International Journal of Technology and Design Education (2022) 32:129–147
https://doi.org/10.1007/s10798-020-09613-x

Children's interactions with technology in teachers' self-reported activities in Sweden's preschools

Tor Nilsson[1] · **Peter Gustafsson**[2] · **Pernilla Sundqvist**[2]

Accepted: 7 July 2020 / Published online: 7 August 2020

Abstract
This study investigates preschool children's interactions with technology in a Swedish context. The purpose is to broaden our knowledge about children, technology and preschool activities—not only the meanings of technology that is present in everyday preschool activities, but also how children interact with it. Collier-Reed's (Pupils' experiences of technology: exploring dimensions of technological literacy, PhD thesis, University of Cape Town, Cape Town, 2006) category system has been used to analyse data generated in two research circles. The participating preschool teachers were asked to present teacher- and children-initiated activities from their daily practices. 54 cases were identified, of which 40 included children's interactions with technology according to the definitions provided by Collier-Reed. Mapping the results in a matrix representation based on Collier-Reed's two sets of categorisation systems shows two clusters. The first mainly includes teacher-initiated activities, in which children were instructed how to use different artefacts. The second also includes children-initiated activities requiring more engagement as part of Collier-Reed's notion of the *core*. Also, *labelling* was added to the category system in order to adapt it to the Swedish preschool setting.

Keywords Technology · Preschool · Interaction · Curriculum

Introduction

There has been an increasing interest to investigate activities within the field of technology in the preschool setting (e.g. Bairaktarova et al. 2011; Benson and Treleven 2011; Mawson 2013; Thorshag and Holmqvist 2018; Turja et al. 2009). Some of this is due to it being an unexplored research area, although it is also connected to the development of the preschool curriculum for a more subject-related content with clear goals. In recent decades, the directive to support children's development and learning has been emphasised both in the Swedish preschool (e.g. Broström 2017) and internationally (e.g. Van Laere et al. 2014). Bennett (2005) described it as a slide from the social pedagogic tradition towards

✉ Tor Nilsson
tor.nilsson@mdh.se

[1] School of Education, Culture and Communication, Mälardalen University, Eskilstuna, Sweden

[2] School of Education, Culture and Communication, Mälardalen University, Västerås, Sweden

teaching children specific subjects. Teaching in the Swedish preschool is guided by specific objectives in accordance with the preschool curriculum (Sheridan and Williams 2018) that are to be led by preschool teachers based on the children's perspectives and interests. Hence, it is a formalised, but not compulsory education of children, and both planned and spontaneous situations can be regarded as teaching activities. Thus, Sheridan and Williams (2018) emphasise the different competences that preschool teachers need in order to teach. Their own subject knowledge is of importance (e.g. Jones et al. 2013; Sheridan and Williams 2018), as is their ability to design and plan teaching activities (e.g. Turja et al. 2009). The latter has been debated in terms of what teaching in preschool includes, such as well-planned and conducted activities (Ehrlin et al. 2015), free play and the children's own explorations (Campbell and Jobling 2008; Hallström et al. 2015; Hellberg and Elvstrand 2013). Recently, Sheridan and Williams (2018) analysed the quality of Swedish preschools based on the actual teaching that takes place in them. A large number of preschools show low teaching quality in specific content areas and previous research has highlighted that preschool teachers need to improve their content knowledge and didactical skills in order to develop their teaching. Studies explicitly focusing on teaching as a concept in preschools reveal that practising preschool teachers are uncomfortable about using teaching as a concept (e.g. Jonsson et al. 2017). Also, teachers' understanding of teaching, as well as how it is applied in the preschool practice, varies from a total repudiation of teaching, based on the idea that everything that takes place in the preschool is teaching, to lesson plans based on scientific grounds and proven experience (Vallberg Roth 2018). In other words, there is no consensus about expected practices. With regard to the implementation of the curriculum in 2010, The Swedish Schools Inspectorate (SSI) (The Swedish Schools Inspectorate 2012; The Swedish Schools Inspectorate 2017) has also reported that preschool staff are insecure about teaching technology, they do not know what content to include and how to teach it. The children are involved in doing activities, but they do not automatically learn technology.

In Sweden, most research is focused on how preschool staff (i.e. child minders or preschool teachers) interpret the concept of technology and the kind of activities that are related to it in the preschool setting (e.g. Elvstrand et al. 2018; Sundqvist 2016; Sundqvist et al. 2018; Öqvist and Högström 2018). This focus stems from the change in the Swedish preschool curriculum, as described above (The Swedish National Agency for Education 2016). With regard to technology, in a general sense, the curriculum states that the preschool should strive to help each child to develop their ability to: (1) identify technology in everyday life and explore how simple technology works and (2) build, create and construct using different techniques, materials and tools. Hence, as stated these goals are broader than for instance digital technology or educational technology. In July 2019 the curriculum was revised again (The Swedish National Agency for Education 2018). It now includes three goals regarding technology, although this study was conducted prior to this revision.

However, an issue that has not been investigated to any great extent is how preschool children interact with technology as they "identify", "explore", "build, create and construct". From such a study, knowledge can be acquired about the interplay between preschool teachers and the children and between children when using technology, as well as how children approach it. The main point here is that the subject of technology in the preschool is more than simply defining the content or identifying artefacts and their function, but also includes children investigating, trying out, constructing and interacting with technology. Therefore, the aim of the study is to investigate what technology teaching includes in authentic preschool settings. The research question is: How do preschool children interact with technology in teachers' self-reported activities?

Background

This section presents the changes in the Swedish preschool curriculum, previous research on technology education in the preschool and the study's theoretical framework.

Changes in the Swedish preschool curriculum

In line with international changes, the Swedish preschool curriculum now has subject-related goals that have been clarified to further stimulate children's spontaneous interest in learning specific content areas such as technology (The Swedish Ministry of Education 2010; The Swedish National Agency for Education 2016). Other goals covering the preschool assignment in general (e.g. care and safety) are unaffected. Play and creativity are still central to preschool activities and subject-related goals are not mandatory, but rather goals to strive for (The Swedish National Agency for Education 2016). However, the goals to strive for are vague and leave the preschool teacher to interpret how to act (Jonsson 2016). SSI (The Swedish Schools Inspectorate 2012; The Swedish Schools Inspectorate 2017) has also pointed to deficiencies in how preschool staff work with technology.

Our starting point is the Swedish preschool curriculum (The Swedish National Agency for Education 2016) and the verbs that relate to interactions with technology: "identify", "explore", "build, create and construct". The Swedish curriculum we refer to here, dated 2016, was a revision of the first Swedish preschool curriculum including technology goals to strive for. Since it was difficult for the preschool teachers to know what to include in these goals to strive for a work-group was appointed by the The Swedish Ministry of Education. The work-group brought forward suggestions about how to interpret and understand the goals to strive for. Hence, in the Swedish preschool curriculum dated 2016 the work-group's suggestions acted as a non-mandatory support for preschool teachers.

For the first goal—identify technology in everyday life and explore how simple technology works—the work-group's report indicates that the preschool should support "children's creative thinking and … problem solving skills", help "children to see simple technical solutions that can be found around them" and see "different sides of technology and evaluate its advantages and disadvantages" (The Swedish Ministry of Education 2010, p. 16, translated from Swedish by the authors). These formulations indicate that the preschool, or rather the preschool teachers, need to be active and guide or support the children in these activities.

For the second goal—build, create and construct using different techniques, materials and tools—the report mentions "in building and construction play the children explore and create", the importance of "making sketches, drawings and models" and giving children opportunities "to test and investigate different materials, tools and techniques" (The Swedish Ministry of Education 2010, p. 16, translated from Swedish by the authors). These point more to children's free play based on their own interest in investigating technology. However, in the work-group's suggestions we can also find specific directions for the preschool teachers and the importance of free play for achieving each goal. Hence, for further reasoning there is a need to balance the curriculum with its mandatory but vague descriptions of what to strive for, with the work-group's non-mandatory distinct descriptions of the same goals.

Previous research on technology education in preschool

Most research focuses on how preschool teachers understand and relate to technology in their pedagogical work. Some results point to the importance of a teacher's own knowledge of the concept and ability to help the children to understand what technology stands for. Studies show that subject matter knowledge in technology is a prerequisite for the ability to teach the subject, having subject didactic insights and having a positive attitude towards technology as a subject (Sheridan and Williams 2018). Understanding the nature of technology enhances knowledge about technology, which is why it is important for teachers to consciously develop knowledge in this area (Jones et al. 2013).

However, adults often have a narrow view of technology as artefacts, which is then reproduced by the children (de Vries 2016). Even though children's explorations of artefacts and their functional design are important (Turja et al. 2009), we also need to observe the artefact's context and to widen our views of it (Klasander 2010). Creative activities in the preschool (and school) can also be lifted to a higher level than pottering if the teacher is familiar with the different steps in a design process (Turja et al. 2009).

The results regarding preschool teachers' apprehensions show a narrow view of technology as being related to computers and a more developed view as problem solving (Öqvist and Högström 2018) and that technology can be everything (Elvstrand et al. 2018) and has been categorised in an overall system (Sundqvist 2016). However, the fact that preschool teachers have a developed view of technology does not necessarily mean that this is shared by the children. On one hand, Mawson (2013) reports that some children may not have encountered the concept at all and have no understanding of what technology can stand for, although on the other hand, preschool teachers also explain that a common preschool practice is to name the artefacts, thus developing children's vocabulary (Sundqvist et al. 2018).

Many preschool teachers do have a reasonable or even well-developed view of technology (Elvstrand et al. 2018; Mawson 2013; Sundqvist 2016; Sundqvist et al. 2018; Öqvist and Högström 2018). Also, the above points towards a broad repertoire in preschool teachers' work, which is also observed in international research, with everything from well-planned and conducted activities (Ehrlin et al. 2015; Mawson 2013) to free play and the children's own explorations (Campbell and Jobling 2008; Hallström et al. 2015; Hellberg and Elvstrand 2013). These extremes can be described as adult-directed and child-directed activities in that they deal with the balance between, on the one hand, the preschool teachers' task to inspire and interest the child in technology and, on the other hand, how children's own interest affect the activities (Sundqvist 2017). The former may be problematic, because we know that many preschool staff describe their own experiences of technology in schools in negative terms (Elvstrand et al. 2018). At the same time, children have a spontaneous interest in technology, which provides an opportunity to work with technology in the preschool.

Theoretical framework

This study is framed by Collier-Reed's (2006) ideas about technology education. However, we are aware that these ideas mainly relate to secondary- and tertiary level education in South Africa. We have therefore adapted his ideas to fit a Swedish preschool setting. Collier-Reed's own research methodology is phenomenography, which together with a technological literacy framework informs his thesis. Collier-Reed and colleagues (e.g.

Collier-Reed et al. 2009; Ingerman and Collier-Reed 2011; Luckay and Collier-Reed 2011) later developed their ideas about the category system, although due to the reasons elaborated on below, we base our theoretical and analytical framework on Collier-Reed's earlier work (2006).

We first of all summarise Collier-Reed's (2006) ideas about what technology is. However, as the Swedish preschool curriculum includes interaction, we particularly focus on this aspect and the purpose of technology education. In Collier-Reeds discussion of the outcome of his thesis for secondary and tertiary level technology education in South Africa, we can see how different lines of thoughts may transcend to how technology education is carried out in Swedish preschools. The first relates to what technology is, i.e. the nature of technology, or the actual content of it. Here, the emphasis is on the difference between the *product* centred (the artefact) view of technology, which is most common amongst younger children, and the *process* centred (the process of artefact progression) view. This is further emphasised by the notions of *using* and *making* corresponding to *product* and *process* respectively, see Table 1 below. There is also a shift from the artefact itself (*product*) to person as the developer (*process*). According to Collier-Reed, the perceived equality between technology and information technology has consequences for teaching and learning (e.g. difficult to master). In *using* and *making*, interaction is important. Collier-Reed's (2006) framework offers a possibility to analyse interaction and interpret the results. According to Collier-Reed, hands-on capability and capacity are important when someone interacts with technology. Capacity implies a sense of power to interact. Collier-Reed's categories of description include categories in which pupils have the capacity to interact with technology or not (see Table 2 below). If pupils lack this capacity an instruction or direction by a teacher is needed. However, pupils who have both the capability and the capacity to interact with technology may embrace it. Interaction is self-initiated and there is a desire to understand both the function and the form.

As the curriculum goals to strive are vague and needs interpretation (Jonsson, 2016) and the curriculum does not provide any guidance as to how children should interact with technology (The Swedish National Agency for Education 2016) the work-group's suggestions (The Swedish Ministry of Education 2010) are used to make the links between the curriculum and the theoretical framework.

With respect to the first curriculum goal to strive for the work-group suggests: "children's creative thinking and … problem solving skills", help "children to see simple technical solutions that can be found around them" and see "different sides of technology and evaluate its advantages and disadvantages". Hence, with respect to Table 1 and Collier-Reed's (2006) categories of description of what technology is the work-group's suggestions cover both *product* and *process* and *using* and *making*, thereby indicating that all four of these categories of descriptions may be related to the curriculum's first goal. Also, with respect to Table 2 and how children interact with artefacts the preschool teachers need to be active in guiding or supporting the children in order to fulfil the first goal. However, the work-group's suggestions may also indicate that children already have the *capacity* to interact with technology.

For the second goal, which seems to be *process* centred and described by the three latter categories (see Table 1), the work-group's suggestions also point in a direction towards *products*: "in building and construction play the children explore and create", the importance of "making sketches, drawings and models" and enabling children "to test and investigate different materials, tools and techniques". For instance, using a brush is the application of an artefact (*product*). When shifting perspective, the second goal to strive for also points towards *capacity* rather than *lack of capacity* (see Table 2 below). However,

Table 1 Collier-Reed's (2006) categories of what technology is

Characteristic	*Using* (U) *Making* (M)	Name of category of description (meaning)	Short definition
Product	U	Technology as an artefact	A physical, tactile thing. People are absent
		Technology as the application of artefacts	People use technology (artefacts)
Process	U + M	Technology as the process of artefact progression	How technology is done (developed) by someone in a process
	M	Technology as using knowledge and skill to develop artefacts	People develop or evolve technology. Focus on function and design
		Technology as the solution to a problem	There is a problem and the purpose for technology is to solve it and improve quality of life

Table 2 Collier-Reed's (2006, p. 101) categories of interaction

Characteristic	Name of category of description (meaning)	Focus
Lack of capacity	Interaction with a technological artefact is through direction	Interaction with a technological artefact is as the result of a directive by someone and is not something that happens spontaneously. There is reluctance to make a first move toward approaching an artefact. Pupils are on the outside looking in towards an artefact as a reified object
	Interaction with a technological artefact is through instruction	Fear of entry no longer inhibits interacting with a technological artefact and the interaction can be self-motivated. The primary focus is having instruction enable the use of the artefact
Capacity	Interaction with a technological artefact is through tinkering	Pupils self-initiate an interaction with a technological artefact by beginning to tinker with it. They have no need of instruction to enable them to begin this interaction. There is no sense of being intimidated by anything to do with the artefact
	Interaction with a technological artefact is through engaging	The method of interaction is something that is reflected upon and takes place through an engagement with a technological artefact. The barriers to entry into the space of an artefact are now absent and the pupils are creating their own contexts and frameworks within which to work

despite this, preschool teachers may still need to teach children something as they strive towards the goal. For instance, if a child has not made a sketch, drawing or model before, both *direction* and *instruction* may be needed. It should be pointed out that our aim here is not to use Collier-Reed's (2006) sets of descriptive categories in order to provide a complete description of technology in the Swedish preschool curriculum and the work-group's report, but to present possible links between the curriculum, the work-group's report and this study's theoretical framework.

Clearly, Collier-Reed's (2006) sets of categories for technology and interaction can be used in order to think about and explain the preschool practice. This offers an opportunity to combine the sets in a matrix, see Table 3 below. Collier-Reed argues that technologically literate pupils are positioned at the *core*. The *core* is the intersection between the two most advanced categories in each descriptive set. What is important to bear in mind here is that in Collier-Reed's thesis technology education is about moving from the less advanced categories towards the more advanced categories. It is also about preparing secondary level pupils for engineering education and profiling. Pupils who are profiled in the *core* are likely candidates for an engineering programme, although the *core* is not an indication that a pupil will succeed in such a programme. However, with that in mind, issues relating to pupils outside the core and the purpose of teaching technology arise.

Secondary pupils who only interact with technology through *direction* or *instruction* need to be empowered (Collier-Reed 2006) in order to be interested in learning more. Having fun is not sufficient; the teacher also needs to provide a non-threatening, supportive environment and structured activities.

From a preschool perspective, children are interested in the world around them, including technology (e.g. Elvstrand et al. 2018), although at present there is a debate about whether or not to teach subject matter, finding a balance between being inspired to learn and letting children follow their own interests (e.g. Sundqvist 2017). In all this, the preschool teacher is a key figure when teaching technology and designing activities (e.g. Jones et al. 2013; Rohaan et al. 2008; Turja et al. 2009). Hence, the *core* may become a theoretical way of understanding what technology education in Swedish preschools looks like.

Methodology and data collection

This study has been conducted within a larger project including two research circles conducted over a full year, some results have been published (e.g. Sundqvist et al. 2018). The research circle is a form of action research that is participant-based in character (Stringer 2014). Researchers and practitioners participate in a research circle as equal partners in a common process to investigate and search answers to questions posed by the practitioners

Table 3 A schematic visualisation of the core (shaded)

	An artefact	Application of artefacts	Process of artefact progression	Using knowledge and skill to develop artefacts	Solution to a problem
Direction					
Instruction					
Tinkering					
Engaging					

For a complete description see Collier-Reed (2006)

(Andersson 2007; Stringer 2014). This forms an interplay in which all the participants contribute and knowledge is shared and developed.

The knowledge that is acquired then helps the participating preschool teachers to deepen their own understanding, in our case of technology, and to see the technology content in their daily activities. However, the research circle also provides opportunities to answer research questions. McKenney and Reeves (2012) call this research through intervention. Even though other forms of methodologies, such as questionnaires with open questions or interviews, can be used in order to understand more about how children interact with technology, it is likely that such methodologies would not have an additional effect on the preschool teachers' own understanding and practices. However, such methodologies may still be used as a complement to the research circle in order to yield additional data.

The research circles were carried out in two different Swedish municipalities. One circle consisted of six preschool teachers and two researchers. In the other research circle, 13 preschool teachers and two researchers participated. One of the researchers took part in both circles and all preschool teachers are female. All the circle meetings were video recorded and transcribed verbatim. In the larger project each research circle met seven times in the year for approximately 2 h each time. The participating preschool teachers came from different preschools and were all appointed by their managers due to their interest in preschool technology education.

Before starting the research circles the preschool teachers were asked to answer a questionnaire (Collier-Reed 2006) in order to map out the technology inventory profile for the groups. This procedure made it possible to discuss the concept and content of technology in the first meeting of each research circle based on the questionnaire results, statements used in the questionnaire and how the preschool teachers interpreted these statements. Thus, a common understanding of technology was established in the research circles based on Collier-Reed's categories for technology (e.g. Sundqvist et al. 2018). Prior to the second meeting the participants agreed to document and report on activities from their daily practices in which technology was present. This step was initiated by the researchers for two reasons. Firstly, to gain insight in how the preschool teachers had interpreted the subject area technology in Swedish preschool. Did they for instance report on activities following the curriculum, science activities or did they only focus on information technology? Secondly, to identify what the authentic Swedish preschool practice looked like. The children involved in the activities included groups of younger children aged 1–3, groups of older children aged 4–5, and in some cases children with special needs.

Before each research circle all researchers met to discuss the outline of each circle. Between each meeting the participating researchers discussed how to move each circle forward. The video recordings were watched and clarifying questions were prepared. This was documented by the researcher who participated in both research circles. The discussion resulted in different choices for each circle. Hence, during the research circles more material was prepared by the researchers than could be used.

Data analysis

The data analysed in this study were obtained by the participants themselves between the first and second meetings in each research circle. Hence, all the data were self-reported by the participants based on their own knowledge of technology and views of a preschool activity involving technology. The two category systems developed by Collier-Reed (2006) were used to map the technology content and interactions with technology in the activities. The reason to include both systems is because interaction in this framework concerns interactions with something, namely the technology content. Although the two category systems (Tables 1 and 2) were developed from interviews with year 11 pupils in South Africa, the category systems used to describe the technology have been adopted and tested in a Swedish context for preschool teachers (Sundqvist et al. 2018) and primary school teachers (Nilsson et al. 2016).

In previous studies (Nilsson et al. 2016; Sundqvist et al. 2018), we found that the system of categories describing meanings of technology was functional for the teachers' own identification of technology activities. In order to take this further we applied Collier-Reed's (2006) second category system describing interactions with technology. This was done because the curriculum describes interactions with technology in terms of: "identifying", "exploring", "building, creating and constructing" (The Swedish National Agency for Education 2016). Also, in their report on pre-service teachers' interactions with technology, Luckay and Collier-Reed (2012) used a statistically revised category system combining *direction* and *instruction* (see Luckay and Collier-Reed 2011). However, from an analytical point of view, Elvstrand et al.'s (2018) argument that children have a spontaneous interest in technology challenges the statistically revised category system. From a preschool practice perspective, there are important differences in how the categories *direction* and *instruction* were defined (Collier-Reed 2006).

From the presentations by the preschool teachers during the second meeting in each of the research circles, the first step in the analysis was for two of the researchers to independently categorise 48 identified activities using Collier-Reed's (2006) categories. This was done by reading through the transcripts several times to become familiar with the content of that activity and the described context and then fitting the actions described by the preschool teachers into the categories. Hence, the analytical process was deductive and the way the preschool teachers explained the context influenced our interpretation of the activity (i.e. the proper category). Only activities with a technology content were analysed; other activities concerning for instance science were removed at this stage. Also, sometimes the activities were so complex that two or more categories could be applied. At the same time, the researchers analysed the type of interactions that were identified in the activities in a similar manner. However, not all the presented activities included an interaction with technology.

After this initial step the two researchers compared their coding and any discrepancies were discussed until consensus was arrived at. In these 48 activities a total of 54 cases, i.e. unique technology-related actions, were found in which a category of technology was identified (artefact—solution to a problem). In total, 40 of these 54 cases included children interacting with technology (direction—engaging). Finally, the 40 cases were mapped in a matrix according to who initiated the self-reported activity (child or preschool teacher initiated) and the kind of technology category/interaction category for each case, thus visualising the *core* as presented by Collier Reed (2006, pp. 148–149), see Table 4.

Table 4 The table shows number of identified categories in a matrix where the columns are the categories used for technology and the rows the categories used for interaction with technology

	artefacts	the application of artefacts	the process of artefact progression	using knowledge and skills to develop artefacts	solutions to problems	*Total*
direction						*0*
instruction	T	14T		4T	T	*20T*
tinkering		5C, 2T		C, T		*6C, 3T*
engaging		T	C	3C, T	4C, T	*8C, 3T*
Total	*T*	*5C, 17T*	*C*	*4C, 6T*	*4C, 2T*	*14C, 26T*

The shadowed four squares show the 'core' region after Collier-Reed (2006). C refers to a child initiated and T to the preschool teacher initiated

Validity, reliability and ethics

As the data generated in this study derives from the research circles, validity and reliability has been considered from the specific aspect of participant-based research (Anderson and Herr 1999). Five aspects of validity can be identified: outcome validity, process validity, democratic validity, catalytic validity and dialogic validity.

Here, the outcome validity in relation to this study's research questions is discussed. Given this aspect, we looked at the validity in the analytical process by comparing the independent interpretations of two of the researchers (inter-rater reliability) followed by their joint discussion resulting in consensus on all the results. In the research circle, the ongoing process have influenced how different participants chose their activities. In fact, some of the preschool teachers acknowledged it themselves. They said they had used their 'technology spectacles'. With them on they could identify children involved in technology related activities. Hence, the preschool teachers did pay attention to more advance activities in their daily practice than they typically do. Also, they were influenced by other participants as they explained their activities and learned from each other. However, in order to increase the validity in the analytical process the activities were analysed by the researchers using Collier-Reed's (2006) framework.

The outcome or findings are results of an ongoing process in the research circle with reflective cycles and problematisations of the practice. As the discussions and questions raised by the participants in the research circle were open and transparent, no restrictions have been applied by the researchers. Thus, democratic validity is also secured. The catalytic validity reflects the reorientation of the research process in its view of reality and also with respect to the researchers' roles. Here the practitioners' presentations and their views have led us to our results from an open standpoint. Also, dialogic validity has been upheld in that one researcher participated in both research circles and the three researchers had follow up meetings between the research circle meetings to discuss their experiences of and reflections on them.

The reliability we describe emanates from three aspects taken from Storfors (2014): adaptive reliability, ability to review and interactivity in process. As adaptive reliability is achieved by adapting the method to the context, we can see this as being built into the method of a research circle. The goal and activities were determined by the participants' own actions. There was an internal ability to review, in that one researcher participated in both circles and all the researchers had research meetings for reconciliation. However, an external ability to review within the framework of the research circles was not present. The possibility for interactivity in the process, i.e. being objective in the work and independent of specific people, has not been explicitly addressed, although as the research circle builds on an active participation of *all* its members it would not be functional if one person dominated or the circle became dependent on that person.

Throughout the project we have followed the guidelines for good ethical research practice laid down by The Swedish Research Council (2017). For the participating preschool teachers, their managers were responsible for selection to the project, which we as researchers had to accept. The purpose of the research project, methods, how the data was used and stored and how the results would be published were communicated both in writing and orally to all the participants and their managers before the study began. Each participant was also able to choose whether to give consent to the audio recordings, to the video recordings or neither of them. Everyone consented to the video recording of the meetings. Since the participating municipalities were responsible for the children in the activities, they declined our request of obtaining informed consent from the children and legal guardians. From an ethical point of view we could include how the preschool teachers described the activities and what the children did as they participated in them. Hence, from an ethical perspective it was not possible to include what the children learned during the same activity.

Results

Technology as the application of artefacts, using knowledge and skills and finding solutions to problems

Technology in the preschool mainly relates to the application of artefacts, using knowledge and skills and finding solutions to problems. Table 4, below, presents the resulting matrix of the categories for technology and categories for interaction with technology. Notable are the single cases in *artefacts* and *the process of artefact progression*, which suggest that the self-reported activities describe technology in three ways.

The table shows that the category *application of artefacts* dominates with more than half of all the activities. These activities are often initiated by the preschool teachers. *Using knowledge and skills* and *solutions to problems* are also present. These two categories include activities that are initiated by both the children and the preschool teachers. From a visual point of view, there seems to be a shift from preschool teacher-initiated activities to the left in the table, whereas child-initiated activities are more to the right.

Interaction with technology is through instruction, tinkering and engaging

Regarding the categories for interaction with technology, Table 4 shows that interaction with technology through *instruction* is the most common, with 20 cases in total. In fact, all the self-reported activities concerning *instruction* are preschool teacher initiated. The categories *engaging* and *tinkering* are also represented in the activities and here it is the children who initiate most of the activities. The empty spaces in the matrix indicate that there are no activities in which a child interacts with technology through 'direction'.

The combined categories

When focusing on the results for the single matrix elements, representing the combined categories, we find that the most common combination is *application of artefacts* through *instruction,* which accounts for about one third of all the cases. All these activities are preschool teacher initiated. An example from the transcript of one of the participating preschool teachers that was coded as *application of artefacts* through *instruction* is:

> We have a waste bin like that too… when we change nappies. Now the children are allowed to change their own nappies to practise dressing and undressing. We also have a waste bin that is operated by a foot pedal. The little ones find it really fascinating. They push down with their foot and put their hands on the lid. It doesn't open. [laughs]. That alone is technology.

We understand this activity as follows: the preschool teacher shows the children how the waste bin works by pushing down the pedal (the input) so that the lid opens (output). There is no further use of the waste bin after this demonstration.

Another example is:

> These pictures are from the youngest [the preschool teacher shows pictures from her daily work with the children]. We can look at that, everyday technology. Peeling with a potato-peeler, using scissors, buttoning up. Right here they use these frames, but it is the same as fastening buttons and zipping up their own clothes.

We understand this activity as follows: the preschool teacher shows the children how to use a potato-peeler and a pair of scissors, but nothing more. However, in addition to the *instruction*, the children also *tinker* with the artefacts.

An example of *tinkering* with the *application of artefacts* is when the children study the properties of ferromagnetic materials. A preschool teacher describes the following scenario:

> They [the children] put it [a magnet] on a whiteboard so that it sticks, but they then realise that if they put it in the longitudinal direction it slides down but is still stuck to the board. This has spread to all the children. One child started it, and now everyone has taken their place beside that whiteboard and: "Look here, look here!" Everyone does the same, and that is also technology. They have found different ways of using them. They have put them in different places in the building. "Where do they stick?" [the children ask.]

Notable in Table 4 is Collier-Reed's (2006) *core*. The result shows that eleven, or about a quarter of the self-reported activities are positioned here, with a majority in *engaging*. Activities within the *core* are both teacher and child initiated. The following illustrative examples are described by two different preschool teachers. The first is coded as *tinkering* and *using knowledge and skills to develop artefacts*. A young child is playing on his own:

> He has these old wooden sticks and a mat like that for wiping your feet on. They don't use this entrance. He's made a catapult. He's 1.5–2 years old. He sits and pulls the sticks so that they fly near or far. … How does he do that? He puts them in the holes [in the doormat] and then pulls with his hand and stretches with his foot. …. Here [the preschool teacher shows a picture of the event] it flies up. He did it for a long time and had a lot of fun with it.

In the following example the preschool teacher describes a situation in which a child finds a *solution to a problem* by *engaging* with technology:

> I had a boy who was going to get something [from a shelf], and when [I] asked, "How are you going to reach that?" Instead of me lifting it down … he fetched a chair and then: "Look, this is an aid." That's also technology.

It is reasonable to summarise the results in this study as: technology in the self-reported preschool activities as *the application of artefacts*, *the use of knowledge and skills to develop artefacts* and *solutions to problems* in that order, and that interaction with technology occurs through the categories *instruction*, *tinkering* and *engaging*. Dominating the results are the application of artefacts through *instruction* or *tinkering* and activities in the high complexity corner, the *core*, covering 32 of all 40 cases. Thus, two separate clusters in the matrix form the (qualitative) nature of the children's interactions with technology. One cluster concerns the application of artefacts through different means of interaction and the other cluster is the *core*. There are also apparent differences between these two clusters. In the first it is more common for the preschool teacher to initiate the children's interactions with technology, whereas in the *core* the children themselves initiate most of the interactions with technology.

Discussion

The aim of this study was to investigate what technology teaching includes in authentic preschool settings. In a Swedish perspective an authentic preschool practice is guided by different objectives in accordance with the curriculum (Sheridan and Williams 2018). However, the goals to strive for are vague and leaves the preschool teacher to interpret how to act (Jonsson 2016). Also, a large number of preschools show low teaching quality (Sheridan and Williams 2018). Our results show that the children initiate half of the activities within the *core*, whereas a majority of the activities outside the *core* are initiated by the preschool teachers. We present them as two clusters. Hence, they show two qualitatively different ways of how children interact with technology. The activities outside the *core* appears to be connected to the first goal in the Swedish curriculum for the preschool, which is "*to identify technology in everyday life and explore how simple technology works*". (The Swedish National Agency for Education 2016).

Here, the main content in the children's activities is to explore *the application of artefacts* through *instruction* or *tinkering*. However, if *tinkering* is self-initiated, see Table 2, how is it possible to be teacher-initiated? Concerning *instruction* the preschool teachers show the children how to use artefacts, but the preschool teachers also provide an educational environment. For us, both these ways provide opportunities for children to interact with artefacts in different ways. This strengthens the picture of a practice with activities that are well-planned and conducted (Ehrlin et al. 2015) and the importance of children's own exploration and free play (Campbell and Jobling 2008; Hallström et al.

2015; Hellberg and Elvstrand 2013). Hence, in the self-reported activities there seems to be a balance between preschool teachers inspiring and interesting children in technology and the children's own interests (c.f. Sundqvist 2017). The activities also act as a move from children's *lack of capacity* towards *capacity* (Collier-Reed 2006). It is not uncommon for preschool teachers to, initiate an activity, or for their activities to both inspire and instruct the children to try different applications of artefacts in order to develop *capacity*. There, the preschool teacher selects and supplies materials and artefacts and makes them available for the children to use, hence they provide an environment in which the children can interact with the artefacts by themselves (*tinkering*). However, SSI (The Swedish Schools Inspectorate 2012; The Swedish Schools Inspectorate 2017) has reported that although children are involved in doing technology, nearly no teaching in technology takes place. Such results emphasise the importance of relevant activities. For example, Turja et al. (2009) argue that when creating activities in the preschool it is important to lift them to a level above pottering. Hence, with respect to possible learning, such activities do require the presence of a qualified preschool teacher (cf. Jones et al. 2013; Sheridan and Williams 2018).

However, from a methodological perspective, it is important to discuss the outcomes of these activities. We analysed 40 self-reported activities, with second-hand narratives and did not observe the preschool practice ourselves. The context is the research circle in which the preschool teachers' task was to document activities from their daily practices. The activities were then discussed in order to develop the preschool teachers' own understanding of what technology is and what possible interactions with technology might look like. Hence, documenting the outcome of the activity for the child (i.e. if the child had actually learned something during the activity) was not part of the task and has therefore not been analysed here. This leads to the fact that we cannot analyse the actual learning that takes place (cf. Mawson 2013; Sheridan and Williams 2018; Turja et al. 2009).

The reason for not including learning is due to the design of the research circle and what the representatives for the municipalities themselves had agreed to. This also refers back to research ethics and the municipalities' own legal responsibilities towards the children, which we could not violate. So, even though several activities are within the *core*, the children may not have encountered the concept of technology at all during the activities, or even learned anything with regard to the curriculum goals to strive for (cf. Mawson 2013). So, from a research point of view, the self-reported activities only show that the children are both interested in technology (cf. Elvstrand et al. 2018) and interact with it (Collier-Reed 2006). This second cluster, the *core*, is connected to the second goal in the Swedish curriculum for the preschool: *build, create and construct using different techniques, materials and tools*. It indicates that there is a difference in the interaction with technology that can be traced back to the verbs used in the curriculum. Thus, there is a real opportunity to provide activities that make use of the children's own construction skills and creativity in order to develop an understanding of technology as *knowledge and skills* and *solutions to problems*. In fact, based on our data some preschool teachers do that. Therefore, we maintain that the notion of the *core* is valid in a preschool setting and offers fruitful explanations, although with regard to learning and the theory behind the *core* (e.g. secondary technology education, engineering programmes, being technological literate) we would not want to equate Collier-Reed's *core* with the *core* that we believe exists, or is possible to develop, in the everyday preschool practice.

Even if we find the *core* valid in a preschool setting we have already pointed out one issue with the two sets of categories, namely that *tinkering* and *engaging* may be organised by the teachers, but then the children act within that educational setting. Another issue concerns the goals to strive for and the work-group's report (The Swedish Ministry of Education 2010), and the common Swedish preschool practice. There are technology-related activities falling outside Collier-Reed's analytical framework in which preschool teachers develop young children's language and vocabulary as a possible first step to introducing an artefact (cf. Sundqvist et al. 2018). From a preschool perspective such activities are important and we argue that an interaction does exist between artefact, child and preschool teacher. It is about the *product* without the *using* and the *making*. It is about *labelling* and the child's own interest (cf. Elvstrand et al. 2018) and the child has what Collier-Reed (2006) describes as *ownership*. Thus, we argue that from a preschool perspective, both *using* and *labelling* should be used to describe the children's interactions with artefacts (*product*). Hence, a development of the Collier-Reed framework is needed.

The final issue concerns the absence of the category *direction*. It may be seen as a quality indicator and is in line with the above argument. Collier-Reed (2006, p. 101) describes this kind of interaction as taking place "in a formalised context where pupils are required to respond to the directions of an authority". However, another explanation may be the task which was given to the preschool teachers between the first and second meeting in each circle. In fact, they did search for an authentic practice and they tried their best to find something they could report back to the other participants.

But, if the children show interest in technology, as they often do (Elvstrand et al. 2018), and have *ownership*, it is in line with both the Swedish preschool curriculum (The Swedish Ministry of Education 2010) and the social pedagogic tradition (Bennett 2005) for the preschool teacher to use that input when designing activities. Also, even though the preschool teacher may have their own negative experiences of technology (Elvstrand et al. 2018), which Collier-Reed (2006) emphasises as fear in the definition of the category *direction* (cf. secondary education), this is probably not the first thing a child experiences when encountering a new artefact (cf. Elvstrand et al. 2018). Children, even from young age, seldom *lack the capacity* to interact with technology. Hence, there is a possibility for preschool teachers to encourage the children and help them to interact with technology in more advanced ways. However, from an analytical point of view, as above with *labelling*, there is a possibility to develop Collier-Reed's analytical framework regarding interaction further in order to adapt it to a preschool setting. In fact, if the preschool teacher *labels* artefacts it is a form of *instruction* in order to develop the child's language. Hence, it is about developing *capacity* and, from a qualitative analytical preschool perspective, we argue that *instruction* may be something else than defined by Collier-Reed (2006). Hence, even if it is possible in a high-school/university setting to statistically merge the categories *direction* and *instruction* (Luckay and Collier-Reed 2011), *labelling* is needed to describe what takes place in an authentic preschool practice. Hence, the definitions of the categories *direction, instruction* and *labelling* are useful in a preschool setting. However, in order to take the discussion further additional data from the authentic preschool practice are necessary.

Conclusions and implications

We conclude that the category system developed by Collier-Reed (2006) can be used in a preschool setting, but that from a preschool perspective a refinement would facilitate covering the common *labelling* made by the preschool teachers.

The self-reported technology related activities are both teacher and child initiated and fall into two main clusters. The first cluster appears to be connected to the first goal in the Swedish preschool curriculum, which is "to identify technology in everyday life and explore how simple technology works". Here, the main content in the children's activities is to explore *the application of artefacts* through *instruction* or *tinkering*. The second cluster is connected to the second goal in the Swedish preschool curriculum: *build, create and construct using different techniques, materials and tools*. Hence, there is a difference in the interaction with technology that can be traced back to the verbs used in the curriculum. In the presence of a qualified preschool teacher, there is a real opportunity to provide activities that make use of the children's own construction skills and creativity in order to develop an understanding of technology as *knowledge and skills* and *solutions to problems*.

Opportunities for further research open up if we emphasise the *core* in the everyday preschool practice and develop a picture of what technology teaching in preschool is. More authentic activities focusing on both what the preschool teachers do, how the children interact with technology and what they learn are important features to cover. This is in fact necessary in order to understand the directive to teach Swedish children technology in order to achieve the curriculum goals. The work-group's report (The Swedish Ministry of Education 2010) provides guidance for preschool teachers, but if we want the children to be involved in activities within the *core*, we also need to know how they are organised. This is a concern that Sheridan and Williams (2018) also address. What should preschool teachers do in order to provide well-planned activities and at the same time identify and stimulate children's own explorations and free play?

Acknowledgements Open access funding provided by Mälardalen University.

References

Anderson, G. L., & Herr, K. (1999). The new paradigm wars: Is there room for rigorous practioner knowledge in schools and universities? *Educational Researcher, 28*(5), 12–21.

Andersson, F. (2007). *Att utmana erfarenheter. Kunskapsutveckling i en forskningscirkel. [To challenge experiences. Knowledge development in a research circle]*. Stockholm: Lärarhögskolan.

Bairaktarova, D., Evangelou, D., Bagiati, A., & Brophy, S. (2011). Early engineering in young children's exploratory play with tangible materials. *Children Youth and Environments, 21*(2), 212–235.

Bennett, J. (2005). Curriculum issues in national policy-making. *European Early Childhood Education Research Journal, 13*(2), 5–23.

Benson, C., & Treleven, T. (2011). Designerly thinking in the foundation stage. In C. Benson & J. Lunt (Eds.), *International handbook of primary technology education: Reviewing the past twenty years* (pp. 137–150). Rotterdam: Sense Publishers.

Broström, S. (2017). A dynamic learning concept in early years' education: A possible way to prevent schoolification. *International Journal of Early Years Education, 25*(1), 3–15.

Campbell, C., & Jobling, W. (Eds.). (2008). *Technology education in early childhood settings* (Vol. 1). Brisbane: Centre for Learning Research, Griffith University.

Collier-Reed, B. I. (2006). *Pupils' experiences of technology: Exploring dimensions of technological literacy.* Ph.D. thesis, University of Cape Town, Cape Town.

Collier-Reed, B. I., Case, J. M., & Linder, C. (2009). The experience of interacting with technological artefacts. *European Journal of Engineering Education, 34*(4), 295–303. https://doi.org/10.1080/03043790902987352.

de Vries, M. J. (2016). *Teaching about technology: An introduction to the philosophy of technology for non-philosophers* (2nd ed.). Cham: Springer.

Ehrlin, A., Insulander, E., & Sandberg, A. (2015). Natural science and technology: Interpretations of entrepreneurial learning in early years of education. *International Journal of Infonomics, 1*(1), 2–5.

Elvstrand, H., Hallström, J., & Hellberg, K. (2018). Vad är teknik? Pedagogers uppfattningar om och erfarenheter av teknik och teknikundervisning i förskolan. [What is technology? Preschool teachers' conceptions and experiences of technology and technology education in the preschool]. *Nordic Studies in Science Education, 14*(1), 37–53.

Hallström, J., Elvstrand, H., & Hellberg, K. (2015). Gender and technology in free play in Swedish early childhood education. *International Journal of Technology and Design Education, 25,* 137–149.

Hellberg, K., & Elvstrand, H. (2013). Pedagogers tankar om teknik i förskolan [Pedagogues thoughts on technology in preschool]. Retrieved August 6, 2019 from https://old.liu.se/uv/lararrummet/venue/pedagogers-tankar-om-teknik-i-forskolan?l=sv.

Ingerman, Å., & Collier-Reed, B. I. (2011). Tecnological literacy reconsidered: A model for enactment. *International Journal of Technology and Design Education, 21,* 137–148. https://doi.org/10.1007/s10798-009-9108-6.

Jones, A., Buntting, C., & de Vries, M. J. (2013). The developing field of technology education: A review to look forward. *International Journal of Technology and Design Education, 23*(2), 191–212.

Jonsson, A. (2016). Förskollärares kommunikation med de yngsta barnen i förskolan: med fokus på kvalitativa skillnader i hur ett innehåll kommuniceras. [Preschool teachers' communication with the youngest children in preschool: With focus of qualitative differences in how a content is communicated]. *Tidsskrift for Nordisk Barnehageforskning, 12*(1), 1–16. https://doi.org/10.7577/nbf.1232.

Jonsson, A., Williams, P., & Pramling Samuelsson, I. (2017). Undervisningsbegreppet och dess innebörder uttryckta av förskolans lärare [The concept of teaching and its meaning expressed by preschool teachers]. *Forskning om undervisning och lärande, 5*(1), 90–109.

Klasander, C. (2010). *Talet om tekniska system [Speaking of technological systems].* Ph.D. thesis, Linköping University, Department of Social and Welfare Studies, Norrköping, Sweden.

Luckay, M. B., & Collier-Reed, B. I. (2011). *The development and validation of an instrument—The technological profile inventory—To determine students' levels of technological literacy in South Africa*. Paper presented at the 4th international conference of education, research and innovation, Madrid, Spain (pp. 764–772).

Luckay, M. B., & Collier-Reed, B. I. (2012). Comparing the technological literacy of pre-service teachers and secondary school students in South Africa. In *Proceedings of EDULEARN12 conference,s* 2nd–4th July 2012, Barcelona, Spain.

Mawson, W. B. (2013). Emergent technological literacy: What do children bring to school? *International Journal of Technology and Design Education, 23*(2), 443–453. https://doi.org/10.1007/s10798-011-9188-y.

McKenney, S., & Reeves, T. C. (2012). *Conducting educational design research*. New York: Routledge.

Nilsson, T., Sundqvist, P., & Gustafsson, P. (2016). A pilot study of the technological literacy among primary school teachers in Sweden. Paper presented at the PATT-32: Technology education for 21st century skills, Utrecht, The Netherlands.

Öqvist, A., & Högström, P. (2018). Don't ask me why: Preschool teachers' knowledge in technology as a determinant of leadership behavior. *Journal of Technology Education, 29*(2), 4–19.

Rohaan, E. J., Taconis, R., & Jochems, W. M. G. (2008). Reviewing the relations between teachers' knowledge and pupils' attitude in the field of primary technology education. *International Journal of Technology and Design Education, 20*(1), 15–26.

Sheridan, S., & Williams, P. (Eds.). (2018). *Undervisning i förskolan. En kunskapsöversikt. [Teaching in preschool. A review]*. Stockholm: Skolverket.

Storfors, T. (2014). Hur bildad är jag? Om att balansera vetenskaplig grund och beprövad erfarenhet i en forskningscirkel. [How educated am I? About balancing scientific basis and proven experience in a research circle]. In P. Lahdenperä (Ed.), *Forskningscirkeln - en mötesplats för samproduktion* (pp. 27–42). Eskilstuna/Västerås: Mälardalens högskola.

Stringer, E. T. (2014). *Action research* (4th ed.). Los Angeles: SAGE Publications Inc.

Sundqvist, P. (2016). Teknik i förskolan är inte något nytt, men idag är vi mer medvetna om vad vi kallar teknik - Personalens beskrivningar av teknik som innehållsområde i förskolan. [Technology in preschool is not new, but today we are more aware of what we call technology: The staff's descriptions of technology as content area in preschool] (Licentiate), Mälardalen University, Västerås. (Mälardalen University Press Licentiate Theses: 233).

Sundqvist , P. (2017). Challenges of teaching technology in preschool. Paper presented at the TENZ-ICTE conference. Technology: An holistic approach to education, Christchurch, New Zealand.

Sundqvist, P., Nilsson, T., & Gustafsson, P. (2018). Is there a gap to mind in preschool practice when it comes to technology? Paper presented at the IOSTE XVIII, the international symposium on science and technology education for future educational challenges from science and technology perspectives, Malmö, Sweden.

The Swedish Ministry of Education. (2010). *Förskola i utveckling - bakgrund till ändringar i förskolans läroplan. [Preschool in development - background to changes in preschool curriculum.]*. Stockholm: Utbildningsdepertementet.

The Swedish National Agency for Education. (2016). *Förordning (SKOLFS 1998:16) om läroplan för förskolan. Reviderad 2010 och 2016. [Ordinance about the curriculum for preschool. Reviced in 2010 and 2016.]*.

The Swedish National Agency for Education. (2018). *Förordning (SKOLFS 2018:50) om läroplan för förskolan. [Ordinance about the curriculum for preschool]*.

The Swedish Research Council. (2017). *God forskningssed [Good ethical research practice]* (Vol. VR1708). Stockholm: Vetenskapsrådet.

The Swedish Schools Inspectorate. (2012). *Förskola, före skola - lärande och bärande. Kvalitetsgranskningsrapport om förskolans arbete med det förstärkta pedagogiska uppdraget.* [*Preschool, pre School - Learning and Bearing. Quality Review Report on the Preschool's Work with the Enhanced Educational Assignment*]. Retrieved December 5, 2018 from https://www.skolinspektionen.se/sv/Beslut-och-rapporter/Publikationer/Granskningsrapport/Kvalitetsgranskning/Forskola-fore-skola—larande-och-barande/.

The Swedish Schools Inspectorate. (2017). *Förskolans arbete med matematik, naturvetenskap och teknik. [Preschool's work with mathematics, natural science and technology]*. Retrieved December 5, 2018 from https://www.skolinspektionen.se/sv/Beslut-och-rapporter/Publikationer/Granskningsrapport/Kvalitetsgranskning/forskolans-arbete-med-matematik-teknik-och-naturvetenskap/.

Thorshag, K., & Holmqvist, M. (2018). Pre-school children's expressed technological volition during construction play. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-018-9481-0.

Turja, L., Endepohls-Ulpe, M., & Chatoney, M. (2009). A conceptual framework for developing the curriculum and delivery of technology education in early childhood. *International Journal of Technology and Design Education, 19,* 353–365.

Vallberg Roth, A.-C. (2018). What may characterise teaching in preschool? The written descriptions of swedish preschool teachers and managers in 2016. *Scandinavian Journal of Educational Research*. https://doi.org/10.1080/00313831.2018.1479301.

Van Laere, K., Vandenbroeck, M., Roets, G., & Peeters, J. (2014). Challenging the feminisation of the workforce: Rethinking the mind–body dualism in early childhood education and care. *Gender and Education, 26*(3), 232–245.