Cultural meetings? Curricula, Digital Apps and Mathematics Education

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Abstract

In this paper, we explore whether two digital apps used by young children in a Norwegian kindergarten fulfil the requirements set out in the Norwegian curriculum for early childhood. The Norwegian kindergarten culture is based on a social policy pedagogical approach which in recent years has been under pressure by politicians to move towards a readiness for school approach. Using artefact-centric activity theory, we were able to identify how the apps and their use by young children were likely to contribute to the continuation of the established Norwegian kindergarten culture or was likely to support changes to this culture.

Keywords: Norwegian kindergarten culture, mathematical apps, social pedagogical approach, readiness for school approach, artefact-centric activity theory

Introduction

Thirty years ago, Alan Bishop (1990) argued that Western mathematics was a force of cultural imperialism, in that the mathematics of Indigenous cultures were often disregarded in the education system. Inspired by this perspective in this paper, we consider how school mathematics may also come to be a force of cultural imperialism in Norwegian early childhood institutions, known as kindergartens, through the use of digital apps. Although mathematics is recognisable as one of the seven learning areas in the Norwegian curriculum (Ministry of Education, 2017), *Quantities, spaces and shapes*, this learning area is based on Bishop's (1988) six universal mathematical activities (Reikerås, 2008). Consequently, the mathematics in the curriculum is not inspired by school mathematics, although there are some overlaps with it. However, our concern is that the use of artefacts, such as digital apps, that are based on understandings about what is valued in schools could alter what comes to be seen as mathematics in kindergarten and the ways that children should engage with it. This could have long-term implications for what occurs more generally in kindergartens, in a similar way to how Western mathematics has affected what has come to be valued as mathematics in Indigenous and non-Western societies (Bishop, 1990).

Although Norwegian kindergarten attendance is voluntary, 97 % of all children, aged one to six years, attend before they start school (SSB, 2020). Thus, changes to kindergarten traditions have wider implications for Norwegian society. Norwegian kindergartens have a strong focus on play and are considered as being firmly rooted in the social policy pedagogy tradition (Otterstad & Braathe, 2010). The social pedagogy tradition was first described by Bennett (2005) and referred to early childhood institutions where "the pedagogical project is firmly play-based, with much movement, choice and child autonomy in evidence" (p. 11). In contrast to this early childhood tradition is the readiness for school tradition which has more focus on cognitive goals that are deemed necessary for success at school. Activities in this tradition are more-often teacher-led and -controlled.

In recent times, the Norwegian kindergarten field has been under political pressure to provide more specific learning, described as a way to diminish social differences (Jensen, 2009; Zambrana et al., 2020). This has pushed the kindergarten field towards the school readiness tradition (Lange, 2019). Although this push is evident in many recent policy documents that mention mathematics (Fosse et al., 2018), in the current curriculum document, known as the Framework Plan, play retains a key role (Ministry of Education, 2017, p. 20). This has resonance with the stronger emphasis on problem solving in *Quantities, spaces and shapes*, "The learning area shall stimulate the children's sense of wonder, curiosity and motivation for problem-solving" (p. 53).

As well as *Quantities, spaces and shapes*, the Framework Plan has six other learning areas, one of which is *Communication, language and text*. It also emphasises children's control over their learning, "By engaging with this learning area [communication language and text], kindergartens shall enable the children to explore and develop their language comprehension, their linguistic competence and a multitude of different forms of communication" (Ministry of Education, 2017, p. 47). Consequently, despite the ongoing push for more formalised learning in the kindergarten (see Zambrana et al., 2020), children are expected to learn through play, stimulating curiosity and exploration and allowing them to make decisions for themselves including about what problems they want to solve.

One change from previous kindergarten curricula (Alvestad, & Jernes, 2014) is a requirement that digital practices be included as a working method, "Digital practices shall contribute to a rich and varied learning environment and encourage children to play, be creative and learn" (Ministry of Education, 2017, p. 44). Previously, digital practices could be included but were not required experiences for children.

Although the current Framework Plan is a continuation of a kindergarten culture based on the social policy pedagogy tradition (Bennett, 2005), other policy documents that discuss mathematics show a movement towards a readiness for school approach (Fosse, et al., 2018). When mathematical digital games, based on a readiness for school tradition are used in Norwegian kindergartens, there is a risk that children's possibilities to learn mathematics through play, exploration and curiosity are reduced. In this paper, we consider whether young children's engagement with two digital games is in alignment with the current Norwegian kindergarten culture. Our research question is: How might children's mathematical engagement with apps support the continuation of or lead to changes to the Norwegian kindergarten culture?

Mathematical Apps and Approaches to Early Childhood Education

Young children's interactions with mathematical apps are well documented (see for example, Aladé et al., 2016; Papadakis, Kalogiannakis, & Zaranis, 2018). Yet, evaluations of mathematical apps rarely take into consideration cultural differences (Veraksa et al., 2020 forthcoming). This is partly to do with most mathematics education research on apps for young children originating from countries who value the readiness-for-school tradition.

In research on mathematical apps for young children, visuospatial reasoning skills and numeracy are often the focus of attention. Both topics would be in alignment with the Framework Plan's focus on *quantities, spaces and shapes*, as numeracy is part of quantities, while visuospatial reasoning is part of understandings to do with space and shapes (Owens, 2015). The focus on visuospatial reasoning is often related to what is required to make sense of the artefact. Learning, therefore, comes from engaging with the app, rather than the app being designed specifically to "teach" visuospatial reasoning. For example, Lowrie (2015) noted that digital games require children as young as five to use complex visuospatial reasoning skills similar to those needed for functioning outside of the classroom. Lowrie (2015) described visuospatial reasoning skills as highly valuable which needed to be explicitly recognised as part of what children know and can do with mathematics. Research indicated that playing digital games provided better opportunities for young children to gain these skills than traditional teaching (Lowrie, 2015; Lee et al., 2018).

Valuable mathematics in early childhood is often equated with number understandings in research on digital games (see for example, Baccaglini-Frank & Maracci, 2015; Tucker et al., 2017; Papadakis et al., 2018; Veraksa, et al., 2020 forthcoming). In commercially available Greek apps, Papadakis et al. (2018) found that most focused children on number recognition tasks that did not lead them towards higher-order thinking skills and so was of lower value for children to learn. This may be the case because it is easier to focus on number recognition than to provide games that used number understandings in problem solving situations. Nevertheless, as with the focus on visuospatial reasoning, the need for children to engage in apps about numeracy topics is positioned as being important for future school learning.

As well as content, apps are designed around a pedagogical approach. Birklein and Steinweg (2018) identify a range of pedagogical approaches for how young children are expected to engage with mathematical content through apps. These included: programme learning where all children are expected to work through highly structure material in the same way; and the use of everyday life and play which is seen as promoting communication and problem solving. Their app was said to be designed on the latter approach. However, in the examples that they provided from their app, the children were expected to solve problems in a particular way indicating that children needed to gain a specific answer, similar to how a school textbook would introduce and consolidate mathematics learning (see Shield & Doyle, 2013).

Yet, in discussions about evaluating apps, the need to respect a social policy pedagogy approach to early childhood in regard to content or pedagogical approaches has not been discussed (Veraksa et al., 2020 forthcoming). Rather mathematics education research seems to have accepted the need for a readiness for school approach as appropriate for the design of the digital apps, by focusing on how specific information is taught through the app.

Artifact-Centric Activity Theory

To better understand how digital apps could be associated with the Norwegian kindergarten culture, we chose to use artifact-centric activity theory (ACAT) for our analysis, because the apps are in the centre of this theory. ACAT was developed by Ladel and Kortenkamp (2011) in relationship to designing digital resources. In it, the artefact (the digital app) is in the centre and interacts with four components; subject, group, rules and object. The theory indicates how the interaction between the subject–the child–and the object–the mathematics– is mediated by the artefact–the digital game, through a series of internalisation and externalisation processes (see Figure 1). Using ACAT theory, it is possible to determine how the app design influences the children's mathematical engagement and with that information discuss whether this engagement is in alignment with Norwegian kindergarten traditions as outlined in the Framework Plan or whether by showing that children have a different kind of mathematical engagement, the cultural traditions may be being altered.

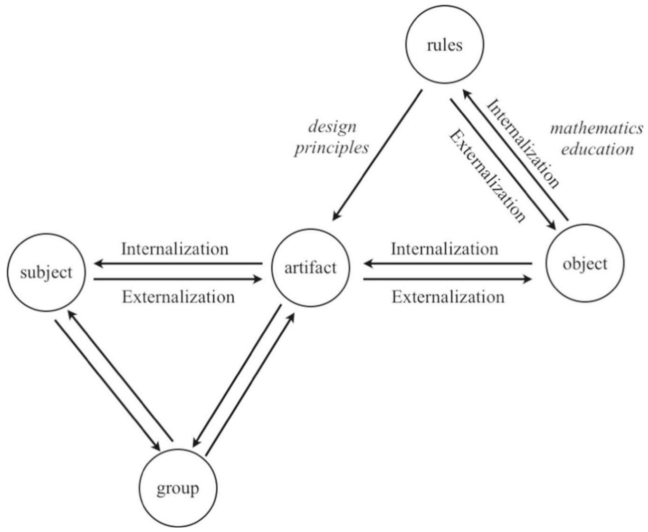


Figure 1: The ACAT framework from Ladel & Kortenkamp, (2011, p. 66).

The choice of mathematical content is internalised into the app, which is then externalised by what is shown on the screens. Based on what is known about mathematics education, the rules, in the top right triangle, which govern the possible actions for engaging with the object, in this case the chosen mathematics, determine the design principles of the app. In this way, the rules internalise the pedagogical approach into the app and externalise the mathematical content through the choice of actions in the app for engaging with the mathematics. For example, the rules, based on the pedagogical approach, determine whether and in what ways feedback is provided by the digital app (the artefact). The possibilities for feedback are incorporated into the design principles.

The subject is the child who engages with the mathematical content through interactions with the artefact. This engagement leads to an internalisation of the mathematical content, by what is made available through the app. The child's actions and speech externalises their understandings of the mathematical content through their engagements with the app. The group, in the lower left triangle, indicates that a subject does not interact in a void with an artefact, but that there are expectations about how the artefact could or should support an individual to be part of a social group. For example, the artefact could influence how a child interacts with a teacher while engaging with the app.

Thus, ACAT provides a way of understanding the complex interactions that contribute to teaching and learning of the object by the subject and from this we can determine whether or not these interactions were in alignment with the existing Norwegian kindergarten culture.

Methodology

The data come from a wider research project in which we are identifying how children mathematically engage with different types of apps, particular to identify those apps that are likely to support young multilingual children to develop their mathematical languages. It became clear in this wider study that the design principles of the apps did not always contribute to children wanting to talk about what they were doing and this made us wonder whether some commonly used apps in kindergartens may in fact be undermining the kindergarten culture, outlined in to the Framework Plan (Ministry of Education, 2017).

We consequently decided to analyse in this paper two apps which provided examples of the extreme ends of what could be considered a continuum of how children mathematically engaged with the apps. The two apps were Tella (https://www.statped.no/laringsressurs/sammensatte-larevansker/Tella---Mattespill-for-de-minste/) and the Kitchen app made by Toca Boca (https://tocaboca.com/app/toca-kitchen/). According to the website for Tella, it is designed for children aged 5-8, but could suit children who are older or younger. It can be used in special needs teaching as well as general teaching and the children are supposed to learn through playing with numbers and fun figures (Hoem, 2014).

In the Toca Boca Kitchen app, the children can prepare and serve food to either a boy, a girl, or a monster. According to the designers of the app, it is meant to be a digital toy that should capture the power of play (Toca Boca, 2020). Every option is available from the start in the sense that you do not have to play through the app to unlock anything. However, though exploring within the app the children find new possible actions and they create their own problems to solve. Toca Boca Kitchen is not labelled as a mathematical app and although the designers do not identify the mathematical object, it is clear from the videos in our wider data set that the pedagogical aspects of the app include creativity, exploration and problem-solving.

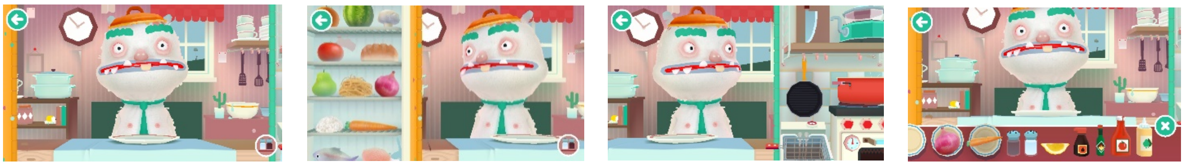


Figure 2: Screenshots from Toca Boca Kitchen

Figure 2 has a series of screen shots from this app (picture 1). The second picture shows the food options in the fridge which can be opened, by dragging the yellow "door" to the right. In the third picture, the different cooking options are shown which become available when the green "door" is dragged to the left. The final picture shows the flavouring options which are available when the "table" is dragged upwards.

Data Collection

Six hours of interactions with digital games were video-recorded at one kindergarten in a large city in Norway, over two months. The data used in this article is a transcript of the first five minutes of a recording, where three children, who each had a tablet, played with two different apps. Although quite short, the clip is typical for how each of the apps were used by children in the wider research. The project was given ethical approval by the Norwegian Centre of Research Data. The parents of the children at the kindergarten were informed at a meeting about the project and provided written consent. The children, whose parents had given approval, were filmed only when they appeared comfortable with this.

In these examples, the three children involved were: Child1, a 5-year-old boy with a multilingual background, who used Norwegian to communicate with his friends in the kindergarten; Child2, also a 5-year-old boy with a multilingual background, who used Norwegian to communicate with his friends in the kindergarten; and Child3 who was a 4.5-year-old girl, who spoke Norwegian in the kindergarten and at home.

The three children were in the kindergarten's library, a room filled with books on shelves and mattresses and pillows on the floor. The children turned the lights off because it was "more secret". The two boys were sitting on mattresses next to each other and the girl was lying on the floor. They each had their own tablet and were free to choose what they wanted to do with it. Installed on the tablets were a wide range of apps to choose from. Two children opened Toca Boca Kitchen and one child opened Tella.

Data Analysis

As ACAT had not previously been used to analyse naturally-occurring situations in which children use commercially-available apps, initially both authors watched the videos and read the transcripts through carefully. From this close reading, it was decided that an analysis that focused on the individual nodes would be too detailed and not provide a clear overview for answering our research question. We, therefore, chose to focus on the two triangles, rules–object–artifact and subject–artefact–group, particularly on the internalisation/externalisation identified in the interactions between the app and the child(ren).

Results and analysis

In this section, we first introduce the transcripts before analysing them, using ACAT. In the transcripts actions are described in brackets (). In the final section of the paper, we provide a discussion and conclusion where we discuss how the analysis informs our research question.

Transcript: Tella

Child1: "Is it fun, Child3? Child3, is it fun?"

Child3: "Yes."

The game presented Child3 with a picture of a small and a big sun and a voice said, "press the largest one". She pressed the largest sun and virtual confetti and a short sound signalled that she answered correctly. Then the picture on the tablet changed to two foxes and the voice repeated "press the largest one". She solved the task and the confetti and sound occurred again,

before the picture changed to two bees, and then to three suns, with the same requirement and feedback. The tablet then presented three flowers and then four flowers.

Child3: "I have to press the largest one."

(She went through a few more tasks where she pressed the largest image).

"I have to press the largest one."

(The app changed to giving tasks where she should press the smallest one).

"This is fun. It's fun. It's fun. First I had to press the biggest one."

"It's fun. Very fun. It's fun."

Analysis: Rules – Object – Artifact

The rules–object–artifact triangle in ACAT focuses on the choice of mathematics that young children should engage with and how it should be presented to them or taught, through the internalisation of the rules in the app. In this interaction, the tasks on the app channelled

Child3 into determining the largest or the smallest, indicating that this was the valuable mathematics that the child was expected to gain. The externalisation of the rules can be seen in the presentation of a series of small tasks, that the child needed to solve them in a set order. This suggests that the design principles were based on the understanding that mathematics should be learnt linearly, moving from simple to more complex tasks. Biggest and smallest were treated as two separate concepts and there was no attempt to support the children using the app to see how they were related. If it was a focus it was an implicit one.

The congratulatory confetti and music suggested that the child needed external feedback to mark getting the correct answer. As the next task did not become available until the child produced the correct answer, it seemed that the confetti and music were specifically so that the importance of the correct answer was noted.

Analysis: Subject– Artifact–Group

The artefact internalised the object (an understanding of "bigger") by providing a series of tasks for the child (subject) that showed pairs or small groups of objects and by asking her to "press the largest one". The child's utterances, "it is fun" and "First I had to press the largest one" as well as her actions showed her externalisation of the understanding about what was the largest object.

In the Tella example, there is little interaction between the Child3 (subject) and the group. The only interaction that occurred was when Child1 asked Child3 two times if it was fun and she answered "yes". It was not clear whether her later utterances were said to the group, to the researcher who was also present in the room or if she was talking to herself. As no one responded to these utterances, it did not seem that the app was supporting her engagement with the group.

Transcript: Toca Boca Kitchen

Child1: "Take this one, right?" (Opens up Toca Boca Kitchen).

Child2: (Opens up Toca Boca Kitchen as well.)

"He says whombaa." (refers to the sound that came when the app was opened).

(Using a virtual knife, Child2 began to slice a virtual piece of fruit into small pieces. Each time he sliced it, the fruit bounced on the chopping board and small parts of it fell off. He kept slicing until nothing was left.)

"Ok, now I don't have any left."

(Child2 threw a piece of fruit in the air and tried to slice it before it landed on the board, but failed.)

"Why can't we do that?"

Child1: "What thinking?"

Child2: "Oh yes, I need to slice them in two?"

(He sliced the fruit while it was on the chopping board.)

Child1: (Finds some food in the fridge.)

"Oh, this is so gross."

Child2: "What is gross?"

Child1: "Is this nuts?"

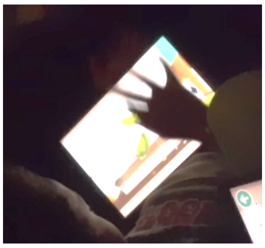
Child2: "I don't know."

(Both children found meat and as they sliced it, the app made chopping sounds. The children continued to slice until everything had fallen off the board.)

Child1: "I took it off."

Child2: "Hey, it made the same sound. And now I am all out of meat."

Child1: "Hey, C2, C2. Andy (another child in the kindergarten) taught me this. Can I show you? You do like this, see."



(Child1 used his finger to throw the banana into the air and then used his finger again to try to slice it by moving his finger many times across the tablet very fast, before it hit the chopping board, but failed to slice it.)

Child2: "You throw it and…"

(Child2 waved his hand in the air, using the same slicing movement with his finger.)

Child1: "Yes, we learnt this. He likes sandwiches. And now I will make a sandwich."

(Child1 threw cheese and sliced it before it hit the chopping board.)

"I am so skilled at this. I made it."

(He fed the monster, which ate the food, paused and then stuck its tongue out.)

"He liked it. He liked it. He liked all of this."

Analysis: Rules – Object – Artifact

The analysis of the rules – object – artifact triangle for Toca Boca Kitchen looks different. Problem solving, as highlighted in the Norwegian Framework Plan (Ministry of Education, 2017) could be considered the object, although the children also could be seen learning about visuospatial reasoning and quantities from interacting with the app. To support children to learn about problem solving, Toca Boca provided a virtual kitchen with a monster (or child) who indicated that they wanted to be feed. There were no set tasks, so the children had to decide what they would do in this virtual environment. In many cases, as in the example, above, the children posed their own problems before trying to solve them. Problem posing and problem solving have been highlighted as important components of mathematics for young children (Fosse et al., 2020).

These focus on problem posing and problem solving are externalised in the design of the app through the provision of food, ways of cooking and flavouring, being always available, with no need to play in order to unlock new options. The app included small hints, such as the monster pausing before it reacted to the food and the food bouncing on the chopping board. These hints provided opportunities for the children to find other actions which could change the monster's reaction to the food or slicing the food in other places apart from the chopping board. This seemed to encourage children's curiosity and creativeness.

In regard to understandings about measurement and visuospatial reasoning, the app provided opportunities for the children to explore different possibilities, which required these mathematical understandings. For example, the amount of time the children had before the food hit the chopping board was influenced by how high they threw the food. If they threw it too high or in an uncontrolled manner it was harder for them to guess where it might fall and they would not be able to slice it.

The object (problem solving) was internalized in the artefact through the incorporation of design principles that invited the children to explore different situations. The app design suggested that it was important for children to pose and solve their own problems.

Analysis: Subject- Artifact -Group

The understandings about problem solving are reflected into the artefact through the design and it was from engaging with the artefact that these understandings could be internalised by the children. This could be seen in their verbal interactions as well as their physical actions on the tablet. The children externalized their understandings about problem solving by engaging with the visible possibilities, such as locating the different foods and ways of cooking, and the invisible possibilities, such as being able to throw food in the air and cut it before it hit the plate, sometimes by following up on hints that suggested that other actions were possible. The virtual kitchen supported the children to pose questions, such as "why can't we do that?" and to try different approaches to slicing food while it was in the air. By doing this, the children gained experiences with problem solving and they learnt that trying different actions on aspects of the app could produce different outcomes or responses, for example, from the monster. This feedback was not an indication of whether they got the "right" answer, but was dependent on their actions (for instance the monster liking or disliking the food that they "fed" it), they could then adjust their actions to gain a different outcome.

In this example, the kind of problems the children choose to explore (externalization), such as ways to slice the food, required the children to use visuospatial reasoning skills as well as measuring. The measuring can be seen in the type of language they use, such as "slice them in two", "I don't have anything left" and "I am all out of…". The problem about how much time they needed to slice the food in two before the food hit the chopping board also required them to engage in estimations of time.

The design of the Toca Boca Kitchen app also supported the two children to interact. Although they worked on their own tablets, the children were exploring aspects of the app in parallel, suggesting that the group aspects of ACAT were much more in evidence. Children verbalised what they were doing in most of the recorded interactions connected to this app, suggesting that it was something that the app itself was contributing to. In this example, the co-exploration by the two children led to verbal and physical interactions. They also referred to other children in the kindergarten, one of whom had shown them how to throw the food in the air and slice it into two pieces. Potentially, by being supported to play together, the children could internalise that problem solving could be done with others. By engaging in verbal conversation, they could also have gained an awareness of how their understandings about problem solving and visuospatial reasoning increased by externalizing their ideas.

Discussion and Conclusion

Our research question was: How might children's mathematical engagement with apps support the continuation of or lead to changes to the Norwegian kindergarten culture? Using ACAT to analysis the examples provided insights, into how the different nodes in the two triangles were connected and contributed to the types of mathematical engagement the children experiences.

Both the apps, Tella and Toca Boca Kitchen provided the children with mathematical experiences valued in the Norwegian Framework Plan (Ministry of Education, 2017), quantity and problem solving respectively. However, the analysis shows how those were quite different in regard to how the mathematical topics were presented and how the children were expected to interact with the apps. Although not marketed as a mathematical app, Toca Boca Kitchen, provided problem posing and problem solving learning possibilities which encouraged children to be curious and creative while learning through play. Consequently, it can be considered more in line with the Norwegian kindergarten culture, as it exemplifies many of the qualities of the social policy pedagogy approach (Bennet, 2005).

On the other hand, Tella, which is marketed as a Norwegian-designed app for the learning of mathematics in kindergartens, might contribute a change in the kindergarten culture, alongside other influences (Fosse et al., 2018). This is because the way that understandings about quantities are presented and engaged with by the child were more in alignment with the readiness for school approach (Bennett, 2005).

Tella presents the mathematical ideas in a linear progression with an expectation that the child will complete each small task correctly. The child was effectively "taught" by the app, the valuable knowledge needed for school. This would be an example of programmed learning as described by Birklein and Steinweg (2018). As such there were limited possibilities in Tella for these digital practices to "encourage children to play, be creative and learn" (Ministry of Education, 2017, p. 44). The learning, at least for Child3, seemed limited as she completed all the tasks correctly and so, perhaps, already knew what was meant by "larger" and "smaller". Almost all of the other children in the data set showed similar engagements with the app, suggesting that they also knew what "larger" and "smaller" meant in this context. Although Tella describes itself as an app that children play (Hoem, 2014), it is unclear what possibilities there were to play given that the tasks were set and the children had to identify the one correct answer. As was noted by Papdakis et al. (2018) in relationship to Greek numeracy apps, playing Tella seemed unlikely to lead to higher-order thinking. Similarly, it did not appear that Tella was likely to “stimulate the children’s sense of wonder, curiosity and motivation for problem-solving” (p. 53) which was a component of *Quantity, space and shape* as set out in the Framework Plan. Although Child3 described the game as fun, it seemed that it was the appearance of the confetti and music which made the game fun, not the actual engagement with the tasks. The limited verbalisation connected to engaging with Tella also meant that it was unlikely that it would support children to “to explore and develop their language comprehension, their linguistic competence and a multitude of different forms of communication” (p. 47). Tella’s clear focus on learning through teaching, rather than exploration and play, suggests that this app is more in alignment with the readiness for school approach.

In contrast, the openness of the virtual environment in Toca Boca Kitchen allowed the children to be creative when posing and solving problems. The children solved problems that they had learnt about from others and they used language, connected to cooking, slicing and throwing, suggesting the cooking environment was familiar. The children used language to explain what they were doing with the app. There was only one utterance, “what thinking” which was not clear and it did not inhibit the communication between the children. This suggests that the app provided learning possibilities connected not just to *Quantities, spaces and shapes,* but also to *Communication, language and text* (Ministry of Education, 2017).

Through using problem solving skills and trying out different options, the children improved their visuospatial reasoning skills as they moved from not being able to slice the food before it landed on the chopping board to finally being able to do so. They did this by determining how high they should throw the food and from which angle they should slice it. This app utilised the possibilities that a virtual environment provided for developing visuospatial reasoning skills (Lowrie, 2015), but in a way that encouraged experimentation.

In regard to the Framework Plan, the app can be considered as fulfilling the requirements for digital practices to "encourage children to play, be creative and learn" (Ministry of Education, 2017, p. 44) as well as "stimulate the children's sense of wonder, curiosity and motivation for problem-solving" (p. 53). This suggests that the app was in alignment with the social policy pedagogy approach (Bennett, 2005) because it focused on broad developmental goals and its use, in Norwegian kindergartens, was likely to support the continuation of this approach.

Our analysis using ACAT was only of two short interactions with two apps. However, the analysis clearly shows that the design of apps have the potential to shape children's interaction with mathematical ideas. In relationship to the Norwegian kindergarten culture, as represented in the Framework Plan (Ministry of Education, 2017), this shaping of mathematical engagement, when combined with other forces pushing towards change (Lange, 2019) could contribute to changes to kindergarten culture. Researching the impact of mathematical apps, designed within the readiness-for-school approach, on the Norwegian culture is important if unintended consequences are to be avoided. All cultural institutions, including early childhood ones, change over time. However, shifting towards the use of apps that "teach" children mathematical understandings through completing a set of linear tasks may have the unintended consequences of reducing the possibilities for children to learn about problem solving, is in itself highly valued in school curricula.

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