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Chapter 7
Integrating Digital Technologies in Teaching and Learning Through Participation: Case Studies from the Xlab – Design, Learning, Innovation Laboratory

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Abstract Technology-rich creative and collaborative learning environments are believed to offer powerful settings for children to become acquainted with computational concepts through playful ways of learning. This chapter draws on a body of empirical research grounded in a Living Lab environment at Aalborg University in Denmark (Xlab – Design, Learning, Innovation), which functions as an educational mediator of playful workshops offering hands-on experience of technologies and creative approaches to experiment- and explorative-oriented activities, where children and teachers can play to learn. The chapter offers insights into understanding the tensions and potentials of such technology-rich environments for participatory-driven creative learning, providing information on practice-related possibilities for and constraints to implementing technology-rich educational designs in early years education.

Keywords Professional learning · Educators · Primary school · Preschool · Digital technology · Participation · Agency · Co-creation · Acquisition · Workshop

Introduction

Digital competence as a concept has gradually come to be addressed in early childhood practices and in policy documents. Recent updates to the curricula for preschools in Denmark as well as Sweden highlight that education should contribute

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to children's ability to act in an increasingly digitalised society and develop their skills in using digital technology in their everyday lives (Ministry of Children and Education, 2020; Medierådet for børn og unge, 2019; Skolverket, 2011, 2018; Utbildningsdepartementet, 2017; Redecker, 2017). This concern relates to digital technology having come to be seen as an important source of support for educators and children's active participation in teaching and learning activities (Brooks et al., 2020; Fleer, 2019). The everydayness of digital technology (Danby et al., 2018) has offered educators access to a range of opportunities to include such tools (e.g. smartphones, tablets, and digital cameras) as part of everyday play and learning. Research shows that, for example, touch-screen tablets can offer children valuable learning experiences (Nilsen et al., 2021; Kjällander & Moinian, 2014; Clarke & Abbott, 2016). However, including digital technology as part of pedagogical endeavours is not simply a matter of educators' willingness to apply new ways of acting with or having access to digital tools; it is a multi-layered process of professional change that includes both the educator's mindset and pedagogical dispositions informing new teaching and learning strategies (cf. Redecker, 2017). This evokes questions of how educators can make sense of present complex demands on enhancing their digital competence to improve technological integration in their everyday educational activities. As Phelps et al. (2011) state, educational change should consider educators' diverse needs in order to avoid replicating historical and cultural practices. According to Bigum (2002), this would include a risk of assimilating, or domesticating, traditional educational approaches. This way of approaching new kinds of challenges may accomplish only temporary or ineffectual solutions. To avoid a replication of conventional ways of doing things, Dorst (2015) stresses that these present-day problems are a new breed, open, and complex and requiring different responses. The author further suggests a design-oriented approach to framing problems, focusing on an organisation's ability to create new avenues in relation to problem situations. In a similar way, Schön (1983, 1987) emphasises that designing and learning are closely coupled forms of investigating challenges and discovering new opportunities. In this way, learning happens by participating in and reflecting on actions carried out in socially well-organised settings, such as in collective situations. This illustrates how understandings of design-oriented approaches as a participative endeavour to support educators' professional learning and development may operate in tandem with individual and collective manners. Therefore, we contend that different understandings and goals when it comes to integrating digital technology in teaching and learning need not be mutually exclusive. The remainder of this chapter considers a participative design-oriented approach promoting educators' agency in and around the integration of digital technology in teaching and learning activities. The study on which this chapter is based included four teams of 12 early childhood educators who participated in a process of co-creative workshops, including individual or collective facilitation sessions along with the researchers. This was intended to encourage collaborative learning among the educators and researchers and to shape individual and collective reflection in and on specific practices, rather than seeking an optimal integration of specific content.

Background

This chapter has arisen from a 3-year project involving how preschool and primary school educators and children develop digital competence using the so-called DIA model: the Digi-DIA project. The abbreviation DIA stands for the Swedish words *delaktighet*, *inflytande,* and *ansvar* (in English: participation, influence, and responsibility).[1]

The project is based on a partnership between a school and preschool district in a municipality in southwest Sweden and the (mobile) research laboratory Xlab – Design, Learning, Innovation at the Department of Culture and Learning at Aalborg University in Denmark. Xlab, founded in October 2016, applies a design-oriented and playful approach to learning, innovation, and digital technology. The lab offers design workshops within the field of education, providing tools and methods for implementing digital designs and technologies in teaching and learning, in order to cultivate ways for practitioners to develop their own approaches to design, learning, and innovation. To do this, the lab is equipped with state-of-the-art technology as well as creative material for exploration, experimentation, idea generation, and other creative methods and knowledge-sharing activities. In the context of the Digi-DIA project, Xlab served as a mobile laboratory where workshops and facilitation were used as tools for learning and knowledge sharing and also as a research method. This was done primarily through hands-on activities with digital technology and critical as well as creative considerations regarding how these could be used pedagogically. The chapter aims to reveal in some detail a description of the challenges and opportunities related to the participative learning processes that emerged within selected early childhood units. We will show how the moves towards integrating digital technology using design-oriented participative learning were gradual and supported by team-based discussions. We hope this chapter, promoting design-oriented approaches and participation, can contribute to new thinking and innovative paths for strengthening practice-based collaboration between educational practice and academia.

The rest of the chapter is organised as follows. We begin with a description of the study's context, followed by a theoretical discussion of the concepts of participation and agency. This is followed by a description of how the research unfolded. Next, we provide examples from the empirical studies within the four teams. Here we elaborate on how the educators on the two teams including children aged 1–3 years cultivated participative workshop expertise within their teaching activities. Furthermore, we address how the educators working with children aged 7–8 years co-created and extended the ways they applied digital technology in their teaching. Finally, we discuss our findings and specify the core challenges involved in the two case examples.

[1] DIA is an abbreviation of the Swedish words *delaktighet*, *inflytande*, and *ansvar*. To help the reader grasp the meaning of this abbreviation, we will henceforth use the English terminology of and abbreviation for the words participation, influence, and responsibility (PIR). The concept of PIR was coined by the principal Tony Roth, from Sweden.

Study Context

We start this section with a further elaboration of the PIR model, followed by a description of how the partnership collaboration was organised in four phases (idea and definition, preparation, implementation, and concluding).

The Participation, Influence, and Responsibility (PIR) Model

The PIR model is a holistic co-creation-oriented leadership model that has served a guiding function for the preschool and school district for 10 years. The holistic perspective is grounded in a synthesis of leadership, experience, co-creation, and knowledge, which together shape the conditions for learning and development (Fig. 7.1).

The model targets a real influence by the educators (regarded as classroom leaders), and when used as intended, teams of educators jointly create goal-oriented teaching processes to be applied in their classroom. Co-creation (the real influence) as such should provide conditions for learning as well as motivation and commitment but should also supply conditions for the educator/leader along with the team to create forward-looking work processes based on the sharing of knowledge and experiences. Thus, in the co-creation part, knowledge and experiences are collectively disseminated to individuals, targeting the development of knowledge. To manage this, the teachers regularly develop the so-called PIR plans to support their pedagogical work. These plans have several functions but are primarily intended to function as a tool for the educators in their everyday teaching activities. The PIR planning consists of three levels (T. Roth, personal communication, August 2020):

Fig. 7.1 The synthesis of learning, which constitutes a holistic foundation for the PIR model

- Level 1: Goal-setting.
- Level 2: Planning of the work process.
- Level 3: Evaluation of the leadership.

In the goal-setting activity (Level 1), educators should involve children in the activity. This should open up for the children to participate in a process in which they, through collaborative and democratic processes, can influence their own learning undertakings. When planning the work process (Level 2), teachers should involve the children by asking them questions about their experiences and knowledge related to the specific topic they are going to deal with. In the evaluation of the leadership (Level 3), the educators should assess the ways the children experienced the lectures and what they learnt from the activities. Through this, the educator/leader gets indications of how the leadership has been received by the children. Through these three levels, educators systematically evaluate their own actions and leadership, which optimally can be related back to the learning synthesis (Fig. 7.1); i.e. leadership – co-creation – experiences – knowledge.

Organisation of the Project

The above-mentioned partnership collaboration began with discussions between representatives of the preschool/school district and Xlab, which were based on a genuine and common interest in working together on developing the preschools' and schools' work with digitalisation. These discussions progressed into concrete plans, resulting in a project plan consisting of four phases (Table 7.1).

In the project's first phase, *idea and definition*, the project management group met and had lively and fruitful discussions about our specific interests, wishes, and desires related to the collaboration. This resulted in a partnership agreement and a 3-year project plan detailing aims and research questions, which as such established a Swedish-Danish alliance focusing on educational challenges related to the integration of digital technology in teaching and learning. In connection with this, we established a project leader team consisting of the two principals of the preschool and school, respectively, two educators representing the district's preschools and schools, and a researcher from the Xlab research laboratory at the university. This group held regular physical and online meetings throughout the project's duration, as well as afterwards. During the process of establishing the partnership agreement, the project leader group from the preschool and school district visited Xlab and Aalborg University.

In the second phase, *preparation*, the researchers visited the preschools and schools on several occasions in order to provide information about the project, to learn about their ways of working and what they wanted to get out of the project, and to enable the educators to get to know us. The educators from the preschools and schools introduced their PIR model profile and explained how they approached it in their daily activities. The researcher from Xlab presented its design-oriented

Table 7.1 The four phases of the Digi-DIA project

Idea and definition phase Sept. 1, 2017–Jan. 31, 2018	Preparation phase Feb. 1, 2018–Aug. 31, 2018	Implementation phase Sept. 1, 2018–Dec. 31, 2019	Concluding phase Jan. 1, 2020–Aug. 31, 2020
Partnership agreement	Researchers from Aalborg University visited the preschool and school district on several occasions	Two baseline investigations including all educators, even those choosing not to participate in the project (August 2018, May 2019)	Final baseline investigation (June 2020)
Project plan	Interviews, informal conversations, and observations by the researchers	The researchers visited preschools and schools several times, carrying out workshops and facilitation along with project participants (individual and collective)	Summative analyses of baseline studies and other data
Visit by participants from the preschool and school district to Aalborg University	Distribution of literature to the project participants	Gathering of data and formative analyses (three times per semester)	Knowledge distribution to educators and municipality department
	Planning of the implementation phase	Writing of scientific articles and feedback to municipality department	Documentation of the project
	Information about the project to all staff members		
	Invitation to participate in the project sent to all educators		
	Project kickoff workshop, August 2018		

and playful approach to learning, innovation, and digital technology, and how we addressed this more concretely in educational practices as well as how this has had implications for teaching and learning among educators and children. These visits among the educators were a way for the researchers to get an understanding of the current state related to how they did or did not integrate digital technology in teaching and learning. We also distributed literature among the educators exemplifying different projects and approaches to working with digitalisation in preschools and schools. This gathering of information, viewpoints, and experiences resulted in insights that formed the basis for an initial project implementation plan. As participation in the project was voluntary, the educators were invited to be part of the project during this phase; 32 of them chose to participate and 17 chose not to. The second phase ended with a project kickoff workshop in August 2018 that included the participating educators.

The third phase, *implementation*, started with a baseline investigation (questionnaire) among all educators (including those who had chosen not to participate in the project). This investigation was carried out three times over the 3 years of the project (August 2018, May 2019, June 2020). During this phase, the researchers visited the preschools and schools several times and conducted workshops and facilitation (individual and collective) in the form of informal conversations, interviews, and demonstrations of different digital technology. It was decided that the PIR plans, which were already an established tool among the educators, should also be used in the project as a means for the educators to specify the use of digital technology in their teaching activities. The PIR plans were collected and analysed by the project leader team and in this way served as a resource, among other data gathered during this phase, to guide us when it came to implementing project activities. They also constituted one of the bases for choosing workshop topics, as well as for framing interviews, demonstrations, and discussions with the educators. Furthermore, data from interviews, observations, and informal conversations as well as from the educators' logbooks and video logs were gathered and regularly analysed within the project leader team. This comprised a formative basis for the implementation of workshops and facilitation and hence functioned as regular feedback to and knowledge sharing with the educators. The writing of a scientific article was initiated, as was the distribution of information at the principals' meetings with the municipality department.

Finally, the *concluding phase* focused on summative analyses of the collected data, including the baseline questionnaires. This was primarily carried out by the researchers but was discussed within the project leader team and communicated to the educators at a half-day seminar. The outcomes were also communicated with the leadership at the municipality level. It is important to note that, while not all of the educators participated in the project, the agenda of the project's activities was sent out to all educators in order to ensure that the project's presence was visible and clear to all. This included the communication of the project's final outcomes.

The project as a whole includes several cases in which teachers and children, facilitated by Xlab workshops and other forms of guidance, integrated different kinds of digital resources (e.g. tablets, Bee-Bot robots,[2] Ladibug document cameras,[3] QR [Quick Response] code scanners[4]) in their teaching activities. The project consisted of 32 educators working with children aged 1–12 years. However, in this chapter, we have chosen to focus on four teams of a total of 12 early childhood educators and how they integrated digital technology in children's play and learning

[2] Bee-Bot is a programmable robot that can be used to introduce coding and problem-solving; see https://www.tts-group.co.uk/blog/2019/01/25/bee-bot-the-story-behind-our-award-winning-programmable-robot.html

[3] Ladibug is a portable document camera that can be connected to a computer and used as a learning and teaching tool, adding visual elements; see https://www.mckeelschools.com/uploads/ibis/useyourdoccamera.pdf

[4] QR codes contain data for an identifier or tracker that points to a website or an application.

activities, i.e. how they think about, implement, and plan for different ways of supporting children's digital learning.

Participation and Agency

Participation became a connecting node in the collaboration between the practice and research teams. One of the project's primary goals was to involve the educators at the preschools and schools by making them 'owners' of the situation that was causing them problems. We were thus interested in their input in identifying the current situation regarding problems and opportunities, as well as how they might be approached or sustained. Therefore, we spent 6 months preparing the project and included the educators through informal conversations while observing how their workdays unfolded, interviews, and a baseline questionnaire. The outcomes from this data showed, among other things, that the participants desired opportunities to participate in co-creative sessions together with their colleagues to make sense of and cultivate their professional learning when it came to integrating digital technology in their everyday teaching and learning activities (Brooks et al., 2020). These kinds of social, intersubjective processes can bind individuals, groups, and organisations together while at the same time unfolding values and habits and, accordingly, providing meaning to the participants' actions as well as fostering learning (Rikkerink et al., 2015; Wenger, 1998). In this way, negotiation and sensemaking through shared practices and experiences could create conditions for a fluid and change-oriented conceptualisation of integrating digital technology in play and learning. Hence, participation in collective sensemaking constitutes a crucial prerequisite for incorporating digital resources in teaching practices (Rikkerink et al., 2015). Expressed differently, engaging educators in participation-oriented and collaborative processes through which they can share knowledge and learn from each other is fundamental in providing them with resources to drive their own professional learning. We understand this as learning through participation which, in line with Andriessen et al. (2013), we view as being recognised at the level of 'how to', 'what to', or 'about what' issues (p. 208). Participating in professional learning thus becomes more than changing a classroom to make it appropriate for implementing digital technology or having access to or the skills to use such resources. This also implies different types of agency among educators. What goes on in such situations can involve agency related to participating in the elaboration of knowledge together with others, such as epistemic agency (Damsa et al., 2010), regulative agency (van der Puil et al., 2004), or relational agency (Edwards, 2007).

In the context of this chapter, the educators primarily strived for a participation metaphor for learning, highlighting co-creation as a key activity to elaborate their learning about how to integrate digital technology in teaching, what kind of technology to use, and what the pedagogical framing should be about. At the same time, co-creation could lead to a long-term community-building, bringing about a sense of belonging and new communicative pathways (Sfard, 1998). However, they also

partly emphasised an acquisition metaphor, considering individual enrichment to be a goal of their learning in terms of improving their individual skills (Sfard, 1998). Sfard (1998) distinguishes between these two metaphors for learning: the participation metaphor, focusing on the activity and context, and the acquisition metaphor, building on the metaphor of acquiring or accumulating knowledge. In the two subsections below, we will unfold these two metaphors, starting with the participation metaphor focusing on co-creation and then discussing the acquisition metaphor focusing on individual and collective efficacy.

Co-creation Metaphor: The Collaborative Setting

Co-creation as a concept is based on a participatory ethos, which has increasingly come to be extended to the political, social, cultural, and scientific spheres (Sanders & Stappers, 2014). Even though co-creation has recently become a widely used term, it can be argued that the participatory ethos is a well-established aspect within participatory research approaches, e.g. in design and action research (cf. Bødker & Grønbæk, 1990). Ind (2013) states that the idea of 'creation' is not only about making things but also involves interpretation and meaning-making. This is an important comment in relation to this chapter, as the co-creation aspect included dimensions of educators' collegial 'making' as well as 'reflection'. For example, in creative workshop activities the participants experimented with different digital technologies and explored their pedagogical potential. Moreover, the workshops included reflective collegial discussions, during which the integration of such teaching and learning opportunities were critically scrutinised. Expressed differently, the reflection dimension can be seen as a 'breaking apart' activity – complementary to the 'making', i.e. in terms of 'putting together' something. This is comparable to what we do during analysis, finding relationships between the parts and the whole and then breaking these relationships apart into constituent pieces, followed by a re-creation of the parts into a new whole (Fig. 7.2). The make-break-re-create model describes the co-creation activities that take place when one investigates issues of *how to*, *what to*, or *about what*. The model combines making, breaking, and re-creating, each of them energising the next. This combination shapes what Sanders and Stappers (2012) term an opportunity space.

Acquisition Metaphor: Individual and Collective Efficacy

The acquisition metaphor describes learning as the acquisition and accumulation of knowledge. Underlying this are primarily cognitive models, in which concepts like transmission, internalisation, and appropriation are demonstrated. However, constructivist models are also represented with an acknowledgement of meaning construction. Some activities can be seen as more acquisition- or participation-oriented

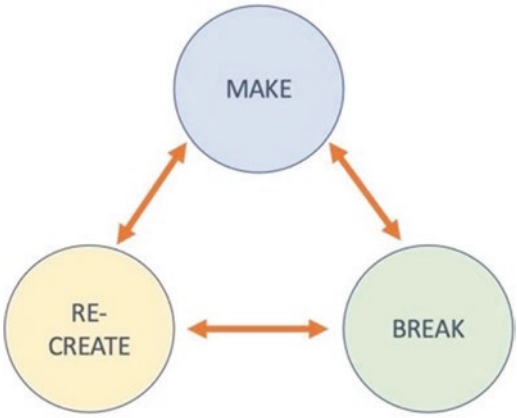

Fig. 7.2 Analytical 'making-breaking-re-creating' cycle. (Inspired by Sanders & Stappers, 2012)

and as such draw on different foundations and viewpoints in regard to questions about, for instance, learning or knowledge construction; for example, the act of acquisition is often equal to that of becoming a participant. Sfard (1998) argues that it is possible to use elements from both metaphors. Bandura (1997) claims that the best way to acquire a new skill or improve one's performance is to practise. Part of learning a new skill or practice is a person's own belief that they are capable of doing it (self-efficacy). The interpreted experience or performance while taking on new challenges influences people's self-efficacy. Bandura (1997) refers to this as the mastery experience. Self-efficacy can also be enhanced through social relations. Observing others, such as colleagues or role models, succeed in a task or being complimented can also positively affect one's self-efficacy (Bandura, 1997).

Collective efficacy, defined as 'a group's shared belief', and explains how joint understanding can influence people's actions (Bandura, 1997, p. 477). According to Bandura (1997, p. 418), collective efficacy can:

> influence the type of future [educators] seek to achieve, how they manage their resources, the plans, and strategies they construct, how much effort they put into their group endeavour.

In Bandura's understanding of individuals' collective efficacy, their shared belief plays a key role in reaching their goal (Bandura, 1995). Conversely, an individual who expects to master a given challenge will also be able to continue trying (Bandura, 2007).

The Research Unfolds

The substantive period of data collection for the research took place during the project's third implementation phase, from September 1, 2018, to December 31, 2019. Professional learning as a form of social participation is also subject to change, e.g. organisational, making it challenging to convey its complexities in standardised

ways. In studying the educators' processes of understanding and implementing digital technology over time, we hoped to bring some degree of authenticity to the research. A key part of understanding the influences of implementing digital technology in teaching and learning situations involved the explorative and reflective discussions between the researchers and educators during workshop activities, informal conversations, and semi-structured interviews. Our target was to build a shared understanding of what we were seeing or experiencing from our respective perspectives as insiders and outsiders and, obviously, this took time. We considered it both important and vital to allow time for 'slow' thinking and progressing. In her chapter, Mirza (2013) introduces the concept of 'thinking space', which she describes as a space where disagreements can be incorporated to become a meaningful activity. In the study discussed in the current chapter, slow thinking became a kind of a thinking space that nurtured the educators' creative and reflective thinking, which in turn step-by-step contributed to mastery and the educators' experience of progression.

The research emerged from a desire to better understand the impact of understanding the *how to*, *what to*, or *about what* relative to implementing digital technology in teaching and learning. When the research required participation of individual educators, e.g. when conducting interviews, supply educators were used to support the team. From this outset, we set up the work as a research project, with the participants supported by their principals. In a letter to the children's guardians, we informed them that we would be filming their children, but only for the purposes of the research. The guardians could return a slip to the preschool or school, stating whether or not they wanted their children to be filmed. Only a few did this, and their wishes were respected throughout the study. The children themselves also had the opportunity to choose not to participate in the video recording. The educators were interviewed individually about the development of their understanding and options in regard to implementing digital technology, as well as about how this was progressing in relation to their pedagogical intentions and other aspects, such as challenges, benefits, likes, and dislikes. They were assured confidentiality.

Workshop as a Research Method

We have mentioned workshops a few times as a co-creative approach to exploring and experimenting in unknown territories. In applying a collaborative action research methodology (Lofthouse et al., 2016), workshops became a key method within the project as we aimed to inspire and foster active participation and engagement among the educators, within as well as between the different workshops. This was not the only target, though; we also wanted to create conditions for sharing and collaboration between the researchers and educators in order to foster sustainable processes that could continue even after the project ended. The workshop method, as previously mentioned, was combined with other methods that were carried out between the different workshops. In this way, together we were able to address the

links between theory and practice in different ways, using workshops, observation, video-recorded material, children's productions, casual conversation, semi-structured interviews, logbooks, and educators' pedagogical planning.

The term 'workshop', often seen in combination with the term 'participation' (Ørngreen & Levinsen, 2017; Ødegaard et al., this volume, Chap. 5), is a method that over a 5-year period has been applied and developed within Xlab based on observations of and talking with different stakeholders. The Xlab researchers explore collaborative learning through playful workshops offering hands-on, reflective experiences of digital technologies and design-oriented approaches. This can be done in the laboratory, which is designed to support cross-disciplinary collaborations including different stakeholders, as well as outside the laboratory in the form of a mobile practice-based laboratory. In this chapter, the stakeholders are educators, children, and leaders of early years education practices.

Analytical Approach

The analysis method applied in this study is thematic (Fereday & Muir-Cochrane, 2010; Braun & Clarke, 2006). This means that it was the empirical data that drove the emergence of analytical concepts. Gathered data were transcribed and reviewed to find patterns in verbal and non-verbal actions as well as in the written documents. In this chapter, we analyse two cases involving four educator teams: (1) four educators working with 1- to 3-year-olds; (2) another group of four educators working with 1- to 3-year-olds; (3) two educators working with 7-year-olds; and (4) two educators working with 8-year-olds. The first case, cultivating participative workshop expertise to implement digital technology, is based on the educator teams working with children aged 7–8. The second case, child-initiated activities as a foundation for implementing digital technology, is based on the educator teams working with children aged 1–3. We present our analysis of each of the cases below by introducing excerpts that are representative of the respective cases. This is followed by our interpretation of what this means, using the analytical concepts related to participation and agency.

Case 1: Cultivating Participative Workshop Expertise to Implement Digital Technology

This case looks at how the educator teams began to make sense of implementing digital technology as part of their PIR planning. In doing so, they were inspired by workshop activities and reflective sparring by the researcher, through which new teaching ideas emerged. Two excerpts are shown below, the first of which involves Jane and Alice, who were initially inspired by workshop activities including

robotics, which afterwards led to iterative and reflective sparring sessions between the two of them and the researcher. This excerpt illustrates part of a conversation between Jane, Alice, and the researcher, in which they reflect upon workshop activities in terms of creative occasions that helped in structuring their own as well as their pupils' explorations with digital technology. The second excerpt focuses on Sofie and Freya, who started requesting sparring from the researcher about what kinds of digital tools they could use for teaching subjects or topics such as the Swedish language, mathematics, or programming. They wanted their teaching to be more child-driven and thought that a more digital and game-oriented approach might be an option. This sparring was followed by iterative mini-workshops at which different technologies were investigated. The first excerpt, below, focuses on the digital tool Osmo[5] and how the educators elaborate on their position in a digitalised teaching context:

1. *Jane*: I've learnt a lot through the workshops we've had during the project. However, as I already use and have used digital tools in my teaching for a while, the sparring between the workshops has been a way for me to move forward. To develop my knowledge.
2. *Alice*: For me it's, in a way, the other way around. I haven't used digital technology a lot; of course I've used laptops and iPads in my teaching, but primarily for the student to search for information. But when we started working together [directed at Jane], I started getting more and more brave and also, perhaps through the project workshops, we started talking about implementing digital technology in another way than we used to do. Before, I didn't want to talk about it, because I didn't know what to talk about. But since we've tested different tools and we've heard from our colleagues about how they use certain tools in their teaching, I think the term 'digital technology' has become more accessible and possible to talk about. And the way we've worked with robotics [directed at Jane], I have a broader perspective, particularly when it comes to the pedagogical aspects of talking about the digitalisation of teaching.
3. *Jane*: I agree with you. The workshops, in a way, gave me a systematic way of… or rather, they triggered me to be more systematic in what I wanted to achieve. I can see that among my pupils as well. When they built their neighbourhood with creative material and the robots [Bee-bots and Ozobots] were the ones who were supposed to show the inhabitants how to use the different resources in the village to support different sustainability actions, it was when they created the houses, the recycling stations, and so on that they started to talk more elaboratively about this (Fig. 7.3). It was necessary for them to talk about it, to look online, to read, to identify the role of the robots and, based on this, code them accurately. Such a good, what should I say, good practice for my pupils.

[5] Osmo consists of tangible wooden pieces that can be used to play digital games – drawing, coding, spelling, etc. Link: https://www.playosmo.com/en/

Fig. 7.3 Children's creation of a 'green' neighbourhood, where Ozobot was to guide the inhabitants to sustainable living

Here the excerpt involving Jane and Alice ends and is followed by the excerpt below of Sofie and Freya's discussion:

1. *Sofie*: I thought I would struggle a lot with introducing new kinds of digital tools to my pupils. I've mostly used laptops or iPads. But this Osmo game was really a good way to do it. I could understand the principles behind the game quite easily, and the children just started using it and solved the technical issues themselves; the only questions they had for me were subject-related.
2. *Freya*: I agree. Have you ordered the programming game, Eva [researcher]?
3. *Eva*: Yes, it should arrive one of these days when I'm still here.
4. *Freya*: Great. Trying out robotics and this Osmo game and talking about them with Sofie and you [Eva], and not considering them technology *per se* but as pedagogical resources that can give my pupils more opportunities to enjoy learning, has /…/ yeah, it's changed my way of thinking about the digitisation of teaching. It's possible to handle. It's good that we [directed at Sofie] work together and talk about all the changes we have to deal with as teachers. I've learnt a lot about digitalisation. It's not a mountain to climb; step-by-step we've learnt about different tools and now I feel much more confident.
5. *Sofie*: Add to this the feedback we've received from the children. We've observed them and asked them questions about their use of Osmo. They liked it because they could collaborate with their friends, they thought it was fun but also tricky, and many of them said they had to think more and be very accurate when solving the tangrams.
6. *Freya*: I could see that they collaborated a lot – they didn't disturb others, but were very concentrated and determined.

7. *Sofie*: And engaged. We've used it for a few weeks now and they still ask to play it.
8. *Freya*: When they worked together, they helped each other. I could see who was more used to digital games than others. But as there are a few different kinds of games, the children can find how they want to work, for example by means of games or building tracks or solving puzzles.
9. *Sofie*: It was great to see how they worked with speech perception.

The first excerpt illustrates the ways co-creative making-breaking-re-creating activities inspired and cultivated the educators' sense of expertise (e.g. line 3). The second excerpt demonstrates how sparring and intersubjective processes provided the educators with resources to drive their own professional learning; this is exemplified in line 4, where Freya stresses that her conversations with Sofie have contributed to her now more relaxed way of dealing with digitalisation in the classroom.

The sense of expertise that the educators expressed in the first excerpt was growing by means of sparring and teamwork, and studying the children's interactions with the digital tools (lines 1, 4, 5, and 8) created an opportunity space for the educators (line 4). In this space, they experienced agency through exploring tools and reflecting upon them with colleagues: a sense of epistemic and professional agency.

In the second excerpt, the educators concretised how acts of making were similar as vehicles for inquiry. This making shaped conditions for reflection on how to accurately make something so that it represents what is required for representing the scenario. In this way, the features of the making-breaking-re-creating model established tensions between the constituents. In turn, these tensions led to an increase, either in understanding or in the number of possible solutions, thereby creating what seemed to be a comfortable relationship between the parties.

The two excerpts demonstrate more of a co-creation than an acquisition metaphor, showing tendencies towards a participatory ethos as well as demonstrating how the parts of the making-breaking-re-creating cycle (Fig. 7.2) spurred each other and created opportunities for agency and sensemaking by means of sharing.

Case 2: Child-Initiated Activities as a Foundation for Implementing Digital Technology

This case demonstrates that the educator teams regarded child-initiated activities as a foundation for implementing digital technology in the everyday activities of children aged 1–3 years. They strived to create an environment where the children could be introduced to digital technology through their own curiosity in exploring the surrounding world. In doing so, they were concerned with recognising and acknowledging the children's desires and questions, and with this as a foundation they introduced the children to different kinds of digital technology. This second case shows part of a longer discussion between four of the educators (Susan, Sofie, Emma, and

Tove), in which they attempt to unfold, in particular, the questions of *how to* and *what to*, as well as *what is required* to develop agency:

1. *Susan*: We've started using the Ozobot robot with the two- to three-year-olds. We experienced that the Ozobots had more to add for our young children; they were also simpler for us to use compared to Bee-bots, which we used to use.
2. *Sofie*: Yes, we started by introducing Ozobot to some of the children. We chose to let them draw their own tracks with coloured Sharpies on a big white piece of paper. However, we noticed that the thing with drawing the tracks on the paper was difficult, as the lines were often too thin. Because of that the robot couldn't follow the tracks. Another difficulty was that many of the children drew the lines very close to each other, and it was again difficult for the robot to follow the tracks.
3. *Emma*: We noticed that the children liked to draw paths with coloured Sharpies and then follow the robot's path and how the colour of the robot changed according to which colour code it was following. It was a wonder for the children.
4. *Susan*: These problems were the reason why we chose to change [from the analogue programming] to investigating apps, so that instead of paper and Sharpies we could use the iPad and the children could use their fingers as drawing tools.
5. *Tove*: It was a helpful shift. The children just loved it. In the apps, not only could the children draw lines, they could also paint – all by themselves. They painted by themselves with their fingers in different colours and then they placed the Ozobot on the iPad and could watch how it moved along the lines (Fig. 7.4).
6. *Susan*: In the program there are ready-made codes. We showed how to add them. This was something they then could sit and work with a little by themselves or with a friend.
7. *Emma*: The kids were very focused, but still laughed and enjoyed what they could do. There wasn't much need for support from us.
8. *Susan*: Another app we tried was one that supplied codes to make the Ozobot dance to the beat of different songs and also flash in different colours. Here, we worked together with several children and could use several robots. The children could choose songs they wanted the robot to dance to.
9. *Tove*: Yes, it was fun. When the Ozobots finished flashing, we could start the music again and all the robots danced at the same time. The children thought this was very funny. The combination of the robots dancing in funny ways and flashing in lots of different colours appealed to the children very much. In the program it was also possible to reset the Ozobot, which we showed the children how to do. In the same program, our older children could continue to work and create their own dances and choose the colours themselves.

Fig. 7.4 A 3-year-old coding tracks for Ozobot (robot) on the iPad while Ozobot is simultaneously using the tracks

10. *Susan*: It was a good learning practice for them. We've also tested other digital tools, like the Bee-bots and Tapioca,[6] but it's the Ozobot that the children want to use repeatedly.
11. *Emma*: I don't know much about digital things. It's Susan and Sofie who find all these apps and [figure out] how we can introduce them to the children. We want the children to use these tools and learn. Like with the Ozobot, they learnt a lot and they had lots of fun. We're outdoors a lot, and then we let the children take photos with our smartphones or iPads. We then revisit the photos when we come back and talk about what we experienced. Most often it's photos of insects and birds, and then we use the Internet to learn more about them. When we sit around the table for lunch, it's by the window, we can see birds in the trees outside the window. Then the older children point and say, 'Look, a house sparrow'. They don't just say that it's a bird.
12. *Tove*: We try to be attentive to their interests. Right now, they're very interested in insects. So, we try to use that and explore further using, for example, the Internet and Bee-bots.
13. *Susan*: But we also want them to experience new digital challenges, so that they're introduced to it in pedagogical ways. They're not too young for that. But it's important to show the parents that we don't just use apps as a time-killer but that it's embedded in our learning goals.

[6] Tapioca is an interface, made of cardboard, which can be used to draw and play music. Link: https://tapioca.toys/cardboard/

14. *Emma*: I must say that I've learnt as much as the children and have probably had as much fun when we've tried these different robots and other digital tools I haven't used before. I would never have introduced this to the children by myself, as I wanted to learn about them first so that I know how they work and all the tricks. But by having done this together with my colleague and the children, I realise that 'll never have the time to explore beforehand as much as I thought I could or wanted, but need to challenge myself and just explore and learn from colleagues and our children. For me, this has been a challenging but rewarding learning curve. To learn that I'll never learn enough about the technology, but start using it anyway and become wiser about how I can use it so that it fits the study plan. It was a relief.
15. *Susan*: Well, that's important, but we also want the children to have fun by doing things together and having a good laugh.
16. *Emma*: But we don't want to rush it, either for us or for the children. What I've experienced is that it's okay that things take time. This has helped me to understand that it's not necessary to rush things just because society, the ministry, and other media stress that we'll be behind if we don't start. I don't mean that we should go on forever, but rushing slowly isn't bad.

In the excerpt, the team attempts to concretise the ways they, together with the children, have explored and implemented digital technology in their everyday teaching activities. They invoke this by acknowledging both an acquisition and a co-creation metaphor. When considering the questions of *how to*, *what to*, and *about what* in relation to the children, they primarily reference the acquisition metaphor and how they established situations for fostering the emergence of the children's coding skills. In their elaboration on how they used the Ozobot robot among the children, they emphasise causality as a driving force in the children's engagement and learning about the relationship between the lines (codes) and the robot's movement. This is exemplified in line 3, where Emma highlights that the children seemed to understand that the Ozobot changing or flashing a certain colour was an effect of the coding. In line 9, Tove connects this to self-efficacy, stressing that by now the older children were skilled enough to code and play with the Ozobot by themselves. Similarly, Emma (line 7) and Susan (line 6) stress that the children repeatedly practised with the Ozobot and coding and thus improved their coding performance.

This excerpt shows the teams' efforts to shape situations, in which the children's interests are essential. Relevant examples can be found in lines 3, 11, and 12, where Emma and Tove elaborate on their determination to take up the matters that the children express as being interesting in one way or another. The teams use this for further inquiries together with the children. Emma and Tove continue on this route, trying hard to address an emotional commitment on the children's part. This is shown in lines 5, 7, and 9, where they repeat references to the importance that teaching evoke enjoyment among the children. However, in line 13, Susan responds to this by noting that what they should transmit are digital challenges, indicating that there should be a balance between joyful and challenging teaching situations.

Finally, in lines 11, 14, and 16, Emma summarises another orientation within this case, which refers to the concept of thinking space, closely related to the concept of mastery experiences. The relationship between these two concepts suggests an experienced balance between the co-creation and acquisition metaphors. The thinking space, in this case, does not refer to disagreements but rather to the matter we have termed *slow thinking*. Susan, in line 15, expresses a slight resistance to the aspect of slow thinking, and Emma (line 16) responds by stating that 'rushing slowly' is not necessarily a bad thing.

Conclusions

The aim of the study discussed in this chapter was to reveal and describe challenges and opportunities related to educators' integration of digital technology in their teaching. In this regard, we have highlighted learning through participation, understood and recognised at the level of *how to*, *what to*, or *about what* questions. The study, which is part of a larger project, included four teams of educators in early years education from a preschool and school district in southwest Sweden. The analysis revealed that the educators' experiences could be described in terms of two opposite but complementary metaphors for learning: the co-creation metaphor, which focused on collaboration; and the acquisition metaphor, which shed light on individual and collective efficacy.

In the practices in which workshops and facilitation (or sparring) have been deployed, it has clearly had an impact on the nature of approaching digital technology in teaching and learning activities. It has also had an impact on relaxed, systematic, and enlightening intersubjective interactions at different levels: between the educators, between the schools and preschools, and between individual educators as well as educator teams and the researcher. We witnessed informal conversations as well as more profound connections being made through participation and agency. Most of the educators did not refer to any everydayness (Danby et al., 2016) of digital technology; however, during the project they developed a professional everydayness involving different kinds of digital tools.

The design-oriented set-up of the research, including observations, interviews, and conversations, helped us arrive at insights that have proven to be rich in terms of enabling us to get a stronger grasp on the phenomenon of the digitalisation of teaching and learning activities in the specific context of the preschool and school district. All in all, this approach had an enhanced participatory character, and by providing continuous feedback to the educators, we enabled them to mutually build upon a common ground (the PIR model).

The types of metaphors identified in the data can be regarded as rather generic. In relating the educators' initial experiences to the use of digital technology in educational settings, they can be aligned with previous studies (Redecker, 2017; Dorst, 2015; Phelps et al., 2011) and as such be made possible to be understood and applied in similar research contexts. Our main contribution involves the benefits of the

making-breaking-re-creating model, with the three constituents together forming an opportunity space. This was more of a collective space compared to the thinking space, which was more applicable as an individual space. However, using Sfard's (1998) argumentation, the two spaces are not necessarily distinguished in this way; it is also possible for people to use elements from both.

Our main implication for the educational practice deriving from these conclusions relates to the organisational design of educational practices. If we want educators to better understand how to make digital technology integration productive, we need to cultivate them in regard to how participation and agency might work and how to deal with crucial aspects when collaborating about specific areas of their work. In our study, this concerned developing shared understanding and the co-creation of knowledge. Another important implication concerns the relationship between the institutional demands and goals, the participants' design and learning processes, and what they perceive as important with regard to participation in professional learning. All in all, we maintain that the different metaphors for learning – co-creation and acquisition – should enable educators to pursue their professional learning interests and advance their knowledge.

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