Routledge
Taylor & Francis Group

Research in Science & Technological Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/crst20

Affordances and obstacles when integrating digital tools into science teaching in preschools

Susanne Walan & Ann-Britt Enochsson

To cite this article: Susanne Walan & Ann-Britt Enochsson (2022): Affordances and obstacles when integrating digital tools into science teaching in preschools, Research in Science & Technological Education, DOI: 10.1080/02635143.2022.2116423

To link to this article: https://doi.org/10.1080/02635143.2022.2116423

RESEARCH IN SCIENCE & TECHNOLOGICAL EDUCATION
https://doi.org/10.1080/02635143.2022.2116423

Routledge
Taylor & Francis Group

Affordances and obstacles when integrating digital tools into science teaching in preschools

Susanne Walan [a] and Ann-Britt Enochsson [b]

[a]Department of Environmental and Life Sciences, Karlstad University, Karlstad, Sweden; [b]Department for Educational Studies, Karlstad University, Karlstad, Sweden

ABSTRACT

Background: Although science and technology are viewed as closely related subjects, they are rarely combined in preschools.
Purpose: This article investigates preschool teachers' perspectives on integrating digital tools when teaching science, asking how and why they use digital tools, and examining the affordances they experience and obstacles they encounter when incorporating digital tools.
Sample: Eighteen Swedish preschool teachers volunteered to participate in the study.
Design and method: Data were collected through group interviews and analyzed using a thematic approach, together with the Technological Pedagogical Content Knowledge (TPACK) framework, to obtain a more detailed picture of the teachers' experiences.
Results: Most of the participants were positive about using digital tools when teaching children science, and they emphasized the need for training on how to use the tools themselves. The preschool teachers viewed digital tools as good complements to other tools when teaching science and to find information about science facts. Moreover, there were generic reasons for using digital tools, such as to stimulate critical reflections among the children, to document activities and to create stimulating learning environments. However, one group of preschool teachers struggled with integrating digital tools when teaching science.
Discussion: Digitalization in preschools and the rest of society is developing. The preschool teachers found possibilities and challenges in using digital tools when teaching children science. Still, future studies are needed to investigate how this will develop. In addition to the results, we found that TPACK served as a useful framework for analyzing and discussing our results. Therefore, we recommend TPACK when analyzing and discussing the use of digital tools in future preschool studies.

KEYWORDS
Digital tools; preschool teachers; science; TPACK

Introduction

The digital revolution is affecting society and all stages of education worldwide. In Europe, a special framework concerning digital competence has been developed and presented in

CONTACT Susanne Walan susanne.walan@kau.se Department of Environmental and Life Sciences, Karlstad University, Karlstad, Sweden
Supplemental data for this article can be accessed at https://doi.org/10.1080/02635143.2022.2116423

DigComp (EU 2019) and further developed in a specific framework for teachers – DigCompEdu (Caena and Redecker 2019). Although this framework includes preschool, it has been shown that the development of digital teaching materials for younger children is lagging (Kjällander and Pilner Blair 2021). Besides new demands on digital competence, it is known that many preschool teachers (PSTs) find it difficult to plan and conduct qualified science activities for different reasons (Olgan 2015; Dogan and Simsar 2018); consequently, children are offered limited science education.

Science and technology are viewed as closely related subjects, but they are rarely combined in preschools (Aronin and Floyd 2013; Parette, Quesenberry, and Blum 2010). A systematic overview did not find any study on the use of mobile technology in teaching science to preschoolers (Crompton et al. 2016). Few studies have been conducted since this overview, focusing on different aspects, for example, on children's learning (Furman et al. 2019), generic skills (Moore and Keys Adair 2015), or the teachers' perspectives (Kewalramani and Havu-Nuutinen 2019; Otterborn, Schönborn, and Hultén 2019; Wilson 2019). However, these authors call for more studies in this area, which is also important for practice. An important reason for this is that PSTs need to learn about both successful and unsuccessful examples, while management and principals need to know which conditions facilitate good teaching practice, since it is known that not only technology itself, but also *how* it is used, affects learning (Crompton et al. 2016).

The aim of this study is therefore to explore PSTs' perspectives on integrating digital tools when teaching science. This aim includes studying how and why PSTs integrate digital tools in science activities, including the affordances they experience and obstacles they encounter.

Digital Tools in Preschools

Digital tools have been used in preschools since the 1990s (Dezuanni and Knight 2015), despite a history of reluctance. The turning point came in 2010 with iPads, which were easy to handle and could be used even by the youngest children (Bølgan 2012; Couse and Chen 2010; Dezuanni and Knight 2015). Recently, programming has become part of preschool activities, and there are studies presenting the particular outcomes of using programs such as ScratchJr, or robots like Blue-Bots (Palmér 2017; Strawhacker, Lee, and Bers 2018). These digital tools are used together with tablets and are sometimes connected to them.

With increasing access to new digital tools, there has been greater demands on PSTs to handle and integrate such tools into teaching approaches and to provide children with opportunities to develop digital competence (Lindeman, Svensson, and Enochsson 2021; Neumann and Neumann 2014; Strawhacker, Lee, and Bers 2018). Several studies investigating the use of tablets in preschools (Neumann and Neumann 2014; Otterborn, Schönborn, and Hultén 2019; Palmér 2015) have concluded that PSTs need more training in this aspect. It has also been found that the available training is often too general and does not help the PSTs in specific teaching situations (Lindeman, Svensson, and Enochsson 2021).

Hardesen and Guðmundsdóttir (2012) emphasized that digitally competent PSTs are not only capable of handling digital tools; they also reflect on their use, how this can stimulate children's learning, and whether other tools would be more suitable in certain

circumstances. In northern Europe, PSTs generally consider digital tools as positive (Nilsen 2018), but they want to develop their competence to create technology-based activities that can contribute to learning (Bølgan 2012; Lindeman, Svensson, and Enochsson 2021; Magen-Nagar and Firstate 2019).

In contrast, it has also been shown that some PSTs are not interested in digital tools and opportunities they provide (Enochsson and Ribaeus, 2021); Kjällander and Johnson Frankenberg (2018). Whether PSTs find digital tools useful has been linked to their views of children and democracy (Enochsson and Ribaeus, 2021). Another reason for reluctance is PSTs' concerns that digital technology is socially and physically limiting (Palaiologou 2016).

Teaching Science with Digital Tools

Although some studies have presented examples of using digital tools in preschool, few have focused on using them to teach science and the benefits of this approach (Kewalramani and Havu-Nuutinen 2019; Otterborn, Schönborn, and Hultén 2019; Yilmaz and Siğirtmaç 2020). Following, we highlight some concrete examples of such studies.

Fleer and Hoban (2012) tested the use of digital animation to make children aware of scientific concepts related to physical forces and dinosaurs. Their results showed that the children expanded their knowledge by creating animations. Fleer and Hoban argued that even though children are, for instance, often interested in dinosaurs, it is unlikely that they would have learned about teeth structures and related this to what the dinosaurs ate without intentional learning, and animations were important in this respect. Furthermore, they found that when the animations were shown to the children, they came up with additional questions, which led to further conceptual development.

Fridberg, Thulin, and Redfors (2018) investigated how tablets were used to support children's learning of scientific phenomena. The children made time-lapse photography and slow-motion videos exploring the different states of water. Fridberg et al. reported enhanced and focused reasoning among the children using these digital tools. On the other hand, Furman et al. (2019) found no difference in children's learning in a quasi-experimental study. They worked with two groups of children and studied fungi and food decomposition and used an inquiry-based model of teaching. The only difference between the groups was the technology used. Although Furman et al. (2019) did not see any difference in science knowledge in their quasi-experimental study, they noted an increase in digital literacy for those using technology. This, as well as increased motivation, has also been noted in other studies (Moore and Keys Adair 2015; Yilmaz and Siğirtmaç 2020). Moore and Keys Adair also found that the use of tablets in science (among other subjects) favored increased autonomy, collaboration, independence, and interaction among the children.

In a systematic review of teaching any subject using digital tools in preschools, it was found that only 54% of the studies showed that the technology transformed learning in a way which could not be done without technology (Crompton et al. 2016). This not only means that technology itself makes a difference but also how it is used. Other studies have focused on the PSTs' views on teaching science using digital tools. These studies have argued for the need for training and time to prepare (Otterborn, Schönborn, and Hultén 2019; Yilmaz and Siğirtmaç 2020). This includes time to contemplate their use, so

that the digital tools do not become a distraction (Wilson 2019). Wilson highlighted that the digital tools allow the PSTs to take photos and videos to watch later, either to observe themselves or as a reminder for the children. A conclusion from Otterborn's study was that how digital tools actually are used in day-to-day educational practice remains to be examined, as does whether digital activities are integrated with other activities or only used separately, since most of the use seems to focus on generic skills and not on subject learning. Contextual factors also affect how and why PSTs use digital technology in science teaching.

TPACK as Theoretical Framework

While there are few examples of studies reporting on the effects of using digital tools when teaching science in preschool, there are also very few examples of preschool studies using the TPACK theoretical framework developed by Mishra and Koehler (2006). Within their framework, they emphasized that teachers need to know *why* they want to use technology in their teaching. Simply introducing the technology is not enough; teachers also need knowledge of *how* to implement it. Hence, in the TPACK framework, they added *technology* to the other important aspects of teaching that Shulman (1986, 1987) already had presented as PCK (Pedagogical Content Knowledge). Mishra and Koehler (2006) argued that in order to use TPACK optimally, it is important to understand how the different aspects interact and to use them under constructive conditions that create the best learning opportunities. Furthermore, they argued that there is not one single technological tool that applies to everyone and is suitable in all learning contexts: to maintain teaching quality, educators must ensure that what is used best suits the activity in question and those who are supposed to use it.

The TPACK framework is visualized in Figure 1, where technological, pedagogical and content knowledge are each represented with a colored circle. The overlapping areas represent combined knowledge, while the dashed line around the circles represents the context. Mishra and Koehler (2006) did not describe the context in more detail in their first version of the framework. Porras-Hernandez and Salinas-Amescua (2013) found this to be limiting; hence, they extended the framework by identifying three levels of context for understanding teachers' knowledge of technology integration into their teaching practice: micro, mezzo, and macro levels. This development of the context has subsequently been acknowledged by both Mishra (2019) and Koehler (Rosenberg and Koehler 2015).

Many studies using the TPACK framework are quantitative studies, which is also the case for three of the five preschool studies we found. These three studies are based on surveys answered by between 147 and 411 teachers working in early childhood education. All the studies focused on technology use in general, rather than science teaching specifically. Blackwell, Lauricella, and Wartella (2016) found that the most influential factor in use, at teacher level, is positive attitudes toward technology. At a school level, the frequency of professional development is the most important factor; however, at student level, it was found that teachers with high-income students used tablets less when teaching. Liang et al. (2013) found that more senior preschool teachers in Taiwan showed some resistance to technology-integrated learning environments. Lavidas et al. (2021) noticed that the perceived self-efficacy in technology for PSTs in Greece is at a satisfactory level compared to earlier studies, and the ICT teacher training program is indicated as the

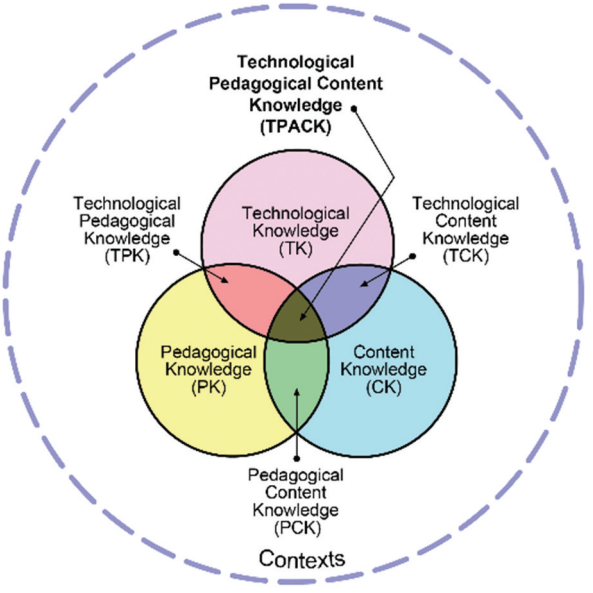

Figure 1. The TPACK model according to Mishra and Koehler (2006). Reproduced with permission from the publisher © 2012. tpack.org.

basic factor for integrating technology. A qualitative case study conducted in Malaysia (Chee et al. 2017), in the subjects of mathematics and literature, shows that the participating teachers needed to learn more about technology to be able to integrate it in their teaching. Kewalramani and Havu-Nuutinen (2019) used the TPACK framework as part of their data analysis to identify how PSTs in Australia and Finland use technology when teaching science. They found that while the PSTs were positive about its use, it is easier said than done. They concluded that the future focus should be on contextualizing, introducing, and adapting technology integration in teaching preschool science.

Research Questions

To explore PSTs' perspectives on integrating digital tools when teaching science, we use the TPACK framework (Mishra and Koehler 2006). This enabled us to analyze *how* and *why* teachers choose to use digital tools when teaching science in preschool. The TPACK framework, as further developed by Porras-Hernandez and Salinas-Amescua (2013), also allows us to analyze the impact of the context in more detail, which forms an important part of analyzing teachers' experiences. The following questions were posed:

How and why do preschool teachers (PSTs) use digital tools when teaching science?
What affordances and obstacles do they encounter?

As mentioned, the TPACK framework has seldom been used in early childhood research, and the study by Kewalramani and Havu-Nuutinen (2019) is the only one we found that also focuses on science teaching, which makes our study an important

contribution within the field. Since the study was conducted in Sweden, we first describe the Swedish context.

The Swedish Context

The Swedish preschool curriculum states that teaching should be based on children learning together and from each other, and also on the interaction between adults and children. Recently, the curriculum has undergone extensive revisions and the teaching of science and development of children's digital competence are both fairly recent introductions. While the use of digital tools was earlier encouraged in preschools, teachers are now obliged to develop children's digital competence. Concerning digital competence, the preschool curriculum states:

> Education should also give children the opportunity to develop adequate digital skills by enabling them to develop an understanding of the digitalisation they encounter in everyday life. Children should be given the opportunity to develop a critical, responsible attitude towards digital technology, so that eventually they can see opportunities and understand risks and also be able to evaluate information. (Swedish National Agency for Education [SNAE] 2018, p. 10)

The concept of *adequate digital competence* is included in the curriculum to enable preschools to face the rapid development of digitalization, but it is not further elaborated. Earlier research has shown that understanding of the concept is complicated and depends on the local context and teachers' own values (Olofsson, Fransson, and Lindberg 2019). Thus, PSTs themselves need to decide when, how, and why digital tools should be used. When teachers at different preschools do not have similar competence and/or views on digital tools, children have to develop their digital competence under very different conditions (Enochsson and Ribaeus, 2021). Even though the use of tablets has been increasing in Swedish preschools for some time now (Fridberg, Thulin, and Redfors 2018; Marklund and Dunkels 2016), many preschools still only have access to one or two tablets per department (Otterborn, Schönborn, and Hultén 2019).

The curriculum is not that specific on science teaching either, although it is a bit more concrete:

> The preschool should provide each child with the conditions to develop [. . .] an understanding of natural sciences, knowledge of plants, animals, and simple chemical processes and physical phenomena, an ability to explore, describe with different forms of expression, ask questions and discuss science and technology. (SNAE 2018, 15)

The curriculum does not state that science teaching should be done with digital tools, and the PSTs have a lot of freedom regarding its use, including teaching digital competence and science. This freedom also brings challenges; thus, Swedish PSTs request clearer guidelines in the curriculum, especially for subject teaching (Otterborn, Schönborn, and Hultén 2019).

Method

Research Model and Procedure

To find answers to our questions, we conducted a qualitative case study (Merriam and Tidsell 2016) and focused on Swedish PSTs' perspectives on integrating digital tools when

teaching science. We used group interviews with stimulated recall (cf. Lyle 2003) based on the PSTs plans, week blogs, pictures, and video-recordings from activities with children.

Research Context and Sample

Eighteen PSTs from three preschools from different municipalities in Sweden volunteered to participate in the study. At the time of the study, they were all participating in a professional development course, covering the integration of digital tools when teaching children science; hence, they had all shown an interest in integrating science and digital technology.

Since this study took place during the pandemic of 2020, we decided from the start not to involve children in the data collection.

Swedish PSTs work together in teams; in total, the study involved six departments with 18 PSTs – three at each department. Each department was responsible for 15–20 children. Table 1 provides an overview of the participating preschools, departments, and the ages of the children. All participating PSTs were women of different ages and with varying degrees of working experience. The PSTs had previously worked with digitalization, both in terms of attending different courses and by taking part in activities with the children.

Since the PSTs work in teams and do not plan or conduct activities with the children alone, we do not refer to them individually; instead, we consider them as representatives of their departments and regard their interview answers as reflections of the team's collective views. Accordingly, when presenting a quotation from a PST in preschool A, department 1, the PST is cited as A1, and as a representative of the whole team, even though all of them participated in all the interviews.

In this study, all digital technological equipment and software are considered *digital tools*. The preschools and different departments had access to the following digital tools:

- physical devices (tablets, projectors, robots, and digital microscopes)
- apps and search engines

All departments were equipped with projectors and had access to tablets. However, in preschool C, there was only one tablet, shared by staff and children. In the other preschools, all PSTs had their own tablets and at least one tablet for the children to share. Preschool B was well equipped; all departments had access to all the physical devices listed above. The PSTs mentioned various robots: Bee-Bots, Blue-Bots, and Spheros. The digital microscopes connected to tablets were called 'web eggs' by the PSTs – this is not a particular brand, but a local term.

Table 1. An overview of the preschool contexts where the participating PSTs work.

Preschool	Department	Children's Ages (Years)
A	1	1–5
A	2	1–5
B	1	3–5
B	2	3–5
B	3	3–5
C	2	3–5

Apps and search engines used included green screens, stop-motion, apps for QR codes, AnimateAnything, Google, YouTube, and different software for taking photos or recording videos. All PSTs mentioned the use of these apps and searching for information using Google. One department in preschool A also used Google Earth. It should be noted that the PSTs could not download any app or software onto their tablets by themselves. Downloads were regulated by the municipality where the preschool was situated, so if the PSTs wanted a certain app, they needed to obtain permission from the municipality's ICT department.

Communication and administrative tools were used all the time by all PSTs, not only when teaching science. Blogs and Instagram were used to share information with parents. The information was not shared publicly, but only with persons involved in the preschool, such as staff and parents.

Instrument Used and its Validation

In this study, we have decided to solely use the elements from TPACK that include technology (T). Kewalramani and Havu-Nuutinen (2019) also set out to only use the T elements. However, in the observational protocol used as part of their data analysis, Pedagogical Knowledge – without the Technology (T) – was included, hence causing some confusion. Walan (2020) has also presented an example that only used the T elements from TPACK in the analysis; this was done consistently, but the study focused on activities in secondary school and not on preschool education. In reality, the PSTs in our study used several strategies and tools when teaching science to children, not only technology (digital tools). However, based on our focus and the posed research question, we only use the T elements from TPACK in our analysis and discussion.

In TPACK, the T elements in focus are defined as follows (see also Figure 1; see expanded definitions at http://tpack.org):

- *Technology Knowledge (TK)* refers to teachers' knowledge of technological devices (hardware) and their uses, as well as sets of software. This relates to the practical handling of digital tools.
- *Technology Content Knowledge (TCK)* concerns teachers' knowledge of the relation between technology (in this case, all kinds of digital tools) and subject content. Hence, how different digital tools can most appropriately embody and support understanding of specific concepts or processes.
- *Technology Pedagogical Knowledge (TPK)* refers to teachers' knowledge of how teaching and learning change when particular technologies are used. Affordances – or obstacles – arise with different digital tools and their relation to teaching practice.
- *Technology Pedagogical Content Knowledge (TPACK)* includes teachers' knowledge of the interaction between technology (digital tools), pedagogy, and subject, and of the strategic application of technology in the teaching situation. This knowledge is dynamic and adaptable to the needs of different students (in our case, children).

The first author collected data through three stimulated recall interviews with PST teams in the different preschools and departments. The interviews were conducted while the course

was ongoing but separate from the course and between its monthly meetings. During the first interview, background data were collected on the number of children in their departments, their ages, etc. This was followed by questions on what the interviewee had recently done in connection with science teaching, the digital tools used, how they were used and why, as well as the results achieved. In the interviews, PSTs' planning materials, documentation from teaching activities (photos and videos), and reports to parents via blogs or Instagram accounts, only open to staff and families connected with the preschools, served as material for stimulated recall. These artefacts further served as documentation presenting what had been planned and what had taken place, so that the reflections were based on real activities and not only on PSTs' thoughts or ideas. All eighteen interviews were audio recorded, and each lasted 1–2 hours. The audio recordings (totaling 24 hours) were transcribed before analysis. All the quotations presented were translated from Swedish. In the second and third interviews with the PST teams, the same questions were used (see Appendix I).

Data Analysis

The transcripts of the interviews were analyzed thematically, as described by Braun and Clarke (2006). The analysis was initially performed by the first author and later discussed and confirmed by the second author. First, an inductive approach was used to sort data into themes based on the research question. The second step was deductive, connecting the identified themes to the T elements in TPACK. The whole process required iterative reading of the transcripts.

Results

The purpose of this study was to gain knowledge of *how* and *why* PSTs use digital tools when teaching children science, including the affordances they experience and obstacles they encounter. However, many of the interviewed PSTs did not only present their perspectives on the use of digital tools when teaching science – they also talked about their use in general terms. We included these comments in our findings, since such general perspectives could also be applied when teaching science.

Seven main themes, with some subthemes, were identified in our analysis, and data were coded using TPACK as a theoretical framework. Figure 2 presents an overview of these themes, which are further explained and exemplified based on quotations from the participants.

Practical Training in Using Digital Tools

All the interviewed PSTs had received training before they started using digital tools when teaching science. Some of them also said that they had access to support from colleagues with special skills in using digital tools:

> We learn more and more about digital tools and how to use them technically, but sometimes we are afraid that we will break something, destroy it somehow and lose the data, but we have all become better at the practical handling of the tools. (A1)

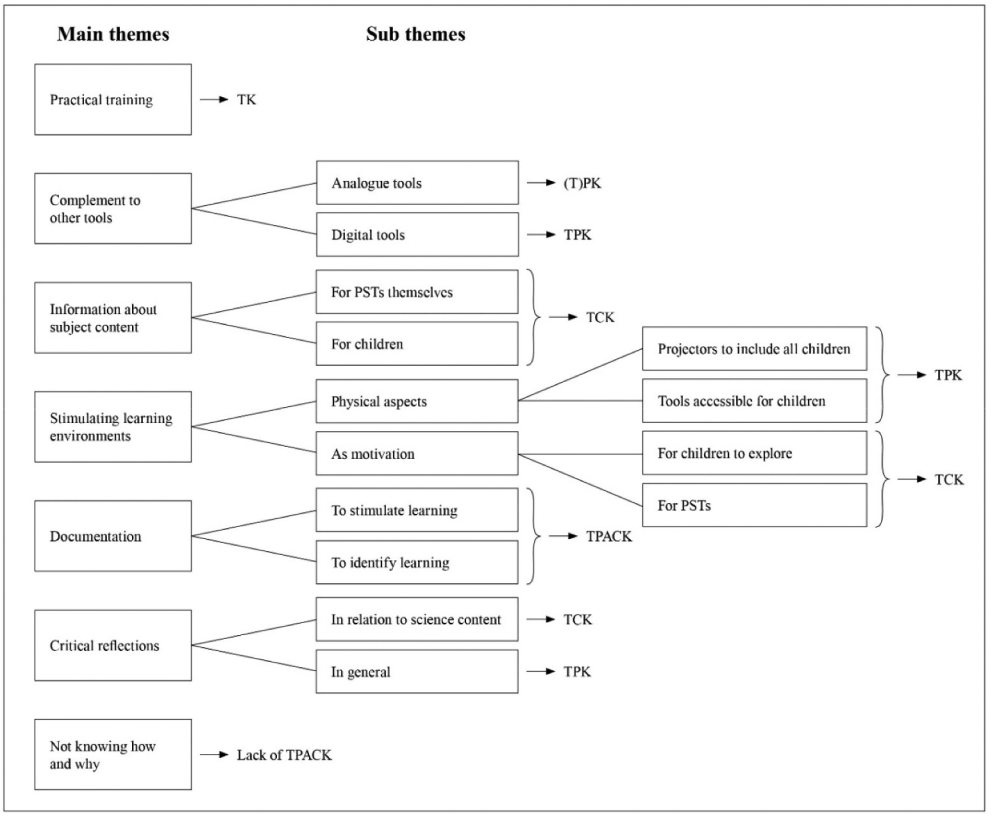

Figure 2. Thematic coding map.

> We have had courses in digitalization and the chance to test some tools before, and we have access to support in the building with two colleagues with special competence in digitalization and the handling of different tools. (A2)

> It's important to know how the tools work and to keep updated and be prepared and that is not always easy. (B3)

> Our focus was on digitalization last year, so we have worked with that a lot, and we have tried several digital tools and feel confident in using them. (C1)

We coded this finding as an example of TK from the TPACK framework perspective (Mishra and Koehler 2006) since this is a prerequisite for using digital tools in teaching.

Digital Tools as Complement to Other Tools

The PSTs in preschools A and B stated that they used digital tools as a complement to other tools. In most examples, they talked about complementing digital and analogue tools; however, there were also examples of combining different digital tools:

> The digital tools should be used as complements to other tools. All children are different, and some are more captivated by the digital, while others prefer the analogue. (B2)

> We want the use of digital tools to become a natural part of our activities, like the other things we do. Analogue and digital, hand in hand. Like if you want to paint a dinosaur, you can do it on paper or on the iPad. You can use various tools in different contexts. You can use the web egg in the forest and the Animate app to animate a birch that provides the children with tasks. It's possible to complement different tools in so many ways. (A2)

We consider the PSTs' perspectives on the use of digital tools as a complement to other tools related to TPACK, as they talked about this both from the TCK and TPK perspectives, thus integrating elements from the framework. Moreover, it could be argued that, since they discussed the digital tools as complementary to analogue tools, a pedagogical knowledge perspective without the 'T' was included.

Digital Tools Used to Find Information about Subject Content

This theme was only explicitly mentioned by PSTs in preschool A1. These PSTs used tablets to search for information on the Internet, for instance, about planets, or to find experiments they could do with the children. They also watched YouTube videos and used Google Earth to find information.

> We search for information about space on the Internet, to learn about planets, for our own sake, so we can share this with the children, and we have watched YouTube videos together with the children about rocket launches and landings on the moon. We also found this great program, *Train Like an Astronaut*, which we used with the children outdoors. Sometimes, we search for nice experiments to do as well, like how to make your own rocket. (A1)

This theme was coded as connecting to TCK, using digital tools to find knowledge about specific science content, for the PSTs themselves, but also to visualize different science phenomena for the children.

Digital Tools Used to Create Stimulating Learning Environments

This theme included subthemes from physical arrangements to motivational aspects, like involving the children in activities and inspiring them to explore. In terms of physical arrangements, all the PSTs mentioned how they used projectors to visualize something they wanted the children to see and to enable all to watch at the same time. They talked about the importance of involving the children in participating in discussions:

> We work a lot with the projector projecting what is shown on the iPad; this way all the children can watch and work with different apps together. (B1)

> We froze water-filled balloons and then we looked at the frozen water balls using the web eggs, and then we saw snow crystals; we projected the pictures on the wall, so all the children could see, and they were really amazed. Some of the crystals looked like hedgehogs. (B2)

Our study has also shown that the PSTs wanted digital tools to be accessible so that children could use them by themselves, and they wanted to arrange special rooms or corners where they could place the tools for this purpose:

> We are at the beginning of creating a digital corner to build a digital learning environment for the children. We want to make it possible for them to do green screen recordings, use stop-

> motion, the Blue-Bots, and things like that. We already have a projector and we have projected on the cube, like, for instance, an aquarium with fishes where the children can swim with the fishes. (A2)

> We have bought a Blue-Bot carpet with a space theme and put it in our space room where we have the cube. And we can project on the cube, so it looks like a rocket. We have also decorated with the rockets the children have made themselves and pictures and models of the planets that we have made in papier mâché, and we are making a digitalization corner there as well where the children can sit and explore, using iPads, the robots, etc. (A1)

The PSTs in our study also gave examples of how they used digital microscopes to motivate the children to explore. The PSTs did not explicitly mention the content learned by the children; rather, they talked about getting inspiration and increasing the children's motivation.

All PSTs from all preschools mentioned digital tools in themselves as motivation to explore. They talked about such use being fun and motivating for children, but also for themselves:

> We animated a stump in the forest with the app AnimateAnything. It was a success. The children really liked it. It was more motivating than just watching an ordinary stump. It triggers their [the children's] imagination. (C1)

> I think it's fun to use digital tools myself. I have become inspired through the Continuing Professional Development course. I think it's such fun to use the green screen and stop-motion, and it's fun to do it together with the children. (A2)

> We have two children here; you can see in our recording. They are lying on the grass, and they use the green screen and pretend that they are swimming with sharks. They had so much fun; you can see that in the video. (A2)

The PSTs also used the app AnimateAnything to provide the children with tasks to inspire them to explore. One example of this was from preschool B, where the children worked with activities exploring the qualities of air:

> Well, we have used the app AnimateAnything to provide the children with tasks. It's like the witch in the story we used. We animated a picture of her, and she asked the children why her hat flew away, and the children were asked to find out more about air. (B1)

In preschool A, they used the same app to stimulate the children to explore their homes on earth:

> We had made earth using papier mâché, and then we animated it using the app and gave the children missions to explore earth. The mission was to find their house using Google Earth. (A1)

The findings, coded as use of digital tools to provide creative learning environments to the children, relate to TPK from the TPACK framework, but also to TCK, i.e. using technology from pedagogical points of view, as well as connecting to the specific teaching of science content.

Digital Tools Used to Document Activities

Besides using digital tools to create stimulating learning environments and thereby supporting children's learning in science, the PSTs also used tablets for documentation.

They often documented the children's activities using the tablets and indeed had done so for a long time, even before digitalization was emphasized:

> A long time ago, we started to use iPads among the staff to document the activities. We mostly took photos. (A1)

However, they now had new methods of using the documentation. Besides the earlier use of informing parents about activities by posting photos and videos in blogs for the families, or on Instagram accounts, a new possibility had evolved. The PSTs had noticed that they could show the photos and videos from their activities to the children and discuss what they had done. This allowed them to stimulate the children's learning even more. Furthermore, when the PSTs watched the videos, they sometimes also noticed how children actually showed that they had learnt or realized something the PSTs had not noticed during the activity. Hence, the documentation served as a tool for the PSTs to identify children's learning.

> We often film the activities and watch the recordings together with the children. Suddenly, we [the PSTs] notice things that happen to the children, how they get some insights, or not. For example, how the youngest children do not always understand that they actually are controlling the Sphero when they steer it through the iPad. (B3)

> We talked to the staff in another department this morning, and they had made a video recording when they were outdoors with the children. They watched the recording with the children and talked about what they had done. The PSTs noticed things that had happened that they did not discover during the activity, because you simply don't have time to notice everything when you're doing the activity; it's a great way to use digital tools. You know, air is not that simple to teach since it's invisible. (B2)

We consider using digital tools for documentation to stimulate children's learning and to help the PSTs a TPACK theme that includes knowledge of how several approaches can be taken using these tools, both pedagogically, but also to stimulate and identify learning about specific content. In the above example, the tool stimulated learning about something that is invisible – air – and is probably quite difficult for young minds to grasp.

Digital Tools to Stimulate Critical Reflections

The PSTs described that they used digital tools (green screens and AnimateAnything) to stimulate the children's critical reflections, both from a general perspective (TPK) and directly related to science content (TCK). The PSTs did not refer to the curriculum, but, as already shown, part of the 'adequate digital competence' stipulated in the curriculum is that children should be given the opportunity to develop a critical and responsible attitude toward digital technology (SNAE 2018).

> They [the children] sit on a broom, and they can be dressed like characters in the story we work with and fly away into the sky. Then we can discuss if this is really possible. (B2)

> The idea of using a green screen is that the children will realize that not everything they see is real, like what they see in movies and on television, so they can develop critical thinking. They can start to ask themselves if things are real. We have worked with the green screen when we studied dinosaurs, and it's really exciting – can you really be chased by a dinosaur? (A2)

Using digital tools for critical reflections, we considered TCK, for example, when the children were allowed to question if it is possible to fly themselves and related this to knowledge about the scientific aspects of air. The PSTs had discussions with the children about dinosaurs, and if they could really be chasing them. Thus, they used the digital tools to critically reflect on scientific content with the children. In previous research, critical thinking has been considered a generic skill (Enochsson and Ribaeus, 2021) that is not specifically related to science.

Not Knowing how to Use Digital Tools when Teaching Science

The final theme we identified was that PSTs did not know how to use digital tools in science teaching. During all meetings with the PSTs in preschool C, they said that using digital tools was problematic. Somewhat paradoxically, they felt confident using digital tools, but they did not know how to connect this aptitude for teaching science. One reason for this may be that they were not so keen on teaching science at all. This is our interpretation, based on comments such as:

> We feel confident in using digital tools, but we don't know how to connect the use to science. We have not really started with science; we have tools and materials, but we don't know what to do. To work with science, well, that is not our decision; it has been decided by leaders, not by us. It's difficult to find natural connections between the digital, science and what children talk about in their everyday life. (C)

Despite these reservations, they had made some attempts: they had used robots to stimulate the children's learning about some animals and what their excrement looks like. They had also used digital microscopes to study spiders together with the children.

> We have used the robots, and the children programmed their way to pictures that show poop from different animals, it was quite ok. The web egg, the children think it's cool. It's fun when you find a spider and inspect it; you can still see what it is, but it's much bigger. Other objects in nature can be more difficult to enlarge and understand what it actually is. (C)

In preschool C, the PSTs declared that they had a lot of digital competence, but in fact this was mostly in handling tools and using them for digital purposes alone, not in integrating them into different teaching activities. Even though they had made some attempts, they admitted that they had not made this connection.

Discussion

The aim of this study was to explore Swedish preschool teachers' perspectives on integrating digital tools when teaching science. This aim includes studying how and why preschool teachers integrate digital tools into activities with science teaching in preschools as well as the affordances they experience and obstacles they encounter. By using the TPACK framework, the analysis shows several ways in which PSTs use digital tools when teaching science. Affordances they highlighted include different ways of creating stimulating and motivating environments and how some tools can be used to make the children understand scientific concepts. Our results also highlight obstacles, which are not directly related to the digital tools but to a lack of digital tools or

training. This forms part of the context of the TPACK framework and is further discussed below.

Summarizing the findings, we notice that the PSTs, first of all, talked about the importance of knowing how to handle the digital tools, which we identified as TK, as described by Mishra and Koehler (2006). This is also in line with previous studies emphasizing the PSTs need practical training in how to use digital tools (Neumann and Neumann 2014; Otterborn, Schönborn, and Hultén 2019; Palmér 2015). We will return to this at the end of the discussion when reflecting on the final theme we identified, with PSts not knowing how to use digital tools when teaching science.

In the second theme, we noticed that the PSts talked about the digital tools as complements to other tools. Kewalramani and Havu-Nuutinen (2019) concluded that integrating digital tools in science teaching in preschool 'is easier said than done' (p. 10), but the TPACK framework allows us to explore this in more detail. Through the analysis, we noticed clear examples of the integration of digital tools and how the PSTs found it important that the activities are well integrated in the preschools' everyday work. Using digital tools as a complement to other tools agrees well with the TPACK framework (Mishra and Koehler 2006). The idea is not that everything in preschool should be digital, but to combine digital tools with analogue tools and create a buffet where children can choose and use a range of tools. The digital tools are complementary to other tools, and, as with any tool, teachers should reflect on and discuss the aims of using one or several tools. Even though TPACK includes knowing *when* to use digital tools and *when not to*, this was never exemplified by the PSTs in our study; they only talked about digital and analogue tools complementing each other (cf. Crompton et al. 2016).

In the third theme, our results show that digital tools are used to improve the conditions for teaching science. This is, for example, done by searching for information about specific science content for the PSTs' own benefit, which relates to the importance of teachers' CK, as presented in the TPACK model (Mishra and Koehler 2006). Using digital tools so search for information was but also used to illustrate different scientific phenomena to the children – like air, as the PSTs did in our study (Furman et al. 2019). We believe that this is common in other preschools as well, even though it was not mentioned by all the PSTs who took part in our study (cf. Enochsson and Ribaeus, 2021).

The fourth theme covered the aspects of creating stimulating learning environments; the PSTs in our study emphasized the importance of making digital tools available to the children. Earlier research (Enochsson and Ribaeus, 2021; Ljung-Djärf 2008) has emphasized the importance of the physical organization of learning environments in positive outcomes. Simply put, if digital tools are placed in locked cupboards, or on the top of shelves that the children cannot reach, outcomes will be different from if the tools can be freely accessed by the children. Using digital tools arguably motivates the children and makes learning more fun by stimulating their imagination, because this was something new for the children (Moore and Keys Adair 2015). Still, the PSTs expressed that using digital tools triggered the children's imagination and thereby made the learning situation exciting. This may well be true, since imagination is involved in the synthesis of new knowledge, allowing us to create mental constructions based on the observation of existing knowledge and what is not present (e.g. Heath 2008); this is central to children's learning (Fleer and Hoban 2012).

In the fifth theme, we identified that the PSTs in our study used digital tools to document activities and to share these with the children to further stimulate learning. This is in line with what has been reported by Wilson (2019). In our study, the PSTs believed that this was a development of their previous use of documentation, which we also find as positive.

In theme six, the PSTs talked about the use of digital tools to stimulate critical reflection among the children. This is, of course, an important part, to reflect upon what is real and what is fake, especially in these days with 'fake news'. There are probably many studies dealing with this, but this was not the scope of our study. We just want to conclude that in terms of what is stated in the curriculum for the Swedish preschool, critical reflection is supposed to be focused on reflections on digital technology itself (SNAE 2018), and this was never mentioned by the PSTs.

Finally, as a reflection on the last theme, PSTs not knowing how to use digital tools when teaching science, we believe that PSTs must have the opportunity to develop their skills in using digital tools if they are to be used successfully in preschools (Bølgan 2012; Hardesen and Guðmundsdóttir 2012; Lindeman, Svensson, and Enochsson 2021; Magen-Nager and Firstate 2019). It is also part of the context at a mezzo-level (Porras-Hernandez and Salinas-Amescua 2013), and the responsibility to find courses and time for training is usually beyond the PSTs' control. Several factors could have influenced the problems experienced by the PSTs at preschool C; moreover, they had limited access to digital tools, which made it even more difficult to get training. However, maybe it was just a matter of them not being aware that they had made connections to teaching science, or that they still needed to develop this competence. This is also part of the context at a mezzo-level (the PSTs' competencies, and local handling by management), or at a macro-level (national courses, teacher education, etc.) (Porras-Hernandez and Salinas-Amescua 2013). Hence, as a number of researchers (e.g. Otterborn, Schönborn, and Hultén 2019; Neumann and Neumann 2014; Strawhacker, Lee, and Bers 2018) have argued, PSTs need to develop their competence in how to integrate digital tools into teaching, and not only use digital tools for their own sake.

Limitations

Even though this study presents results from only three preschools, based on comments from 18 PSTs rather than actual observations taken during activities (which were impossible), we argue that our findings are of wider interest. So far, few studies have been presented in this field, and we therefore believe that our study can add to this slim body of work and make a valuable contribution. An important contribution concerns the conditions for teaching science using digital tools, which we argue adds to the previously limited research specifically on teaching science in preschool using various digital tools. However, our results would have been more detailed if we had also included management, children, and the physical environment. Our recommendation for future studies, therefore, is to conduct observations at preschools, rather than solely relying on PSTs' reports. It is also important to mention that the PSTs in this study were participants from a tech course with a focus on digitalization and, therefore, interested in using digital tools in their practice; thus, this can affect the outcome.

Conclusions

The results of this study showed that the participating PSTs represented numerous ways of using the tools and reasons for doing so. Even though all of them had participated in different courses, they seemed to be in different stages of their TPACK in including digital tools in science education. We should remember that digital tools are not just tools for their own sake; knowledge of how to integrate them in different contexts, in this case when teaching children science, is essential. However, occasionally, the PSTs talked about the use of digital tools in general terms and not specifically from the perspective of teaching science; in those instances, TPK dominated rather than the TCK aspects. We argue that this is also an aspect of digitalization; the problems encountered by PSTs are part of the context, and the PSTs are not the only ones responsible. The development of TPACK takes time, digitalization is still a relatively new phenomenon in preschools, and the PSTs need training and time to practice. The results show that not only general training is needed, but also specific training in using digital tools when teaching science.

We believe that digitalization is now firmly a part of activities in preschools in many countries, and that the use of digital tools when teaching science, or other subjects, may lead to more researchers finding that TPACK can act as a useful framework. So far, few studies have used TPACK related preschool studies (Kewalramani and Havu-Nuutinen 2019). In this respect, our study contributes to and provides possible inspiration for future studies; for example, focusing on the conditions given to PSTs and not limiting studies to PSTs' attitudes and what they actually do, since this can also be due to factors beyond their control. However, to prepare children for a life in society where digitalization is rapidly developing, PSTs' possibilities to stimulate children in this respect are important.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Susanne Walan http://orcid.org/0000-0002-9060-9973
Ann-Britt Enochsson http://orcid.org/0000-0001-7214-1716

Declarations

The authors declare that there are no conflicts of interests.

References

Aronin, S., and K. K. Floyd. 2013. "Using an iPad in Inclusive Preschool Classrooms to Introduce STEM Concepts." *Teaching Exceptional Children* 45 (4): 34–39. doi:10.1177/004005991304500404.

Blackwell, C. K., A. R. Lauricella, and E. Wartella. 2016. "The Influence of TPACK Contextual Factors on Early Childhood Educators' Tablet Computer Use." *Computers & Education* 98: 57–69. doi:10.1016/j.compedu.2016.02.010.

Bølgan, N. 2012. "From IT to Tablet: Current Use and Future Needs in Kindergartens." *Nordic Journal of Digital Literacy* 3: 154–170. doi:10.18261/1891-943X-2012-03-02.

Braun, V., and V. Clarke. 2006. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology* 3: 77–101. doi:10.1191/1478088706qp063oa.

Caena, F., and C. Redecker. 2019. ""Aligning Teacher Competence Frameworks to 21st Century Challenges: The Case for the European Digital Competence Framework for Educators" (Digcompedu)." *European Journal of Education* 54 (3): 356–369. doi:10.1111/ejed.12345.

Chee, J., M. N. Mariani, A. J. Othman, and M. R. Mashitah. 2017. "Exploring the Issue of Content, Pedagogical and Technological Knowledge among Preschool Teachers." *International Journal of Advanced and Applied Sciences* 4 (3): 130–136. doi:10.21833/ijaas.2017.03.020.

Couse, L. J., and D. W. Chen. 2010. "A Tablet Computer for Young Children? Exploring Its Viability for Early Childhood Education." *Journal of Research on Technology in Education* 43 (1): 75–98. doi:10.1080/15391523.2010.10782562.

Crompton, H., D. Burke, K. H. Gregory, and C. Gräbe. 2016. "The Use of Mobile Learning in Science: A Systematic Review." *Journal of Science Education and Technology* 25 (2): 149–160.

Dezuanni, M., and L. Knight. 2015. "Networking iPads into Preschool Spaces." In *iPads in the Early Years: Developing Literacy and Creativity*, edited by M. Dezuanni, K. Dooley, S. Gattenhof, and L. Knight, 142–160. New York: Routledge.

Dogan, Y., and A. Simsar. 2018. "Preschool Teachers' Views on Science Education, the Methods They Use, Science Activities, and the Problems They Face." *International Journal of Progressive Education* 14 (5): 57–76. doi:10.29329/ijpe.2018.157.6.

Enochsson, A. B., and K. Ribaeus 2021. ""Everybody Has to Get a Chance to Learn": Democratic Aspects of Digitalisation in Preschool." *Early Childhood Education Journal* 49 (6): 1087–1098. doi:10.1007/s10643-020-01117-6.

EU. (European Union). 2019. "*Dicomp. Digital Competence Framework for Citizens*." Retrieved 9 March 2021 from https://ec.europa.eu/jrc/en/digcomp/digital-competence-framework

Fleer, M., and G. Hoban. 2012. "Using 'Slowmation' for Intentional Teaching in Early Childhood Centres: Possibilities and Imaginings." *Australasian Journal of Early Childhood* 37 (3): 61–70. doi:10.1177/183693911203700309.

Fridberg, M., S. Thulin, and A. Redfors. 2018. "Preschool Children's Collaborative Science Learning Scaffolded by Tablets." *Research in Science Education* 48: 1007–1026. doi:10.1007/s11165-016-9596-9.

Furman, M., S. De Angelis, E. Dominguez Prost, and I. Taylor. 2019. "Tablets as an Educational Tool for Enhancing Preschool Science." *International Journal of Early Years Education* 27 (1): 6–19. doi:10.1080/09669760.2018.1439368.

Hardesen, B., and G. B. Guðmundsdóttir. 2012. "The Digital Universe of Young Children." *Nordic Journal of Digital Literacy* 7: 221–225. doi:10.18261/1891-943X-2012-03-06.

Heath, G. 2008. "Exploring the Imagination to Establish Frameworks for Learning." *Study Philosophy of Education* 27 (2): 115–123. doi:10.1007/s11217-007-9094-7.

Kewalramani, S., and S. Havu-Nuutinen. 2019. "Preschool Teachers' Beliefs and Pedagogical Practices in the Integration of Technology: A Case for Engaging Young Children in Scientific Inquiry." *EURASIA Journal of Mathematics, Science and Technology Education* 15 (12). doi:10.29333/ejmste/109949.

Kjällander, S., and K. P. Blair. 2021. "Designs for Learning with Adaptive Games and Teachable Agents." In *Digital Learning and Collaborative Practices: Lessons from Inclusive and Empowering Participation with Emerging Technologies*, edited by E. Brooks, S. Day, and S. Selander, 69–90, New York: Routledge.

Kjällander, S., and S. Johnson Frankenberg. 2018. "How to Design a Digital Individual Learning RCT-study in the Context of the Swedish Preschool: Experiences from a pilot-study." *International Journal of Research & Method in Education* 41 (4): 433–446. doi:10.1080/1743727X.2018.1470161.

Lavidas, K., M. A. Katsidima, S. Theodoratou, V. Komis, and K. Nikolopoulou. 2021. "Preschool Teachers' Perceptions about TPACK in Greek Educational Context." *Journal of Computers in Education* 1–16. doi:10.1007/s40692-021-00184-x.

Liang, J. C., C. S. Chai, J. H. L. Koh, C. J. Yang, and C. C. Tsai. 2013. "Surveying in-service Preschool Teachers' Technological Pedagogical Content Knowledge." *Australasian Journal of Educational Technology* 29 (4). doi:10.14742/ajet.299.

Lindeman, S., M. Svensson, and A-B. Enochsson. 2021. "Digitalisation in Early Childhood Education: A Domestication Theoretical Perspective on Teachers' Experiences." *Education and Information Technologies* 26: 4. doi:10.1007/s10639-021-10501-7.

Ljung-Djärv, A. 2008. "To Play or Not to Play – That Is the Question: Computer Use within Three Swedish Preschools." *Early Education and Development* 19 (2): 330–339. doi:10.1080/10409280801964069.

Lyle, J. 2003. "Stimulated Recall: A Report on Its Use in Naturalistic Research." *British Educational Research Journal* 29 (6): 861–878. doi:10.1080/0141192032000137349.

Magen-Nagar, N., and E. Firstater. 2019. "The Obstacles to ICT Implementation in the Kindergarten Environment: Kindergarten Teachers' Beliefs." *Journal of Research in Childhood Education* 33 (2): 165–179. doi:10.1080/02568543.2019.1577769.

Marklund, L., and E. Dunkels. 2016. "Digital Play as a Means to Develop Children's Literacy and Power in the Swedish Preschool." *Early Years* 36 (3): 289–304. doi:10.1080/09575146.2016.1181608.

Merriam, S. B., and E. J. Tidsell. 2016. *Qualitative Research: A Guide to Design and Implementation*. 4th ed. San Fransisco: Jossey-Bass.

Mishra, P. 2019. "Considering Contextual Knowledge: The TPACK Diagram Gets an Upgrade." *Journal of Digital Learning in Teacher Education* 35 (2): 76–78. doi:10.1080/21532974.2019.1588611.

Mishra, P., and M. J. Koehler. 2006. "Technological Pedagogical Content Knowledge: A Framework for Integrating Technology in Teacher Knowledge." *Teachers College Record* 108 (6): 1017–1054. doi:10.1111/j.1467-9620.2006.00684.x.

Moore, H. C., and J. Keys Adair. 2015. "I'm Just Playing iPad": Comparing pre-kindergarteners' and pre-service Teachers' Social Interactions while Using Tablets for Learning." *Journal of Early Childhood Teacher Education* 4: 362–378. doi:10.1080/10901027.2015.1104763.

Neumann, M. M., and D. L. Neumann. 2014. "Touch Screen Tablets and Emergent Literacy." *Early Childhood Education Journal* 42 (4): 231–239. doi:10.1007/s10643-013-0608-3.

Nilsen, M. 2018. "*Children's and Teachers' Activities with Tablets and Apps in Preschool*." (Published Doctoral dissertation). Gothenburg: Acta Universitatis Gothoburgensis.

Olgan, R. 2015. "Influences on Turkish Early Childhood Teachers' Science Teaching Practices and the Science Content Covered in the Early Years." *Early Child Development and Care* 185 (6): 926–942. doi:10.1080/03004430.2014.967689.

Olofsson, A. D., G. Fransson, and J. O. Lindberg. 2019. "A Study of the Use of Digital Technology and Its Conditions with A View to Understanding What 'Adequate Digital Competence' May Mean in A National Policy Initiative." *Educational Studies* online. doi:10.1080/03055698.2019.1651694.

Otterborn, A., K. Schönborn, and M. Hultén. 2019. "Surveying Preschool Teachers' Use of Digital Tablets: General and Technology Education Related Findings." *International Journal of Technology and Design Education* 29 (4): 717–737. doi:10.1007/s10798-018-9469-9.

Palaiologou, I. 2016. "Teachers' Dispositions Towards the Role of Digital Devices in play-based Pedagogy in Early Childhood Education." *Early Years* 36 (3): 305–321. doi:10.1080/09575146.2016.1174816.

Palmér, H. 2015. "Using Tablet Computers in Preschool: How Does the Design of Applications Influence Participation, Interaction and Dialogues?" *International Journal of Early Years Education* 23 (4): 365–381. doi:10.1080/09669760.2015.1074553.

Palmér, H. 2017. "Programming in preschool—with a Focus on Learning Mathematics." *International Research in Early Childhood Education* 8 (1): 75–87.

Parette, H., A. Quesenberry, and C. Blum. 2010. "Missing the Boat with Technology Usage in Early Childhood Settings: A 21st Century View of Developmentally Appropriate Practice." *Early Childhood Education Journal* 37: 335–343. doi:10.1007/s10643-009-0352-x.

Porras-Hernandez, L. H., and B. Salinas-Amescua. 2013. "Strengthening TPACK: A Broader Notion of Context and the Use of Teachers' Narrative to Reveal Knowledge Construction." *Journal of Computing Research* 48 (2): 223–244. doi:10.2190/EC.48.2.f.

Rosenberg, J. M., and M. J. Koehler. 2015. "Context and Technological Pedagogical Content Knowledge (TPACK): A Systematic Review." *Journal of Research on Technology in Education* 47 (3): 186e210. doi:10.1080/15391523.2015.1052663.

Shulman, L. S. 1986. "Those Who Understand: Knowledge Growth in Teaching." *Educational Research* 15 (2): 4–14. doi:10.3102/0013189X015002004.

Shulman, L. S. 1987. "Knowledge and Teaching:Foundations of the New Reform." *Harvard Educational Review* 57 (1): 1–22. doi:10.17763/haer.57.1.j463w79r56455411.

SNAE. 2018. *Curriculum for Preschool*. Stockholm: SNAE.

Strawhacker, A., M. Lee, and M. U. Bers. 2018. "Teaching Tools, Teachers' Rules: Exploring the Impact of Teaching Styles on Young Children's Programming Knowledge in ScratchJr." *International Journal of Technology and Design Education* 28 (2): 347–376. doi:10.1007/s10798-017-9400-9.

Walan, S. 2020. "Embracing Digital Technology in Science Classrooms: Secondary School Teachers' Enacted Teaching and Reflections on Practice." *Journal of Science Education and Technology* 9(3): 431–441.

Wilson, C. 2019. "*iPads in the Early Childhood Science Classroom: An Exploration of iPad Use in Hands-on Science Activities*." [Master's thesis, Queensland University of Technology]. https://eprints.qut.edu.au/132659/2/Catherine%20Wilson%20Thesis.pdf

Yilmaz, M. M., and A. Siğirtmaç. 2020. "A Material for Education Process and the Teacher: The Use of Digital Storytelling in Preschool Science Education." *Research in Science & Technological Education* 1–28. doi:10.1080/02635143.2020.1841148.

Appendix I

Interview questions. (original questions posed in Swedish)

First interview:

Name, teaching experience?

How many children in your group? What are the ages of the children?

What kind of previous experience/education do you have in using digital tools when teaching?

What kind of digital tools do you have at your preschool department?

What kind of science theme do you work with at the moment with the children?

What have you been doing so far?

What kind of digital tools have you used?

How has this worked out?

Second and third interview:

What have you been doing since the last time we met that is related to teaching children science and using digital tools?

How has it worked out? What has been positive? What has been challenging? How did you handle the challenges?

What kind of effects do you see on the children?

Why do you use the specific digital tools? How do you find them and get access?

In what way do you think that using the digital tool/tools stimulates the children?