Poststructuralist, postmodern and postcolonial approaches, queer theory, sociology of childhood, alternative viewpoints of child development, and issues such as language and identity, the discourse of difference, new information technologies, stories and voices, curriculum, culture and pedagogy, or any combination of such ideas
Early Child Development and Care	Research, planning, education and care of infants and young children, including multidisciplinary works on early child development and care

Early Childhood Education Journal	Curriculum, childcare programs, administration, staff development, family-school relationships, equity issues, multicultural units, health nutrition, facilities, special needs, employer sponsored care, infant/toddler programs, child development, advocacy
Early Childhood Research & Practice	Development, care, and education of young children
Early Childhood Research Quarterly	Early childhood development, theory, and educational practice
Early Education and Development	Early childhood education and children's development
Early Years: An International Research Journal	Early childhood education and early childhood care
Education 3-13: International Journal of Primary, Elementary and Early Years Education	Primary education, including early years teaching and practices and the transfer to secondary education
European Early Childhood Education Research Journal	Early childhood education, psychology, sociology
International Journal of Early Childhood	Research with young children and children's early education and care, across various social and cultural contexts
International Journal of Early Years Education	Theories, research, policy, and innovative practices that sustain effective early years education
Journal of Early Childhood Literacy	Issues related to the nature, function and use of literacy in early childhood that include the history, development, use, learning and teaching of literacy, as well as policy and strategy
Journal of Early Childhood Research	Early childhood education and care in fields of arts, education, health, law, social work, therapy, sociology, history
Journal of Early Childhood Teacher Education	Information and ideas about research and practice in pre-service teacher preparation and in-service professional development
Journal of Research in Childhood Education	From empirical research projects to small-case studies carried out in naturalistic settings, such as schools and community centers

Monographs of the Society for Research in Child Development	Child development and its related disciplines
The Elementary School Journal	Education theory and research and implications for teaching in child development, cognitive psychology, sociology, and school learning and teaching
Voices of Practitioners	Early childhood teachers’ systematic study of an aspect of their own classroom practice
Young Children	Practical suggestions for early childhood educators and addresses important topics from multiple perspectives

I read all abstracts of the studies located through my initial phase of search as a first screening. For studies that I identified as uncertain in terms of the full set of inclusion criteria, I read the method and findings sections as a second screening.

Appraise Studies and Finalize the Sample

I appraised the quality of each study to make sure the data I gathered were both valuable and reliable. Referring to Major and Savin-Baden (2010), I used the list of criteria outlined in Table 3 as a guide to determine the reliability of the studies I included in the qualitative research synthesis. For each possible study, I judged whether it met all standards of quality (yes or no). Only seven studies met all quality standards, and these ultimately comprised my final set of studies included.

Table 3

Criteria for Appraisal of Research Studies

Criteria	Response	
There is acknowledgement of researcher stance	Yes	No
There is congruity between researcher stance and methodology	Yes	No
There is congruity between methodology and research goals.	Yes	No

There is congruity between research goals and research questions	Yes	No
There is congruity between research questions and data collection techniques	Yes	No
There is congruity between research questions and data analysis	Yes	No
There is congruity between research questions and presentation of findings	Yes	No
There is congruity between methodology and interpretation of findings	Yes	No

Reflect Upon the Process

Reflecting upon the process of studies selection, I clarify the unit of analysis before the data analyzing. The unit of analysis for this step was at the study level. For the first research question, *How have studies of making and maker-oriented activities with digital tools in early childhood classroom settings been designed?,* I collected data from each study and analyzed across the study to look for themes. For the second research question, *how do teachers understand making as a teaching method?,* I looked across the expressed teachers' understanding of Digital Making in all relevant participants. There were 52 participants in total across the included studies, so analyses of common themes are aggregated across all data provided.

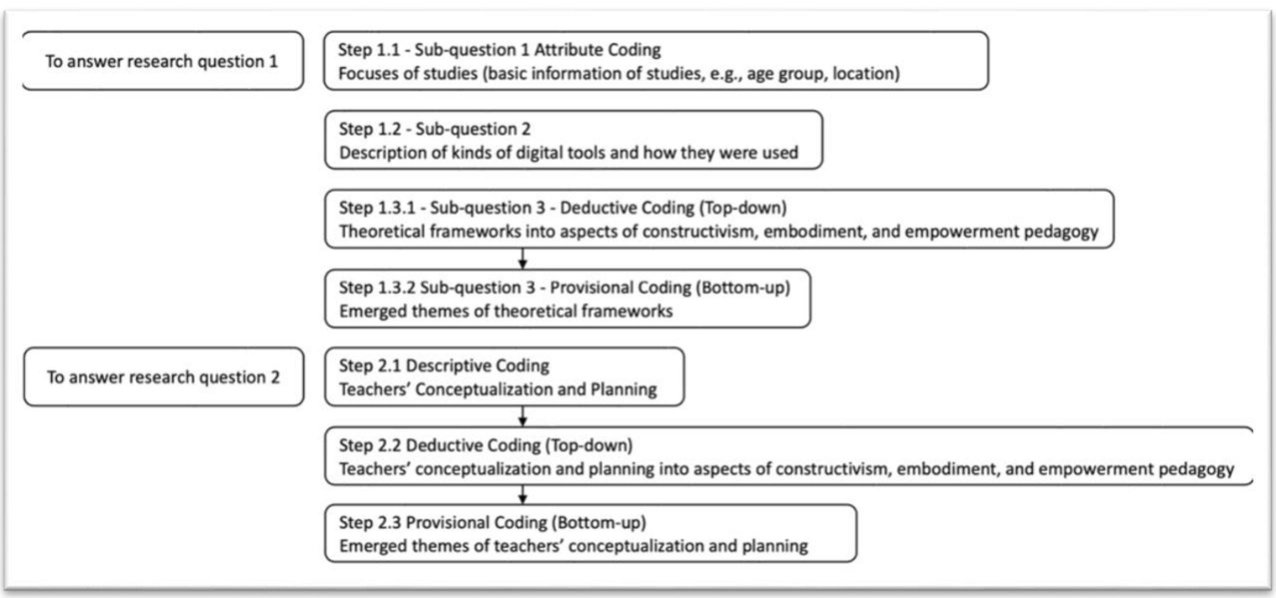
Analyzing and Synthesizing the Data

According to Major and Savin-Baden (2010), the analysis of a qualitative research synthesis is to "develop first order themes and codes, as well as locate themes across studies" (p. 62), while the synthesis is to combine themes across the studies and identify second order themes across studies. For both research questions of this qualitative research synthesis, I did the analysis and the synthesis. Therefore, I structured this section based on the two research questions, instead of steps of data analysis.

I used a Microsoft Excel spreadsheet to curate, code, and analyze the articles that met inclusion criteria. My process of analysis included two major steps, each of which I describe in this section (see Figure 1). Fundamentally, my methods of analysis align with those described by Miles et al. (2018) in that every step was meant to find patterns and themes in the set of qualitative data that I gathered. Analyses of data are organized by research question, in part because I used different coding methods to answer them.

Figure 1

Steps of Data Analysis



Analyses to Support Investigation of Research Question 1

To support the investigation of the first research question: *How have studies of making and maker-oriented activities with digital tools in early childhood classroom settings been designed?,* I followed three steps.

In Step 1.1, after I finalized the list of relevant studies, I conducted attribute coding to answer the first sub-question, *What were the contexts of these studies?.* Attribute coding, identified by Miles et al. (2018), can provide information of various aspects for further reference in analyzing the qualitative research synthesis. This step enabled me to identify basic descriptive information, and to analyze similarities across the studies. I documented (a) the author(s), (b) year of publication, and (c) type of study, and then extracted information as (d) methodology, (e) the age range of children, (f) study location, (g) curricular structure of the school, and (h) teachers' experience.

In Step 1.2, to answer the second sub-question, *What digital tools have been used in these studies, and for what purposes?,* I collected kinds of digital tools in the study and how activities were planned.

In Step 1.3, to answer the third sub-question, *How, if at all, have these activities been designed to align theoretically with tenets of constructivism, embodiment, and empowerment?*, I collected theoretical frameworks of the selected studies. In the theoretical frameworks section, I listed aspects of the three theories of constructivism, embodiment, and empowerment at the end of each section. I defined each code from these aspects of theories, as listed in Table 4. Since the studies were about Digital Making, in Step 1.3.1, I put the theoretical frameworks into a top-down analysis with the aspects of the theoretical frameworks in this synthesis, which was the theories of constructivism, embodiment, and empowerment pedagogy (see Table 4). In Step 1.3.2, the aspects that were not covered in the three theories were coded as emergent themes. I listed and defined codes of the emergent themes as a bottom-up analysis (see Figure 2).

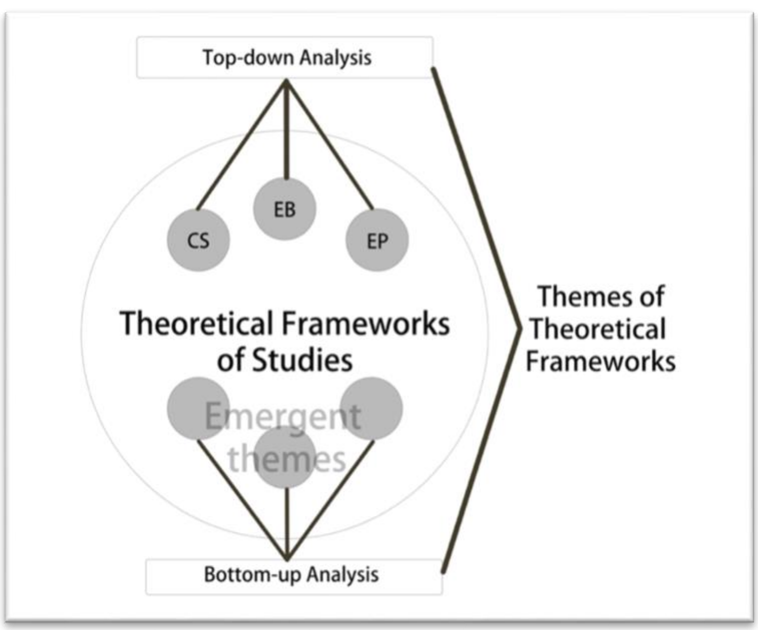
Table 4

Definition of Deductive Coding from Theoretical Frameworks

Code name	Tenet of theory
CS - Social	Learning from social activities
CS - Children-tools Relationship	Learning from interactions of relationships between children and digital tools
CS - Productive	Digital Making supports development of productive skills (e.g., planning, designing)
CS - Problem Solving	Digital Making supports development of problem-solving skills
EB - Senses	Meaning-making process comes from our senses
EB - Environment Interactions	Environment provides interactions
EB - Tools in New	Using tools for new purpose, in new way, to make new things
EP - Culture	Learning is based on meaningful problems related to culture
EP - Agency	Learning should contribute to children’s agency development

Figure 2

Top-down and Bottom-up Analysis for Theoretical Frameworks among the Studies



Note. CS = the theory of constructivism. EB = the theory of embodiment. EP = empowerment pedagogy. Emergent themes = aspects of theoretical frameworks of the selected studies that do not fall into aspects of the three theories.

For the data synthesis of the third sub-question, *How, if at all, have these activities been designed to align theoretically with tenets of constructivism, embodiment, and empowerment?,* I looked for frequency of the themes of theoretical frameworks on Excel spreadsheets across the studies. The frequency helped me make inferences about how the Digital Making activities in the selected studies have been theoretically designed.

Analyses to Support Investigation of Research Question 2

To answer the second research question, *How do teachers understand making as a teaching method?,* I conducted three steps. In Step 2.1, I conducted descriptive coding using only evidence from the included studies about teachers' conceptualization of Digital Making or planning for Digital Making activities. Descriptive coding, as defined by Miles et al. (2018), includes the summarization of the basic topic of the data. I coded either participant teachers' own words from author's fieldnotes, or the author's conclusion of teachers' perspectives. Informed by Mishra and Koehler (2006) and Swallow and Olofson (2017), I constructed a set of five codes, which are summarized in Table 5. These codes reflect my understanding of key aspects of teachers' conceptualization of their work. I labeled teachers' understandings as CONCEPTUALIZATION (CON), or PLAN.

Table 5

Definition of Descriptive Coding of Teachers' Understandings

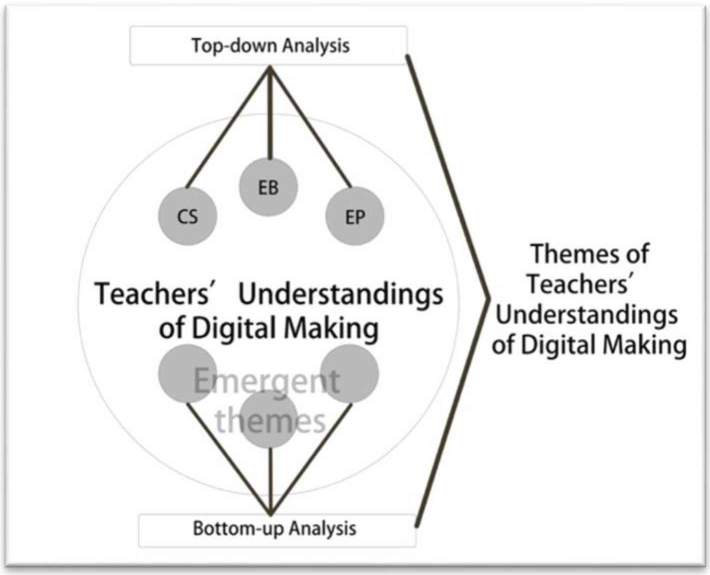
Code	Description of code
CON - Learning Benefits	The learning benefits the teacher sees in making and maker-oriented activities with digital tools as a pedagogical approach.
CON - Integrate	The teacher's perceptions of why and how to integrate making and maker-oriented activities with digital tools into teaching
CON - Job	The teacher's understanding of their job as the teacher during the making and maker-oriented activities with digital tools
CON - Teacher-student Relationship	The teacher's understanding of their relationships with students during the making and maker-oriented activities with digital tools
PLAN	The teacher's activity planning

Note. CON is the abbreviation for Conceptualization.

In Step 2.2, I used deductive coding, using principles aligned with the three theoretical frameworks (see Table 4), to construct a top-down theoretically driven representation of teachers' understandings about Digital Making. And in Step 2.3, to explore data that did not fit neatly into my top-down theoretical codes, I used provisional coding as the bottom-up analysis. Provisional coding, as identified by Miles et al. (2018), "begins with a start list of researcher-generated codes" (p. 69). I did the bottom-up analysis to investigate on what data suggests about teachers' understanding of Digital Making besides the aspects of the three theoretical frameworks and identify themes in all-other data related to teachers' perspectives on making (see Figure 3).

Figure 3

Top-down and Bottom-up Analysis for Teachers' Understandings of Digital Making among the Studies



Note. CS = the theory of constructivism. EB = the theory of embodiment. EP = empowerment pedagogy. Emergent themes = teachers' understandings that do not fall into aspects of the three theories.

The top-down and bottom-up analyses of each the relevant studies was collated in a matrix display to show the themes of teachers' understandings of Digital Making (see Table 6). Using the frequency data among the matrix tables to inform this qualitative research synthesis, I was able to make inferences about the ways that teachers' understanding of Digital Making aligned with theories of embodiment, constructivism, empowerment pedagogy, and other emergent themes. I report these inferences in the results section.

Table 6

Matrix Display of Teachers' Understanding and Aspects of Theories

Tenet of theory	CON - Learning Benefits	CON - Integrate	CON - Job	CON - Relationship	Plan
CS - Sensibly					
CS - Social					
CS - Relationship					
CS - Productive					
CS - Problem Solving					
EB - Senses					
EB - Environment Interactions					
EB - Tools in New					
Emergent themes					

Inter-coder Agreement

I sent two of the seven studies and the definition of the codes in Table 4 and Table 5 to a colleague. He coded the two articles into an Excel sheet. I checked the differences between his result and mine and we had 20/23 (87%) agreement. We discussed the three different codes. He had three codes repeated in one study. We both agreed that the three codes could be combined into other codes in the study and reached consensus.

Results

In this chapter, I present the results of my qualitative research synthesis according to the steps I described in the methods chapter to answer my research questions:

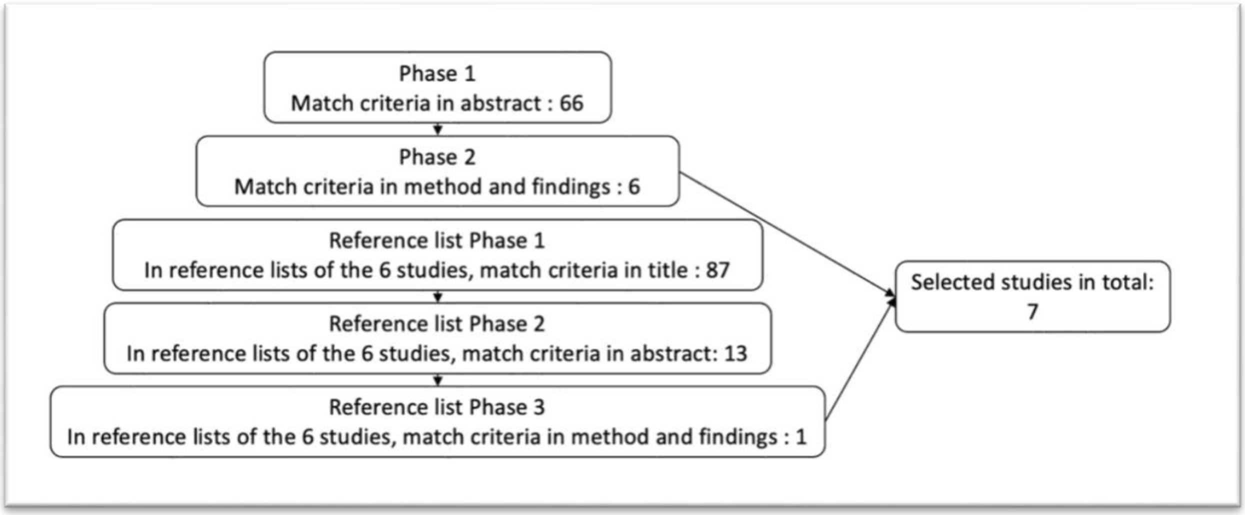
1) How have studies of making and maker-oriented activities with digital tools in early childhood classroom settings been designed?
   a) What were the context of these studies?
   b) What digital tools have been used in these studies, and for what purposes?
   c) How, if at all, have these activities been designed to align theoretically with tenets of constructivism, embodiment, and empowerment?
2) How do teachers understand making as a teaching method?
   a) Using documentation of teachers' lesson planning and retrospective interview data reported in studies of making in early childhood classroom contexts, what can we learn about how early childhood educators conceptualize and then implement making in their classroom practices?

Study Selection

The number of relevant studies that were selected during each phase from the *method* section is as shown in Figure 4.

Figure 4

Phases of Study Selection



Study Selection: Results of Phase 1

In this section, I present results of my keyword searches and abstract scans, organized by platform. The result of the Phase 1 study selection (base on the abstract) is as shown in Table 7. During the searching process, I used search strings from all three groups listed in Table 1. When the searching showed no results, I searched with two groups: ("digital making" OR "physical making") AND "teacher*". When searching in educational journals, because the journals were situated in early childhood journals, I did not include age group in the searching.

Table 7

Results of Phase 1 Study Selection

Platform	Search strings Used	Number of Studies	
		Searched	Selected
PsycInfo database (ProQuest)	Ab("digital making" OR "digital device") AND ab("Young child*" OR kindergarten OR "early childhood" OR preschool OR "primary school" OR "elementary school") AND ab(teacher*)	1	0

	Ab("arts-making" OR "making art" OR "studio-based STEM" OR "makerspace") AND ab("Young child*" OR kindergarten OR "early childhood" OR preschool OR "primary school" OR "elementary school") AND ab(teacher*)	2	1
	Ab(3D OR virtual) AND ab(produce OR production OR making) AND ab("Young child*" OR kindergarten OR "early childhood" OR preschool OR "primary school" OR "elementary school") AND ab(teacher*)	1	0
Early Childhood Journals			
Child Development (SRCD) + Child Development Perspectives	Makerspace AND ab(teacher)	2	0
	Arts-making AND ab(teacher)	22	0
	Studio-based AND ab(teacher)	1	0
	Ab(digital) AND ab(teacher)	1	0
Contemporary Issues in Early Childhood	Ab(digital) AND ab(teacher)	7	3
	Ab(arts-making) AND ab(teacher)	8	1
Early Child Development and Care	Ab(digital) AND ab(teacher)	12	8
European Early Childhood Education Research Journal	Ab(digital) AND ab(teacher)	10	6
International Journal of Early Years Education	Ab(digital) AND ab(teacher) AND (making OR make)	15	6
Early Education and Development	Ab(makerspace) AND ab(teacher)	1	1
	Ab(digital) AND ab(teacher)	3	0
Early Childhood Education Journal	Teacher AND "arts-making" AND digital	4	2
	Teacher AND "makerspace" AND digital	1	0
International Journal of Early Childhood	Teacher AND "arts-making" AND digital	3	1
Early Childhood Research & Practice	Teacher AND digital	1	0
Early Childhood Research Quarterly	Ab(teacher) AND ab(digital)	4	1

Childhood Education	Ab(digital) AND ab(teacher)	10	3
Journal of Early Childhood Teacher Education	Ab(digital) AND ab(teacher)	4	1
Early Years: An International Research Journal	Ab(digital) AND ab(teacher) AND (making OR create OR build)	7	3
Journal of Early Childhood Research	Ab(digital) AND ab(teacher) AND (making OR create OR build OR construct)	5	2
Journal of Research in Childhood Education	Ab(digital) AND ab(teacher) AND (making OR create OR build)	8	0
Young Child	Teacher AND digital AND makerspace	1	1
	Ab(teacher) AND ab(digital) AND (making OR create OR construct)	2	0
Educational Organizations			
The National Association for the Education of Young Children	Digital AND teacher AND "young child" AND (make OR create OR construct)	2	2
the Canadian Education Association	Teacher AND digital AND makerspace	4	2
the International Literacy Association	Teacher AND digital AND makerspace	8	4
National Education Association	Teacher AND digital AND makerspace	4	0
American Educational Research Association	Teacher AND digital AND makerspace	4	0
Dissertations and Theses			
ProQuest	Digital AND teacher AND makerspace AND child	38	6
Reference List	N/A	87	13
Repeated Studies		9	
Total		274	66

Note. ab = search the search strings in the abstract of the study.

The searching and selecting results are shown in Table 6. I searched 274 relevant studies, where nine of them were reported in two different sources. I narrowed down to 66 studies after initial review.

Study Selection: Results of Phase 2

I based the identification of relevance of the 66 studies in the Phase 1 on abstracts. Some studies did not have the information of my selection criteria in their abstracts. Therefore, in Phase 2 I looked at the method and findings of the study in the body of the article to further narrow down the selection. After Phase 2, I had six studies.

Reference Lists

I reviewed the references lists of the six studies from Phase 2. I selected 87 articles from the reference lists, based on their titles. After reviewing the abstracts of all 87 studies, I retained 13 studies for the second phase of review. I selected one study after the third phase of review of methods and findings. As shown in Figure 4, I had 7 studies at the end as my dataset. All 7 studies included the perspectives of teachers of children aged 3-8. Teachers' perspectives were conveyed through interviews where they described their understanding of making and maker-oriented activities with digital tools, or through authors' fieldnotes of classroom observations that described teachers' activity planning. All the learning activities include digital technologies. The activities in the studies also include either physical operation of tools or virtual or physical artifact production.

Description of Studies Retained

In this section, I summarize each of the seven studies retained for analysis and explain how each met all inclusion criteria:

Kewalramani et al. (2020) investigated new digital technologies: Internet of Toys (IoToys), which are "physical toys connected with the internet" (p. 198) that provide opportunities for children aged 0-5 years, to interact with peers and materials. Children developed digital literacies while playing the IoToys to complete tasks through coding, and sharing their experience proximally with peers and teachers, or online through social media. Using questioning techniques to prompt, Casie (the educator) asks Eddie and Jo (children) to enquire about what sorts of things they would like Botley (the IoToys) to do for them and where they would like Botley to go for an adventure. She encouraged children to manoeuvre him through an obstacle course constructed by the children. In this direct quotation provided in the study, we can see how the children learned coding by manipulating buttons to move the IoToys. We can also see how Casie supported the children's learning by verbalizing her observations and through questioning:

> Casie: It looks like Eddie's reading his cards, have a look at him. He's looking at what his cards are saying and then ... Transmit. Go!
>
> Jo: Transmit [mimicking teacher?]
>
> Casie: means go straight
>
> Casie: Did you rubbish bin it, Eddie? [Eddie shakes head no]. You press the rubbish bin there. Now you can press the arrows again. [Eddie re-codes Botley].
>
> Casie: [Pointing to code cards] So is he going? [Botley runs into plastic flag] Here he goes! I wonder if he's going to get a ball.
>
> Jo: [Squeals] He comes! (p. 205)

Thirty-four teachers from four countries, Australia, Norway, Scotland, and England participated in this study. In the learning activity, teachers introduced coding knowledge with visual directional cards so that children could operate the robot and code the robot to move physically. Moreover, the IoToys offered children a platform to build a physical robot city with wooden blocks, where children learned about multi-modalities in a digital-integrated environment and saw technologies as "an artefact among many" (p. 207).

Fridberg and Redfors (2020) studied teachers' roles in an inquiry-based STEM activity using Blue-Bot, a programable robot. Five teachers from five different preschools in Sweden participated in this study. Learning activities included programming the robot to make it move to a desired spot to complete the task of matching picture cards related to science knowledge. In this direct quotation provided in the study, we can see how the child participated in the Digital Making activity as programming Blue-Bot by showing steps:

> A boy participating in the activity of Preschool teacher 2, states 'There's one and two and three ...', at the same time showing with his hand stepwise in a grid how the Blue-Bot should be programmed, the statement categories are considered to be both Algorithm and Mathematics. (p. 8)

Jack and Higgins (2019) studied how teachers defined educational technology and how they used it. Twelve teachers from eight school settings, including "Local Authority (LA) nursery schools, a private nursery, LA primary schools and a free school" (p. 227), in the North East England participated in the study. Five of the eight school settings had programmable toys, or remote-control toys. I collected teachers' perspectives of Digital Making from fieldnotes of focus-group discussion and interviews. In the study, teachers saw their roles as supporting children to operate the digital tools at first and support other types of learning after. The study listed seven types of learning that were brought up by teachers: (1) personal social emotional, (2) physical, (3) communication and language, (4) literacy, (5) mathematics, (6) understanding the world, and (7) expressive arts and design. In this direct quotation provided in the study, we can see how teachers understood activities with digital tools in early childhood education as open-ended:

> Interviewees were asked about the benefits children obtained from using technology. While some answers suggested children were using technology to learn operational skills or to do closed activities, the majority supported the claim that technology was being used in a much more open-ended way. (p. 232)

Forbes et al. (2021) studied the nature of children's learning in technology-enhanced makerspace. Twenty-four teachers of students aged 5-8 years, from three schools in Australia participated in this study. The technologies in the study were 3D printer and iPad. The activity was child-centered and project-based where children were required to design artifacts with a 3D printer to solve a science-related problem. The learning activities were captured by screens. In this direct quotation provided in the study, we can see the data of children's learning process with 3D design app that was captured by screens:

> students interacted with different parts of a 3D design app to find out how it worked, … students' questions and statements were about what was happening on-screen as designs developed, … student actions and dialogue related to interest in creating and ideating different aspects of the designs-in-progress, … students described how and why they were manipulating objects, … students saved and named objects in the application gallery. (p. 181)

Cameron's (2015) dissertation studied the integration of various digital tools in K-3 school settings. Three teachers from three different school districts in the United States of Colorado, participated in this study. Two of the teachers were using iPads and smart boards for media display or communicating with the internet. The third teacher described robotics activities with Bee-Bots and Cube-lets. I included data about the third teacher. The learning activities with Bee-Bots and Cube-lets are mix-aged free-play activities, followed by inquiry-based coding activities with teachers doing scaffolds with arrow cards to direct children remote controlling the robots. In this direct quotation provided in the study, we can see how young children explored the programable robots:

> These younger group of children (3-year-olds) in the first class were mainly playing with the robot Cube-lets and Bee-Bots. They played with the Bee-Bots and tried to make it do what they wanted it to do. They talked and tried to help each other program the robot to make it move in a certain direction. They were successful about half of the time. One boy tried to use the Cube-lets but instead of putting the blocks together to make the robot do something specific, he just liked the click all the blocks together. These 3-year-olds were mainly exploring and playing with the Bee-Bots and the Cube-lets. (p. 74)

Marsh et al. (2019) published a part of their MakEY (Makerspace in the Early Years) project, which investigated four settings in England: two nursery schools and two primary schools. The research group took observation field notes and had interviews with six staff members. The study investigated three levels of learning outcomes from the makerspace: maker agency (personal level), maker funds of knowledge (relational level), and post digital maker play (institutional level). The activities described in the study were in the nursery school and primary school where children make physical objects with digital technologies such as circuits, LEDs, laser cutters and 3D printers. Two of the four activities also included creating virtual spaces with Google Tilt Brush. In this direct quotation provided in the study, we can see how Digital Making was integrated with children's activity:

> Activities: (i) Watching a theater performance with Moomin puppets; (ii) Drawing Moomin characters, which were then laser cut; (iii) Using the wooden characters in shoebox theaters; (iv) Writing play scripts for their theaters; (v) Creating clay Moomin

> models; (vi) Scanning those using Qlone app and creating 3-D digital models; (viii) Printing the 3-D digital Moomin figures on a 3-D printer; (ix) Using the clay and 3-D printed models to make green-screen animated films using the app iMotion; (x) Importing the 3-D digital Moomin models into Google Tilt Brush and creating a virtual reality Moominvalley. (p. 225)

Highfield (2015) wrote about the research *The Robots Are at Kindy* in the book *Technology and Digital Media in the Early Years* about technology in early childhood and discussed simple robotics and coding in programmable robots for young children. In Chapter II of the book, the researcher described a series of tasks completed by 31 children ages three to four and interviewed their teachers. Robot toys in this study included “Lego NXT™, Robopet by Wowee Toys, a ‘recycled robot’ made by one of the children with boxes, Bee-bots, and Probots (TTS Group)” (p. 153). The author discussed how programmable robots can support children’s learning, but I only coded the text relating to teachers’ practices. In this study, coding activities were integrated with mathematic knowledges. The activities were embedded in children’s daily experiences like coding the robots to dance “hokey-pokey”. Children’s free-play activities about remote controlling the robot to climb different ramps indicated their potential science knowledge of angle of incline and the teacher guided the children to measure the ramps and found differences.

Design of Studies about Making and Maker-oriented Activities with Digital Tools

To address the first research question, *How have studies of making and maker-oriented activities with digital tools with young children been designed?*, I analyzed the seven-study dataset in three parts. First, I identified the basic information such as the author, year of publication, type of study, methodology, age of children, the location of study, digital devices in the study, the curricular structure in the studied settings, and teachers' background information of the seven selected studies to understand the phenomenon of studies about digital making. The results are shown in Table 8. The collection of basic information was to understand the contexts in which making and maker-oriented activities with digital tools took place.

Table 8

Study Information

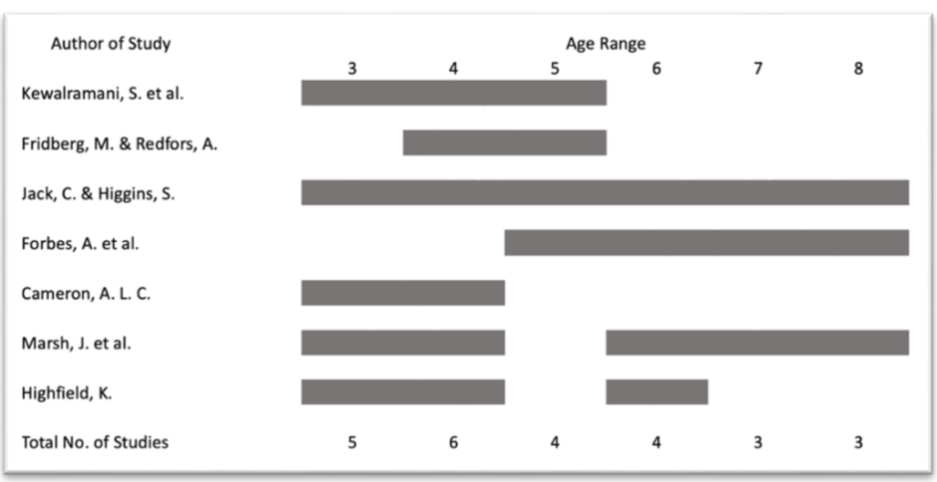
Information	Study 1	Study 2	Study 3	Study 4
Author	Kewalramani, S. et al.	Fridberg, M. & Redfors, A.	Jack, C. & Higgins, S.	Forbes, A. et al.
Year	2020	2021	2019	2020
Type of study	Research article	Research article	Research article	Research article
Methodology	Observation, interview, multimedia message	Observation	Interview	Teacher interviews, surveys, journals, student interviews, iPad screen recordings
Age	3-5 yr	4-5 yr	3 - 8 yr	5-8 yr
Study location	Australia, Norway, Scotland, England	Mid-sized towns Sweden	North East England	A metropolitan city in Australia
Curricular structure	Child-center; play-based	N/A	N/A	STEM valued
Teacher's background information	Teachers had valid qualifications	Teachers had professional development about science teaching	Teachers' pedagogical beliefs were child-led; play-based. Teachers didn't have sufficient knowledge of using digital tools	Teachers had no experience of 3D technology or makerspace and participated in pre-project training
Digital devices	Different kinds of IoToys	Blue-Bot	Camera; computer; IWB; iPads; recording devices; programmable toys; audio players	iPad; 3D printers

Information	Study 5	Study 6	Study 7
Author	Cameron, A. L. C.	Marsh, J. et al.	Highfield, K.
Year	2015	2019	2015
Type of study	Ph.D Dissertation	Research article	Research (book chapter)
Methodology	Observation, interview	Observation, interview	Interview, videotaped experiences, children's drawn representations.
Age	3-4 yr	3-4 yr; 6-8 yr	3-4 yr; 6 yr
Study location	Rural Colorado (U.S.)	Northern England	U.S.
Curricular structure	STEM (technology skills for cognitive and social ability)	Play-based	N/A
Teacher's background information	Teachers were all qualified preschool teacher	Teachers received pre-project training	N/A
Digital devices	Makerspace; Robotics; Bee-Bots; Cube-lets	iPad; Computer; 3D printer	Robotic toys: Lego NXTTM, Robopet by Wowee Toys, a "recycled robot" made by one of the children with boxes, Bee-Bots, and Pro-bots (TTS Group).

As shown in Table 8, five of the seven studies were published after 2019, while two are in 2015. Five of the seven studies are research articles, while one is a Ph.D. dissertation, and one is a research study described in a book chapter. All the studies include different forms of observation like class observation, teachers' working journals, screen recordings of iPad, and videotaped learning experience. Six of the seven studies include interviews with teachers or teachers and students. Three of the seven studies used other media for recording data like multimedia message on the internet, surveys, and children's drawn representations. For the age group, five of the seven studies have the target age group as 3 to 4 years old, five of the seven studies include 5 to 6 years old, three of the seven studies have 6 to 8 as the target age group (see Figure 5). Six of the seven studies are in or include studies in Europe, two include studies in Australia, and two include studies in the United States. In the selected studies, the teaching contexts are play-based (2/7) and value children's learning of STEM subjects (2/7). All teachers in these studies are qualified teachers in early childhood education. Three of the studies provided pre-project training as a part of the project, which provides the teachers with more knowledge of the digital tools as teaching tools and context.

Figure 5

Age Range of Child Participants in Each Study



Digital Tools and Activities in the Studies

Through my process of study selection, I came to realize that I needed to develop a nuanced definition of Digital Making that fit these data. Building from Honey and Kanter (2013), Mills (2010), Sheridan et al. (2014), Spiro and DeSchryver (2009), and Wohlwend et al. (2017), I defined Digital Making as activities that involve the creation or manipulation of physical and digital artifacts with *digital* tools, and that involve a process of exploration of new ideas, development of digital literacies components such as information, media, and technology skills, as well as digital making and meaning-making skills, along with interaction with materials and peers. Table 9 summarizes the types of tools used in these studies and children's activities with them, as reported in the studies.

Table 9

Description of Activities with Digital Tools

Digital tool	Children's activities with the digital tool
Programmable Robots	Children manipulate the buttons of robots to make them perform physical actions.
Operatable Toys / Remote Toys	Children operate toys, which are connected to the Internet, and share their actions with the toys through the Internet.
iPads apps for 3D printer	Children have constructive activities in virtual format in iPad apps and/or print their design with 3D printers.

Analytically, I operationalized this definition by determining whether the digital tools were used in the study *for creation* or *for manipulation*. I did not include using screen activities with digital tools as digital making because this type of activity does not, generally, have children manipulating physical objects. For example, reading storybooks on iPad was not Digital Making. In Table 10, I show a categorical analysis of the tools and whether they are used for creation or manipulation in these studies. I describe how these categories of digital tools were used in each study in this section.

Table 10

How the Use of Digital Tools Meet the Definition Criteria of Digital Making

Digital tool	Criteria in the definition	
	Creation	Manipulation
Programmable Robots		✓
Operatable Toys / Remote Toys		✓
iPads apps for 3D printer	✓	

Programmable robots and operatable toys are the most common digital tools, with five of the seven studies having included them. Programmable robots are robots with buttons, conducting movement according to the operator's command (Cameron, 2015; Fridberg & Redfors, 2020; Highfield, 2015; Jack & Higgins, 2019). Programmable robots enabled children to build their confidence in using robots, and by debugging (solving problems in the programming process to have the robots perform physical movement as directed), children built up resilience as their socio-emotional development. For the operatable toys (Kewalramani et al., 2020), children interacted with the toys, had their actions recorded, and shared their feelings proximally (face-to-face with peers and adults) or online (with the platform within the toys). The other two studies used iPad apps like Google Tilt Brush for virtual constructing and/or a 3D printer to perform the constructing process in the making activity (Forbes et al.,2021; Marsh et al., 2019). The designs of making and maker-oriented activities with these digital tools are as follows.

Programmable Robots and Operatable Toys

In the study by Kewalramani et al. (2020), the use of Internet of Toys (IoToys) combined physical toys with the internet. The internet linked children's activity with physical toys to the virtual world and turned children's 2D artefacts into 3D artefacts. Children also could develop their digital literacies, as defined earlier as information, media, and technology skills, in terms of making action with digital tools by picking up coding knowledge. The learning of coding was embedded in physical activities. There was an activity where children built physical robot cities with wooden blocks by coding robots to perform actions. This activity brought personalized features to the learn and play process as children were making decisions and designing their robot's figures. Children developed self-agency when they were making decisions. They participated in the physical world and communicated with other children as robots. The internet feature of these toys brought more sharing opportunities for children during the learning and playing process. This sharing feature supported children to express themselves.

In the study by Fridberg and Redfors (2020), coding knowledge from programmable robots was embedded in traditional learning activities such as matching cards. During the activity, robots were used as a way of completing the task, same as drawing a line to match objects. With the use of programmable robots, children developed digital literacies of coding knowledge and problem-solving skills through the de-bugging process. The mindset of de-bugging builds the foundation of children's further study on digital technologies. For example, "the children talk to each other and to the preschool teacher about trying and re-trying, making errors and what should be corrected in the programming to make the Blue-Bot® reach its goal" (p. 10).

In Jack and Higgins' (2019) study, children had free play with programmable robots (Bee-Bots). During the activity, teachers provided mats for children to explore. As reported in the study, teachers thought programmable robots could benefit children with learning outcomes of "communication and language, understanding the world, expressive arts and design" (p. 231).

In Cameron's (2015) study, programmable robots were provided for children to explore mostly on their own. The study also included inquiry-based coding activities that involved children moving the robots from one picture to the next by coding. As it was described in the study, the teacher "She had the children pick picture cards. Then, the children were to program the Bee-Bot to go from one picture to the next" (p. 74). Programmable robots, as unfamiliar objects, naturally drew children's attention. Moreover, in the mixed-aged setting, children from the older group had more experience of operating the robots. Children developed the sense of collaboration and communication skills by offering help to younger group of children.

Highfield's (2015**)** study described children's activities with a range of different programmable robots including "Lego NXT™, Robopet by Wowee Toys, a 'recycled robot' made by one of the children with boxes, Bee-Bots, and Probots (TTS Group)" (p. 153). Activities included inquiry-based learning of basic mathematic knowledges of coding. The activities were either children's experience based, or free play based. Children could collaborate to code the robots to do the hokey-pokey dance. Remote controlling the robots by coding also enabled them to learn about physic knowledges like the angle of incline when climbing ramps. This activity refuted the stereotype that digital tools were all about virtual things in teaching and learning by presenting opportunities of learning like "Build a bridge—Construct a bridge that your robot can move across. Try a variety of materials to investigate opportunities", and "Dancing Bots—Teach (program) the robots to dance and then perform a dance with your robot" (p. 157). Another form of digital tools in Digital Making in the seven selected studies is iPad applications and 3D printers. I present the use of iPad application and 3D printers in the following section.

iPad Applications and 3D Printers

Two of the seven selected studies included the use of iPad applications or other Web 2.0 platforms and 3D printers. The study by Forbes (2021) trained teachers to follow the Innovation Design Engineering Organization model (IDEO). This model included five phases of scaffolding children's design process: (a) discovery, children understood the enquiry and gather inspiration to solve the problem by exploring each part of the 3D printer, (b) interpretation, children searched for meaning and framing opportunities and start to visualize their designing ideas on the screen of the 3D printer, (c) ideation, children generated ideas and refine the ideas for solutions, (d) experimentation, children made prototypes and revise them based on the feedbacks, and (e) evolution, children evaluated the project outcomes and search for more improvement. The design activities were inquiry-based and building on children's experiences. Teachers helped children to complete designing projects step by step while encouraging them to collaborate. Children were greatly engaged in the activities while developing digital literacy of constructing things with 3D printer.

From the four projects described in the study by Marsh et al. (2019), the PABLO app, the iMotion app, interactive whiteboards, circuits, laser cutters, the Qlone app, 3D printers, and the Google Tilt Brush were used in digital making activities. Two of the four projects involved exploring light and color. Children had activities with physical materials like cardboard boxes and digital tools like the PABLO app to learn about light and shadows. The productive activity was making animations with a projector, tablet, and the iMotion app. Building on their experience of drawing, children used circuits as the new material for drawing. Building on their experience of decorating a Christmas tree, children used laser cutting and circuits to decorate the Christmas tree. The other two projects included laser cutters, the Qlone app, 3D printers, the iMotion app, and the Google Tilt Brush. Children used digital tools to make physical construction with 3D printer. The object of 3D printing was from children's theater experience or their imagination. Children first drew and laser cut the models from the theater performance and used clay, the Qlone app, and 3D printers to create the models. The models were finally used to create green-screen animated films with the iMotion app. The 3D printed models were than imported into the Google Tilt Brush to create virtual spaces for children to explore more. Activities described in this study are construction of not only physical objects like decorated Christmas tree and puppet models, but also digital productions like animations and virtual villages.

Theoretical Frameworks of the Studies

In my synthesis of the design of studies, I assumed that the theoretical frameworks used in these studies represented the authors' views of Digital Making in early childhood education. The theoretical frameworks of the seven studies were all different. There are two studies that did not have theoretical frameworks. Jack and Higgins (2019) did not have a section of theoretical framework but reviewed the development of educational technology in early years and revealed how teachers in early childhood education understood and used educational technology. Highfield's (2015) book chapter described the research of how programmable robots can support children's learning of STEM concepts. There was no theoretical framework section. They based their research on an overview of STEM in early years and an overview of programmable robots. I did not include theoretical frameworks for these two studies because the researchers did not conceptualize the information from literature review as their theoretical frameworks and therefore it would not reflect the researchers' view of Digital Making in early childhood education. I analyzed the quotes of the researchers' detailed description as shown in Table 11.

Table 11

Theoretical Frameworks of the Studies

Study	Theoretical framework	Description from the study
Kewalramani et al., 2020	Guided Interaction	Such interactions are characterised by demonstrating, enjoying, explaining, instructing, managing modelling, monitoring, promoting, providing feedback and supporting. (p. 199)
Fridberg & Redfore, 2020	botSTEM (Robotics and STEM education for children and primary schools)	The activities aim to introduce integrated STEM teaching scaffolded by robotics to four to eight-year-old children supported by the botSTEM didactical frame-work that links inquiry and engineering design principles. (p. 3)
Jack & Higgins, 2019		N/A
Forbes et al., 2021	Maker Literacies Framework	Identify and understand the processes, skills, and knowledge involved in meaning and artifact creation in Makerspaces involving young children… [the framework] describes three dimensions: Operational, Cultural and Critical, which describe, in general terms, the knowledge, skills and values demonstrated by students as they engage in Making tasks. (p. 173)
Cameron, 2015	Developmentally Appropriate Practice	Teaching young children in ways that (1) Meet children where they are, as individuals and as a group, (2) Help each child reach challenging and achievable goals that contribute to his or her ongoing development and learning, (3) Teachers do this through intentional teaching and purposeful play: (a) The curriculum and experiences need to actively engage children. These experiences should

		be rich and include teacher-supported play with an integrated curriculum, (b) The teachers need to be intentional in their decisions on how to organize their day, (c) Teachers should provide a time when children have choice and the learning experiences and teaching strategies to help individual children make optimal progress. (p. 12)
Marsh et al., 2019	Interpretations of sociocultural theories from the constructivist and developmental orientations of Piaget's theories	We propose that children's freely chosen activities in makerspaces can be understood by combining three perspectives: personal–individual, social–relational and cultural–institutional. (p. 222)
Highfield, 2015		N/A

The synthesis of theoretical frameworks included two steps of analysis. Step 1 focused on deductive coding with aspects of the three theories, constructivism, embodiment, and empowerment pedagogy. Step 2 included provisional coding for the emergent themes aside from the aspects of theories in Step 1 (see Table 12).

Table 12

Definition and Examples of the Provisional Codes for Theoretical Frameworks Analysis

Code name	Definition	Sample excerpt
Enjoyable	The theory marks the learning activity as enjoyable or engaging.	Such interactions are characterized by demonstrating, enjoying, explaining, instructing, managing modelling, monitoring, promoting, providing feedback and supporting" (Kewalramani et al., 2020. p. 199)
Instructor	The theory marks teacher's role as an instructor and teacher's instruction strategies.	Teachers do this (Developmentally Appropriate Practice) through intentional teaching and purposeful play" (Cameron, 2015. p. 12)

Combining the aspects of the theory of constructivism, the theory of embodiment and empowerment pedagogy as listed in Table 5, I listed the analysis of elements that I pulled out from theoretical frameworks of the five studies. The result of theoretical frameworks of the five studies categorizing is shown in Table 13. The symbol "✓" in each cell represents that the aspect is included in the study.

Table 13

Result of Theoretical Frameworks Analysis

Tenet of theory	Study 1	Study 2	Study 4	Study 5	Study 6	Total
CS - Social			✓	✓	✓	3
CS - Children-tools Relationship	✓				✓	2
CS - Productive			✓			1
CS - Problem Solving	✓	✓	✓	✓	✓	5
EB - Senses			✓			1
EB - Environment Interactions	✓		✓			2
EB - Tools in New						0
EP - Culture		✓	✓	✓	✓	4
EP - Agency			✓		✓	2
Enjoyable	✓			✓		2
Instructor	✓	✓		✓		3

As shown in Table 13, all the five studies that had theoretical framework sections in text, mentioned problem-solving in their theoretical framework sections. Four of the seven studies mentioned culture in their theoretical frameworks. These studies emphasized that learning should be embedded in real-world problems connected with children's life. Three of the seven studies' theoretical frameworks mention children's learning under the social context. Three of the seven studies' theoretical frameworks mark the teacher's important role in using instructional strategies to support children's learning. None of the theoretical frameworks of the seven studies discussed children using tools in new ways or for new purpose in the learning process.

Teachers' Perspectives of Making and Maker-oriented Activities with Digital Tools

I present the results of teachers' perspectives of Digital Making according to steps from the *method* section: categorizing teachers' perspectives of Digital Making, synthesising teachers' perspectives of Digital Making with aspects of theories in matrix display and looking for emergent themes beyond the aspects of theories.

Primary Descriptive Coding for Teachers' Perspectives

I first coded all the seven selected studies for their findings and results related to teachers' perspective of making and maker-oriented activities with digital tools according to the descriptive coding of teachers' conceptualization (CON) and planning (PLAN) as described in Table 5. In this analysis, for each of the seven studies, I looked for examples of idea units that aligned with each of the codes listed in Table 14. So, within each of the studies, and using the definitions I have outlined in Table 14, I coded the data for examples of teachers' expression of learning benefits, integration and so on. The frequencies of the idea units differed by study, but in Table 14, I provide the total number of times each of these codes appeared across the whole data set of seven studies.

Table 14

Results of Descriptive Coding of Teachers' Perspectives

Code name	Definition	Sample excerpt	Codes number
CON - Learning Benefits	The learning benefits the teacher sees in digital making as a pedagogical approach.	The adult-directed activity becomes an introductory task, a framing activity that allows children to build confidence and competence in using the robot. (Kewalramani et al.,2020, p. 206)	28
CON - Integrate	The teacher's perceptions of why and how to integrate digital technologies into teaching. E.g.,	In her words, inquiry instruction is a great way to integrate technology into the classroom. (When using inquiry instruction and technology) it doesn't become forced, and it's not overly structured. It's more exciting and engaging and kids do it because they want to do it and not because they have to do it. (Cameron, 2015, p. 77)	18
CON - Job	The teacher's understanding of their job as the teacher during the digital making activity.	The children are being supported by the educator to use Osmo, Monster which then became a group activity where the children showed different aspects of the proximal interactions inherent in GI, such as explaining (Johan explains that the language is English), enjoying and supporting. (Kewalramani et al.,2020, p. 205)	4
CON - Teacher-student Relationship	The teacher's understanding of their relationship with students during the digital making activity.	This study positions educators and children as collaborators who share the learning experience with a common focus of having a similar level of fun with IoToys as with their experience with physical toys. (Kewalramani et al.,2020, p. 210)	3
PLAN	The teacher's activity planning.	She began by connecting robots with something that the students were familiar with, the human body. (Cameron, 2015, p. 72)	22
Total			75

Top-down Coding

To find the themes of teachers' perspectives of making and maker-oriented activities with digital tools, I first used the top-down analysis. This analysis is to find whether teachers' conceptualization and planning of the digital making activities matches with the theoretical framework of this study, which is also the foundation of making and maker-oriented activities in early childhood education. After getting the 75 codes from the former step, I put the codes of each study into the matrix display with the aspects of the theories of constructivism, embodiment, and empowerment pedagogy as defined in Table 5. The example of each aspect of the theory of constructivism (CS), the theory of embodiment (EB) and empowerment pedagogy (EP) is as shown in Table 15.

Table 15

Examples of Top-down Codes

Code name	Definition	Sample excerpt
CS - Social	Learning from social activities.	Children socially collaborated with each other in a positive manner and came to a mutual decision about constructing the ‘Robot City’ as a home for their robots to live. (Kewalramani et al.,2020, p. 207)
CS - Children-tools Relationship	Learning from interactions of relationships between children and digital tools.	the “shadow puppet” unit provided inquiry opportunities for students to investigate scientifically the ways in which light interacted with materials – which materials were opaque, transparent or translucent, and that the shape of the shadow was due to light traveling in straight lines. (Forbes et al., 2021, p. 175)
CS - Productive	Digital Making develop the productive ability.	(iii) Using the wooden characters in shoebox theaters;… (v) Creating clay Moomin models; (vi) Scanning those using Qlone app and creating 3-D digital models; (viii) Printing the 3-D digital Moomin figures on a 3-D printer; (ix) Using the clay and 3-D printed models to make green-screen animated films using the app iMotion; (x) Importing the 3-D digital Moomin models into Google Tilt Brush and creating a virtual reality Moominvalley” (Marsh et al., 2019, p. 225)
CS - Problem Solving	Digital Making develop problem solving skills	when IoToys are integrated they can become a platform for rich symbiotic explorations, creativity, collaboration and problem solving (Kewalramani et al.,2020, p. 210)
EB - Senses	Meaning-making process comes from our senses.	While building a robot city, children collaboratively made Botley (and another IoToy - Coji) travel through a tunnel constructed with wooden blocks, allowing children to understand the play in a multi-modal and integrated environment where technologies are not the defining or central component of an environment, but rather an artefact among many (Kewalramani et al.,2020, p. 207)
EB - Environment Interactions	Environment provides interactions.	educators and children…experience resources such as IoToys and consider the child’s environment to be composed of a number of interactions (i.e. with

		artefacts, agentic beings – peers and guiding adults – and the cultural context) where children co-construct their explorations and learning (Kewalramani et al.,2020, p. 119)
EB - Tools in New	Using tools for new purpose, in new way, to make new things.	(i) Making light boxes with cardboard boxes that had clear tops, using cellophane and DIY torches (flashlights); (ii) Creating light shows in a blackout tent, using the app PABLO; (v) Creating animated films using an overhead projector and colored transparent shapes, a tablet, and the app iMotion. (Marsh et al., 2019, p. 225)
EP - Culture	Learning is based on meaningful problems related to culture and children's living experience.	Teacher data suggests these Making units strongly focused on developing students' capabilities in Cultural Dimensions, such as Engagement, Collaboration and Communication, Creativity, Maker Efficacy and Attitudes/Dispositions, indicating a prevalence of interpersonal and intrapersonal disposition and skill development. (Forbes et al., 2021, p. 180)
EP - Agency	Learning should contribute to children's agency development	This vignette shows maker agency in operation, in that Henry gained confidence and control through his engagement in the maker project. As he sat down and asked, "What are we making today?", he was demonstrating the development of a maker mind-set, which fostered his active agency (Marsh et al., 2019, p. 226)

I reviewed all the 75 codes from Step 1. To synthesize the frequency of teachers' expressed ideas in ways that aligned with the theories, I created Table 16. In this table, you can see all of the aspects of theory for which I coded in the first column. Along the top row, headings are the four categories of conceptualization of Digital Making and planning for Digital Making that I constructed based on Mishra and Koehler (2006) and Swallow and Olofson (2017) (see Table 5). The number entered in each cell represents the number of articles that included teacher understanding of Digital Making that could also be coded with each theoretical tenet. So, for example, there were three studies that included teachers who talked about their understanding of the learning benefits of Digital Making activities for young children in relation to the social or collaborative aspects of the activities. There was just one study that included a teacher's description of their job or what it means to be a teacher and that connected to the importance of conceptualizing social, collaborative Digital Making activities. All seven studies, however, included teacher insights about planning for Digital Making activities that emphasized social and collaborative elements.

Table 16

Overview of Top-down Analysis

Tenet of theory	CON - Learning Benefits	CON - Integrate	CON - Job	CON - Teacher-student Relationship	PLAN	Total
CS - Social	3	2	1	1	7	14
CS - Children-tools Relationship	1	1	1	1	2	6
CS - Productive	0	0	0	0	2	2
CS - Problem Solving	5	0	3	0	4	12
EB - Senses	1	0	0	0	1	2

EB - Environment Interactions	1	0	0	0	1	2
EB - Tools in New	0	0	0	0	1	1
EP - Culture	1	4	1	0	2	8
EP - Agency	5	0	0	0	0	5
Total	17	7	6	2	20	52

As is shown in Table 16, when thinking about Digital Making in early childhood education, teachers grounded their conceptualizations and planning in tenets of the theories of constructivism and empowerment pedagogy more often than in the theory of embodiment. Regarding the tenets of theory of constructivism specifically*, learning from social activities* was the most frequently mentioned in teachers' activity planning across the seven studies. The development of *problem-solving* skills was most mentioned for as an identified learning benefit and as a consideration in teachers' planning for making with their students. Teachers' understandings of the learning benefits of making and maker-oriented activities with digital tools also seemed to align with the aspect of *agency* from empowerment pedagogy. Five articles included teacher perspectives that focused on how children can be empowered and develop their self-identity through digital making. Teachers' integration of digital making also seemed to align with notions of *culture* that are integral to empowerment pedagogy. Eight studies included teacher perspectives that aligned with the notion that children's learning through making should be informed by, or embedded in their living environment and connect to their life experiences.

One surprising insight that emerged from this analysis was that studies of teachers' perspectives of making and maker-oriented activities with digital tools did not all include teacher voices or interview data as evidence of teachers' thinking about making. More often, these studies focused on teachers' activity planning rather than on teachers' own descriptions of the maker activity designs or why they planned the way they did. In all of the seven studies, teachers' activity planning was more often the focus of the research than teachers' descriptions of their conceptualization. As shown in Table 16, there were very few examples of teacher perspectives that fit with my definitions of "the teacher's understanding of their job as the teacher during the making and maker-oriented activities with digital tools" and "the teacher's understanding of their relationships with students during the making and maker-oriented activities with digital tools".

Bottom-up Coding

To better understand teachers' perspectives of Digital Making, I looked beyond theories of constructivism, embodiment, and empowerment pedagogy for emergent themes using a bottom-up qualitative coding approach. I analyzed teachers' understandings of Digital Making that did not seem to fit neatly with my theoretically informed analytical framework. Among the aspects of codes, I connected the themes among these codes. This process resulted in the construction of six additional codes focused on a range of issues identified by the teacher participants in this set of seven studies. The codes, their definitions and sample excerpts are displayed in Table 17.

Table 17

Definition of Emergent Themes Coding for Bottom-up Analysis

Code Name	Definition	Sample excerpt	No. of studies mentioned
Learning Benefits-Digital Literacy	The author or participant teachers think or use digital making activity to develop or enhance children's capability of using digital technologies and develop children's confidence of using digital technologies.	In this case, the adult-directed activity becomes an introductory task, a framing activity that allows children to build confidence and competence in using the robot. (Kewalramani et al.,2020, p. 206).	5
Learning Benefits-Engaging	The author or participant teachers think the activity can attract children's attention. They therefore view Digital Making as engaging or use digital technology to engage children.	Peer-peer interactions facilitate positive problem solving, where Casie continues to join in as a play- mate, inviting and interacting with the children as well to join into the constructions using other resources such as wooden bricks (multidimensional interactions) and conversations to build the robot city and engage in the play (multimodal interactions). (Kewalramani et al.,2020, p. 208).	3
Activity-Teacher's Instruction	The author or participant teachers think, or use instructing strategies to engage children and meet the learning objectives.	How many steps is it to the door or the chair or the desk? Teachers can scaffold this based on the child's number concepts and encourage children to work in pairs or small groups to scaffold learning and documentation. (Highfield, 2015, p. 157).	3
Activity-Sharing	The activity in the study involves children's sharing of experience or thoughts.	Children use multiple modes to convey meaning and share experiences during play with any means available to them (IoToys, physical resources). (Kewalramani et al.,2020, p. 204).	3

Activity-STEM	The activity in the study is based on learning objectives of STEM.	The activities hence combine robotics and STEM and this study provides novel knowledge of how teachers with a sciencing attitude and children talk to each other during activities including digital or analogue programming. (Fridberg & Redfors, 2020, p. 11).	2
Activity-Free Play	The activity in the study is child-centered in the form of children's free play.	Jenna noted that her, "students have been able to explore what it is like to learn in a future-focused setting, they're able to investigate real world problems independently and explore their critical thinking skills and designing skills. (Forbes et al., 2021, p. 179).	3

A frequency analysis of studies covering the above codes represents another part of the themes and patterns in making and maker-oriented activities with digital tools, as a supplement to the theory-driven analyses. The frequency of the appearance for each code in the seven studies is as shown in Table 18. The number refers to how many articles have included these ideas (codes). The maximum number is seven.

Other than the learning benefits of Digital Making from aspects of constructivism, embodiment, and empowerment pedagogy, benefits of Digital Making for children's development of digital literacy and making the activities engaging are also highly valued as learning benefits for Digital Making across the seven studies. These learning benefits are among the key elements of teachers' reported decisions to use making and maker-oriented activities with digital tools in their teaching practice. Children are expected to be more skilled in using computer language or coding language. Moreover, digital technology proficiency, confidence, and competence in using digital technologies as robots are also expected to be developed in the activity.

In terms of activity planning, the importance of appropriate teacher instruction is highlighted. During the activities, children were usually asked to share their feelings and experiences. The reported teaching strategies revealed teachers' perspectives of Digital Making in terms of teachers' understandings of their job and their relationships with children. For example, in Highfield (2015), there was a description of teachers' instructions:

> In modeling the process of learning and investigation the teachers stepped back from the position of expert and became co-players, participants, exploring the technology—experimenting with what worked and what didn't, demonstrating dispositions for learning, and modeling reflection and revision. The teachers also modeled the thinking

> process out loud for the children 'in the beginning I thought … now I think …' using questioning to promote active knowledge construction. (p. 156)

The curriculum structure of early childhood education settings with Digital Making also included the reported importance of STEM subjects. Within STEM-focused activities, children were most often encouraged to play freely. As reported in these studies, the value placed on STEM subjects and the availability of children's free-play time were essential to teachers' perspectives of Digital Making. STEM concepts are embedded in children's inquiry-based hands-on activities. For example, in Cameron (2015), a teacher described her idea of integrating STEM concepts into Digital Making:

> Inquiry instruction is a great way to integrate technology into the classroom. (When using inquiry instruction and technology) it doesn't become forced, and it's not overly structured. It's more exciting and engaging and kids do it because they want to do it and not because they have to do it. (p. 77)

Summary of Results

To summarize, findings for the first research question, *How have studies of making and maker-oriented activities with digital tools with young children been designed?*, show that across these seven studies, the age groups of participating children were evenly distributed from ages 3 to 8. All of the studies took place in developed countries with well-developed early childhood education curricula and programs. School contexts emphasized play-based approaches and/or placed value on STEM subjects in activity planning. Three of the seven studies provided pre-project training for teachers. As noted, the studies were most often informed theoretically by the principles of constructivism and empowerment pedagogy. The digital tools used in the seven selected studies were programmable robots, remote toys, and 3D printers for children to manipulate, design and create. Children participated in a range of activities using these digital tools. Activities included (a) using Internet of Toys to experience 3D play comparing to 2D play with digital screens, (b) using programmable robots to have play-based and inquiry-based learning of coding, (c) exploring each part of a 3D printer, (d) using iPad applications to design for 3D printing, (e) using iPad applications to learn about lights and shadows to decorate a cardboard box, (f) using circuits for drawing, (g) using laser cutting to decorate a Christmas tree, and (h) using Google Tilt Brush to create virtual spaces.

To summarize results in response to the second question, *How do teachers understand making as a teaching method?*, I analyzed teachers' perspectives of Digital Making in two parts, their conceptualization of Digital Making, and their planning of Digital Making activities to support student learning. I analyzed teachers' conceptualization of Digital Making from four elements: (a) the learning benefits the teacher sees in Digital Making as a pedagogical approach, (b) the teacher's perceptions of why and how to integrate Digital Making into teaching, (c) the teacher's understanding of their job as the teacher during Digital Making, and (d) the teacher's understanding of their relationships with students during Digital Making. Teachers' views of the learning benefits of Digital Making aligned with the theory of constructivism and empowerment pedagogy in terms of social activities with adults and peers, interaction with materials, and the importance of developing problem-solving skills and self-identity. Moreover, teachers believed that Digital Making could help children to develop digital literacies. Teachers also saw that because of children's interest in digital tools, Digital Making activities were of great value in engaging children and contributing to children achieving their learning goals.

Although less frequently reported than teachers' understanding of learning benefits of Digital Making, teachers did think about the integration of Digital Making in ways that aligned with constructivism and empowerment pedagogy. Teachers understood Digital Making in terms of the social interactions it affords young children. They also understood Digital Making as a way to connect classroom experiences with children's lived experience and cultures. Teachers understood their jobs in the Digital Making were to create the environmental conditions that allow young children to learn through making and to act as instructors who scaffold children to better express themselves or complete the tasks.

In terms of planning for Digital Making activities, the description of Digital Making activities in all seven of the selected studies reflected elements of constructivism. Children's social activities, the development of sharing, the ability of using their knowledge and experience, and the development of problem-solving skills were most observed. Further, these planned Digital Making activities happened most often in early childhood settings that value STEM subjects, and where free play was a dominant form of activity.

Discussion

In this section, I discuss the results of this qualitative research synthesis, as framed by my research questions. For the first research question, *How have studies of making and maker-oriented activities with digital tools with young children been designed?,* I discuss the design of the studies from perspectives of context, method, theoretical frameworks, and types of activities described in the studies.

For the second research question, *How do teachers understand making as a teaching method?*, I discuss teachers' perspectives from two aspects, teachers' conceptualizations and their planning. Because the amount of data that speaks to these two aspects is different, I discuss the possible reason for such difference.

RQ1: How Have Studies of Making and Maker-oriented Activities with Digital Tools with Young Children Been Designed?

This section discusses the design of studies according to the three sub-questions of the first research question: (a) What were the context of these studies?, (b) What digital tools have been used in these studies, and for what purposes?, and (c) How, if at all, have these activities been designed to align theoretically with tenets of constructivism, embodiment, and empowerment?.

Context of the Studies

Although there are a limited number of studies included in the synthesis, the distribution of participants' ages in the seven studies is even; every age is covered with at least three studies (as shown in Figure 5). The distribution of age range among the seven studies suggests that making and maker-oriented activities with digital tools can support every stage of children's learning from three to eight, and that the learning contents and activities can adjust for different learning needs of children from three to eight.

The seven selected studies were conducted in Australia, Norway, Sweden, United Kingdom, and United States. The five countries are developed nations and part of the Global North. The limited set of national contexts among these seven studies might be due to the focus of teachers' perspectives in this synthesis. Having all the studies carried out in the Global North does not mean that, among the 276 studies, there is not a broad context of making activities in early childhood education. The selected seven studies are based on a broad field of research in the global contexts of making activities.

Four of the studies described that the early childhood settings valued STEM subjects in their curriculum structure and had free play as a dominant form of activity. The appearance of keywords such as *STEM* and *free play* may indicate that Digital Making for young children is more easily integrated in contexts with STEM-based values and curricular orientations. Three of the studies provided additional teacher-training as a part of their project, which suggests that the complexities of Digital Making in early childhood classrooms may require a range of intentional supports to equip teachers with the necessary technical skills and planning methods. More research on the ways that Digital Making are integrated in pre-service teacher education programs is needed (Cameron, 2015).

Three studies captured video data of children as they played with the toys. This form of data collection gathered data from children's points of view for interpretation. Captured video data enabled researchers to interpretate the data from "different perspectives including those of children and educators within their natural settings and IoToys to play environment" (Kewalramani et al., p. 203). Captured video data can be a new form of data collection that could lead to new insights about children's learning. Data of captured video provides data that come directly from children's learning process. This form of data collection provides information from children's point of view. For research purposes, looking on children's performance without a third person can be a big step to reveal child-centered learning. This form of data collection also meets the core ideas of making and maker-oriented activities that situate children at the center of learning. With data from captured video of children playing with toys, future studies of young children can be more objective.

Digital Tools and Activities in the Studies

Digital tools used in the selected studies were programmable robots, operatable toys, and iPad apps for 3D printer. The making of physical objects with digital tools was via 3D printers (Forbes et al.,2021; Marsh et al., 2019). Teachers' understanding of the learning benefits of the design and making process with 3D printers aligned more generally with the learning benefits of making and maker-oriented activities reported in some of the seminal studies of making (e.g., Halverson & Sheridan, 2014; Blikstein, 2013). As a set of research studies focused on young children, teacher perspectives did include the ways that Digital Making could support the development of children's problem-solving skills, opportunities for exploration in an open-ended environment, the development of children's agency, and the development of emergent literacies like digital literacy (Forbes et al., 2021; Marsh et al., 2019). This aspect of teachers' understanding of Digital Making suggests that the Digital Making activities described in this set of seven studies may offer important learning opportunities for young children. The 3D printer activities seem best suited to slightly older children; these activities were conducted with children aged 6 to 8 years old. Considering that very young children have emergent digital competencies, programmable robots and operatable toys seem to be developmentally appropriate materials that can introduce children to digital tools, and to making decisions or solving problems with digital tools. The activities from the selected studies suggested that children's development of the problem-solving skills, decision-making skills, and digital literacies from the manipulation of digital tools seem to be a pre-making stage that builds the foundation for children's further making with 3D printers or other digital tools (Forbes et al., 2021; Marsh et al., 2019). From a critical perspective, it is important to note that computational problem solving with particular tools may also narrow or constrain young children's understanding of digital making (Masoumi, 2015). This concern is why it will be important for future research to focus on young children's maker-oriented learning using various materials for a range of purposes because, as emphasized in the theory of embodiment, children's sensory exploration and manipulation is considered as an essential part of the learning process.

Theoretical Frameworks of the Studies

The theoretical frameworks used to inform the seven selected studies tended to draw on tenets of constructivism (n = 5) and empowerment pedagogy (n = 4) (see Table 13). Just two of the seven studies used theoretical principles related to embodiment. Despite current understandings of learning as situated in the material entanglements of our bodies and environments (Glenberg, 2010; Hagerman & Cotnam-Kappel, 2019; Rowsell & Shillitoe, 2019) the paucity of studies that centred the theory of embodiment, compared to the other two theories, may reflect a limited understanding of this theoretical orientation among early childhood researchers. On the other hand, the presence of two embodiment-focused studies could indicate a growing interest in this theoretical framework. Further studies could explore making and maker-oriented activities with digital tools from the view of embodiment, which could extend our collective understanding of learning through hands-on, maker-oriented activities with a variety of digital and physical materials.

RQ2: How Do Teachers Understand Making as a Teaching Method?

In this section I provide a discussion of teachers' understanding of making and maker-oriented activities in two parts – their conceptualization (of digital making) and their planning (for digital making). The discussion is based on (a) the results of the top-down theoretical analysis of teachers' conceptualizations and planning, the matrix display of aspects of theories of constructivism, embodiment, and empowerment pedagogy, with aspects of teachers' perspectives in Table 16, and (b) the result of the bottom-up analysis in Table 18.

Conceptualization - Learning Benefits of the Activities

As reported in Table 14, I found that 28 of 75 total codes described teachers' understanding of Digital Making in terms of perceived learning benefits (see Table 14), which. is consistent with foundational elements of the theories of constructivism, embodiment, and empowerment pedagogy. Teachers seemed to understand that through Digital Making, young children were provided opportunities to (a) develop problem-solving skills, (b) develop a sense of agency and a sense of self, and (c) learn through social interactions. From the Digital Making activities in the seven studies, children's learning was inquiry-based and child-centered, and often took the form of group tasks. Three of the seven studies were free-play based. Children's learning in Digital Making activities seems to require knowledge of complicated and unfamiliar digital tools relative to the knowledge they need to use traditional physical materials like blocks and paintings. But teachers in these studies reported using making nonetheless, and because of the importance of the various skills (e.g., coding, problem-solving, social interactions) that

Digital Making enabled their students to practice. This part of teachers' understanding of Digital Making is an important finding because research on teacher decision making more generally shows that teachers make decisions about how to teach based on the perceived learning benefits of the approach for their students (National Association for the Education of Young Children and the Fred Rogers Centre for Early Learning and Children's Media, 2012; Mishra & Koehler, 2006). The strong belief in the benefits of making, added to conceptualizations that tended to align theoretically with constructivism and empowerment pedagogy raises a question about whether, for teachers who participated in these seven studies, Digital Making may have been an extension of activities that were already familiar or that aligned with their a priori beliefs. It is not clear from this qualitative research synthesis, however, whether teachers were invited to describe the downsides or the challenges of making with their young learners. To gain a more balanced perspectives on Digital Making with young children, future research could look for teachers' understanding of Digital Making from both perspectives of learning benefits and negative influence on children's learning. Future research may seek to disrupt what seemed to be a nearly universal perception of benefits without a critical counterbalanced perspective.

From the bottom-up qualitative analysis, the emergent themes of teachers' conceptualizations of Digital Making were all about perceived learning benefits. Even though I expected to see other considerations in teachers' conceptualization and planning for Digital Making (i.e., why and how they would integrate digital making, how this aligned with their jobs, or thinking about their relationships with children during Digital Making) teacher perceptions focused mostly on how they understood the learning benefits of making. In addition to the lack of criticality identified above, this finding also raises questions about the scope or opportunity that teachers had to consider other aspects of their work in relation to Digital Making. Future studies should ask teachers about the way that Digital Making as a pedagogical approach intersects with the complexities of their work including in ways that teachers may not like.

Aspects of the Two Theories not Evident in the Dataset.

Besides the aspects of learning benefits that have been mentioned above, there were six aspects of the three learning theories that I expected to see in the dataset but that were not particularly present in the conceptualization and planning data. These aspects are: (a) from constructivism: children learn from interaction of relationships between children and digital tools, (b) from constructivism: Digital Making supports children's development of productive skills, (c) from embodiment: children use senses to have the meaning-making process, (d) from embodiment: children learn from interactions with environment, (e) from embodiment: children learn from using tools in new ways, and (f) from empowerment pedagogy: children have their learning based on meaningful problems related to culture. Given my assumption about the theoretical foundations of making activities in early childhood education, I will discuss the possible reasons for the absence of these six aspects in teachers' perspectives of Digital Making.

Learning from Interaction of Relationships between Children and Digital Tools.

Only one study (Kewalramani et al., 2020) included teachers' mention of the interactions of relationships between children and digital tools as an important aspect of learning through making. In this direct quotation from Kewalramani et al. (2020), we can see how interactions benefited children's development.

> Within the assemblage of interactions among teachers, children and technology, children conceptualise higher mental functions such as problem-solving dispositions, question-driven inquiry, acquisition of speech and language and social learning. (p. 199).

This study is unique in its focus on the complex interactions among teachers, the children, the tools and learning. The complex interactions can be understood as “assemblage of interactions”, which is a concept found in theories of embodiment (Hagerman & Cotnam-Kappel, 2019, p. 3). The other studies did not use the idea of assemblage of interactions but rather focused on children’s use of digital tools and their learning *to use* digital tools. For example, in the study of Jack and Higgins (2019), teachers described their jobs as introducing children to operate programmable toys, or remote-control toys, and when children learnt how to use the digital tool, children would have open-ended play. The only consideration of assemblage of interactions among the seven selected studies suggests that teachers who participated in these studies may have viewed Digital Making as far too technology-centric, like learning about coding, or considering Digital Making as an open-ended free play, bassemblage of interactions” in the study of young children’s learning through digital making.

Being Productive.

None of the seven studies included teachers’ mention of being productive. Although all the seven studies include different forms of production in the activity, the production processes were mainly considered as the aim of the activity instead of opportunities for children’s development through production or as they produce. The process versus product tension may reflect a broader consideration for teachers, which is that of assessment and evaluation of children’s work. It io teachers’ need for evidence of learning. Future research should examine this tension more closely.

The Three Aspects from The Theory of Embodiment.

Among the seven studies, only one study (Kewalramani et al., 2020) seemed informed by two foundational aspects of the theory of embodiment: (a) children use senses to have the meaning-making process, (d) children learn from interactions with environment. In this direct quotation provided in the Kewalramani et al. (2020), we can see how robots were used for children's sensory exploration of wooden blocks and the IoToy in a digital tool integrated environment:

> While building a robot city, children collaboratively made Botley (and another IoToy - Coji) travel through a tunnel constructed with wooden blocks, allowing children to understand the play in a multi-modal and integrated environment where technologies are not the defining or central component of an environment, but rather an artefact among many. (p. 207)

Although some of the Digital Making activities in early childhood education are about manipulation of digital tools, it seems that early childhood teachers may overlook children's physical connection to the materials and the way that learning is situated in those interactions. There are many possible reasons for this including the following three explanations. First, in contexts with limited access to digital tools teachers may be focused on technology use and may overlook embodiment considerations because their focus is on technical skill development. Second, embodiment, as a relatively new theoretical framework comparing to cognitive perspectives and social-constructivist perspectives on learning such as constructivism (Dewey, 1899), may not been entirely integrated in teacher training (Barsalou, 2010; Glenberg, 2010). Third, teacher training courses may not fully consider how learning happens in relation to materials and the environment.

Learning in a Cultural Context.

Among the seven studies, one study (Forbes et al., 2021) included evidence of teachers' understanding of Digital Making as children's learning experience that was based on meaningful problems related to culture and children's living experience:

> Teacher data suggests these Making units strongly focused on developing students' capabilities in Cultural Dimensions, such as Engagement, Collaboration and Communication, Creativity, Maker Efficacy and Attitudes/Dispositions, indicating a prevalence of interpersonal and intrapersonal disposition and skill development. (p. 180)

Children's learning should be based on their lived experiences and cultural context (Blikstein, 2013; Clapp et al., 2020). However, for the balance between developing digital literacies, like coding skills or using iPad for 3D printing, and fundamental learning and development grounded in cultural contexts, studies are leaning towards the developing of digital literacies. Teachers see Digital Making more as the opportunity for children's digital literacies development, than a way to integrate children's cultural contexts in the creation or manipulation process. When Digital Making is more integrated in children's learning, it can be used as a tool to not only support digital literacies development, but also a learning process connected to children's cultural contexts. This aspect of culture seemed underdeveloped in this set of seven early childhood studies but could be the focus of much more research in future.

Conceptualization - Integration of the Activities

In four of the seven selected studies, teachers integrated Digital Making activities with children's interest, and meaningful problems related to culture and children's living experience (Cameron, 2015; Fridberg & Redfors, 2021; Jack & Higgins, 2019; Kewalramani et al., 2020). For example, teachers from the study of Jack and Higgins (2019) "indicated that they wanted child-friendly devices that can be used independently and support their pupils' interests" (p.

232). In the seven studies, teachers' understanding of learning benefits of Digital Making are the reason for teachers' integration of Digital Making. However, in this thesis I selected studies about Digital Making, led to an overlook of possible reasons for not having Digital Making activities in early childhood education. Future studies can investigate the obstacles that teachers may encounter when integrating Digital Making and the possible reasons for teachers or school board to not integrating Digital Making in early childhood education.

Conceptualization - Teachers' Job and Teacher-Student Relationships

Teachers' job, like what they need to prepare, how they should give instructions, and teacher-student relationships during Digital Making activities were rarely discussed across the seven selected studies. Three studies mentioned the way that teachers understand their job of the instructions they would give to children and prepare the environment for the activity (Cameron, 2015; Fridberg & Redfors, 2021; Kewalramani et al., 2020). For example, in the Digital Making activity in Cameron (2015), "the teacher had a mat with pictures on the mat. She had the children pick picture cards. Then, the children were to program the Bee-Bot to go from one picture to the next" (p. 74). One study (Kewalramani et al., 2020) mentioned teachers' participation in Digital Making activity, "Within these interactions the curriculum can be enriched to provide a context for children's explorations where the IoToys, educators and children interact to co-construct play and learning experiences" (p. 210).

Digital Making activities in the seven selected studies were mainly child-centered and free-play based, which may lead to less description of the teachers' role in the Digital Making activity. Moreover, teachers' understanding of their jobs and their relationships with children in Digital Making were collected in form of observation in all the seven studies. One possible reason for the only form of data collection may be teachers' unclear understanding of their work during making and maker-oriented activities with digital tools. Future studies can design interview questions refer to teachers' understanding of their jobs and their relationship with children in Digital Making activities in early childhood education.

Teachers' Planning from Top-down Analysis

In all the seven selected studies, teachers' planning of Digital Making was informed by an understanding of the importance of child-centred, free-play activities that enabled the children to interact socially, concepts that align most closely with the theory of constructivism. This synthesis shows that teachers use Digital Making as opportunities for children to collaborate and develop social and communication skills.

The results of teachers' planning of Digital Making activities aligned with their conceptualization of Digital Making in the seven studies. However, this result of alignment is not strong because none of the seven studies was situated their research questions on the possible difference between teachers' conceptualization and teachers' planning of Digital Making. Future study can investigate on whether teachers' planning align with their conceptualization of Digital making.

Teachers' Planning from Bottom-up Qualitative Analysis

In addition to the theoretically-informed themes, three other ideas were present in these studies in terms of how teachers plan making and maker-oriented activities with digital tools. These ideas were: (a) teachers' instruction, (b) building children's sense of sharing, (c) activities basing on STEM knowledge, and free play-based activities.

Teachers' instructions during the activity were observed and reported in three of the seven studies (Cameron, 2015; Fridberg & Redfors, 2021; Highfield, 2015). The instructions were assigning tasks, scaffolding, and supporting children to complete the task. For example, from the direct quotation in Cameron (2015), we can see how the teacher introduced robotics to their children by comparing the robot to human body:

> She began by connecting robots with something that the students were familiar with, the human body. The teacher compared the human body and body parts of a human with the parts a robot needs to function. Beginning with the human body, they talked about how a body has a brain and a heart. Next, they talked about the body of a robot. They, then, talked about the computer brain and the computer-processing unit (CPU). Then they spent a week talking specifically about senses. They compared human's five senses, how robots sense things, and how senses give humans and robots the information they need to interact with their environment. Finally, they talked about what jobs a robot could do and how robots could be programmed. (p. 72)

The idea of sharing was emphasized in three of the seven studies (Forbes et al., 2020; Kewalramani et al., 2020; Marsh et al., 2019). Sharing is different from social interaction in that in these studies, teachers noted that children shared their knowledge and experience with digital tools to those with less experience of working with digital tools (Marsh et al., 2019). This is an important insight because it suggests that teachers may plan their making activities to encourage the sharing of ideas, skills and even social practices so that all children can participate and grow in meaningful ways, according to what they bring to the activities and according to what they need.

In terms of why teachers plan to integrate Digital Making in their teaching practice, it seems that teachers' planning was grounded in their belief that Digital Making can meet children's learning needs. Teachers would integrate Digital Making in learning activities of STEM concepts like shadows, circuits, via free play activities. Teachers also seemed to report that children were more empowered during free play activities, which enabled them to explore more in the early stage when they had limited knowledge of using digital tools. Coding knowledge and circuits were the STEM concepts most often taught through digital making activities in this set of studies.

Difference between Teachers' Conceptualization and Teachers' Planning

Interestingly, although I applied the two-part conceptualization/planning analytical frame to the qualitative synthesis of this set of seven studies, the differences between teachers' conceptualization of digital making and their planning for and of digital making in their classrooms were quite subtle and, perhaps informed by the same theoretical underpinnings and practical constraints related to the work that they do with young children.

Teachers' conceptualizations of making were mostly grounded in their understandings of the learning benefits of digital making activities, and why and how to integrate digital making activities in early childhood settings in ways that aligned with constructivist and empowerment pedagogical theories. Their planning practices reflected these understandings with a few added nuanced complexities that were not present in evidence of their conceptualizations. The difference between teachers' understanding and their planning of Digital Making was not a surprise, but the nuances of teachers' planning activities were better documented and described in these studies. The better presented data of teachers' planning than understanding of Digital Making may be because it could be easier to observe teachers' actions than to capture the ways that they think about making as a framework for their planning and action. Another possible reason is that teachers may not have had a particularly clear understanding of why or how to integrate digital making activities, or of how digital making did or did not align with their own understandings of what it means to teach young children, but while planning or actually implementing a digital maker activity, their understandings became more concrete or visible. I also wonder whether teachers were unsure about how to navigate their relationship with students through digital making activities.

Summary of the Discussion

Digital Making can provide meaningful learning opportunities for young children, but at scale, this qualitative synthesis suggests that teachers of young children may more often leverage the constructivist ideas of social interaction and the learning benefits of hands-on activity to inform their conceptual understanding of Digital Making than, for example, understandings of Digital Making as an embodied practice that children's interactions with environment and sensory exploration of the materials. Although evidence of teachers' maker-oriented planning reflected an understanding of their students' learning needs and teachers were able to articulate the anticipated learning benefits of Digital Making for their students, it is also clear that these studies were conducted in contexts where child-centred instruction and free-play were already widely used. Given that these studies were also conducted in five developed countries in the Global North, there are important critical questions about the applicability of digital maker-based activities in much more diverse early childhood teaching contexts. Considering that three of the seven selected studies provide teacher training as a part of the research project, it seems that early childhood teachers may not (yet) receive the preparation and support that would help them to integrate making and maker-oriented activities with digital tools in their teaching. This aspect is an important point for future study, particularly for teacher educators working to prepare future early childhood educators.

Conclusion

In this qualitative research synthesis, I looked at seven studies about making and maker-oriented activities with digital tools (Digital Making) in early childhood contexts and examined evidence provided in these studies about how early childhood teachers conceptualize and plan for Digital Making activities. From 274 searched studies, only seven studies met the inclusion criteria of focusing on children aged 3-8 in a formal context of schooling where teachers used Digital Making, and that included teachers' perspectives on making.

There are several findings in the synthesis. The main take-aways about Digital Making in early childhood education are as follows. The first research question, *How have studies of Digital Making in early childhood classroom settings been designed?,* has three major findings. First, the age group among the selected studies is distributed evenly, which means that Digital Making activities can support the learning needs for children aged 3-8. Second, Digital Making activities capture video data, which can present children's learning process without a third person and help researchers to better reveal child-centered learning. Third, young children's manipulation of digital devices can be considered as a pre-making stage. Referring back to the definition of Digital Making in this synthesis:

> Digital Making is defined as activities that involve the creation or manipulation of physical and digital artifacts with digital tools. Digital Making involves a process of exploration of new ideas, development of digital literacies components (such as information, media, and technology skills) as well as meaning-making skills, along with interaction with materials and peers (Halverson & Sheridan, 2014; Honey and Kanter; Wolhwend, 2017) .

The manipulation process engages children's sensory exploration of the materials and prepares young children, who may have emerging digital competencies, with the making skills like problem-solving and decision-making, as well as digital literacies. Although making activities have two parts: process, and product (Halverson & Sheridan, 2014), researchers might need to have a broader consideration and understanding of making skills for young children.

For the second research question, *How do teachers understand Digital Making as a teaching method?*, there are two major findings. First, teachers' perspectives of Digital Making from the seven studies seem to better align with the theory of constructivism, and empowerment pedagogy than the theory of embodiment. But there is a growing interest in the theory of embodiment as a theoretical framework for researching in children's Digital Making activities. Second, teachers' conceptualization of Digital Making are more about learning benefits. This result can indicate that teachers may not have a chance to consider or answer questions about (a) why and how they would integrate Digital Making, (b) how Digital Making approach aligned with their jobs, and (c) their thinking about their relationships with children during Digital Making.

The major limitation of this study is the limited number of studies selected for synthesizing. This limitation may be due to the focus of teacher perspectives in this synthesis. Although this focus of teacher perspectives may limit the representation of Digital Making across studies situated in early childhood contexts, this study may, at best, offer a synthesis of teacher perspective at the very early emergence of Maker Movement (Halverson & Sheridan, 2014) in early childhood settings in national contexts. This low number of studies on Digital Making in early childhood education from teachers' perspective may suggest that teachers' understandings of Digital Making need more attention from global educational stakeholders and scholars.

Since some studies have shown how Digital Making can meet the learning needs of young children, Digital Making as a pedagogical approach could be further developed in the future. The further development of Digital Making in early childhood education is promising. Looking at the date of publication of the seven selected articles, five of the seven studies were published after 2019 and two were in 2015 (see Table 7 and Table 8). The publication years of selected studies implies that the phenomenon of Digital Making started to be formally researched in 2015, when digital tools were promoted in early childhood settings, becoming more diverse since 2019. Although none of the studies is situated in the environment of COVID-19, there can be more studies in the future because the pandemic may have led to an even greater interest in the use of educational technologies (Dincher & Wagner, 2021). For example, there may be new possibilities for teaching young children at a distance that include both digital and physical manipulation of materials and technologies.

For further research, researchers may conduct study synthesis in next few years when making and maker-oriented activities may have become more popularized across a broader set of instructional settings. Importantly, the theoretical assumptions that informed the selected studies are largely based on constructivism and empowerment pedagogy. In future, researchers could leverage the theory of embodiment to study Digital Making in early childhood education as well. In terms of teachers' perspectives about making, researchers can put more focus on teachers' role in the activity and teacher-student relationships. To reveal more about how this pedagogy can support children's learning and development, further studies could investigate other aspects of social development supported by the pedagogy, such as self-identity development, agency development, and social emotional learning. The potential for making to meet young children's learning needs is much more universal than these regional studies represent. Global stakeholders and governments need to make efforts for the integration of Digital Making, and for teacher training and supports to plan for making in ways that align with the teaching goals.

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