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Multilingual Children's Mathematical Engagement with Apps: What Can Be Learned from Multilingual Children's Mathematical and Playful Participation when Interacting with Two Different Apps?

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Abstract The use of digital tools is becoming increasingly common in early childhood education. One key to using digital tools to enhance learning in children may lie in using them the way children tend to when given the choice: as play. This article examines and evaluates multilingual children's mathematical engagement with digital apps, focusing specifically on what might be learned from multilingual children's mathematical and playful participation when interacting with two different apps. Mathematical engagement is here defined by Alan Bishop's six mathematical activities: counting, measuring, locating, designing, playing and explaining. Helenius et al.'s elaboration of mathematical play is used to connect the mathematical play to the play of children. Multilingual children's interactions with digital apps have been video recorded in natural settings in a kindergarten. The findings show that playful digital apps do promote the children's participation in mathematical activities, while apps that aim to provide a formal learning structure seem to promote neither play nor mathematical activities.

Keywords mathematical play, cultural agents, digital apps, multilingual

INTRODUCTION

An OECD report states that the key to using digital tools to enhance children's learning might be to look at the way children themselves use these tools in their own free time (Schleicher, 2019), suggesting that they could be used in a freer, more playful way than they are today. Nordic kindergartens place a strong emphasis on both play and the intrinsic value of childhood (Jensen, 2009). Although kindergarten teachers value play, they seldom bring their ideal pedagogy of valuing play into digital game-playing situations (Vangsnes, Økland, & Krumsvik, 2012), which indicates that pedagogical practices linked to digital games might be particularly vulnerable to learning pressure. Play is often seen as related to learning and the relationship between the two can sometimes be perceived as a dichotomy and lead to an increased pressure to treat play instrumentally, i.e. as a vehicle to achieve academic learning outcomes. A learning area high on the political agenda is mathematics (Lange, 2019), which is closely related to language (Lange & Meaney, 2018; Palmér, 2015). Nilsson, Ferholt, and Lecusay (2018) suggest that the notion of the playing-learning child should be replaced with the playing-exploring child and argue that learning is inherent in both play and exploration.

This learning pressure can be particularly strong for multilingual children. In a research project in Denmark, Palludan (2005) identified that kindergarten teachers spoke to immigrant children in an instructional tone, regardless of the multilingual child's level of Danish, indicating that these children were seen solely as students. It can, however, be challenging for teachers to support multilingual

children's languages (Petersen, 2022). In the process of learning a new language, children often go through periods where they do not use a lot of verbal language (Bligh, 2014). Petersen (2022) found that when multilingual children engage with open-ended apps that contain neither their mother tongue nor the language the children use in their kindergarten, they begin creating their own stories around the content of the app. This is in line with Lange and Meaney (2018) who, based on a survey among multilingual parents, suggest that apps can be useful in supporting the different languages that children speak. In this article, I will investigate what happens when two multilingual children in a Norwegian kindergarten interact with two different digital apps, where one is playful, and one is more focused on formal learning. This will be done within the context of the guiding research question: What can be learned from multilingual children's mathematical and playful participation when interacting with two different apps? The overall aim is to construct knowledge on how to promote children's mathematical play.

Positioning in the Context of Multilingual Mathematics and Digital Games

Digitalisation is often viewed as something negative (Danby, Fleer, Davidson, & Hatzigianni, 2018). A common concern is that digital tools will make children less social (McCarrick & Li, 2007), lead them to inactivity (WHO, 2019) and possibly delay their language development (Collet et al., 2018). Despite this, the use of digital tools is becoming increasingly common in early childhood education (Otterborn, Schönborn, & Hultén, 2019), and the use of digital tools is part of the kindergarten curriculum across Norway, Sweden and Denmark (Børne- og Socialministeriet, 2018; Ministry of Education, 2017; Skoleverket, 2018). An obligation to teach digital practices, despite a negative view of digitalisation, is likely to exert pressure on kindergarten teachers. Alvestad and Jernes (2014) argue that when kindergarten teachers lack training and experience in using digital tools, their insecurities might lead to commercial developers gaining more influence over what kind of digital tools are to be used in kindergartens. Given the pressure for learning, it can be challenging for kindergarten teachers to choose playful apps.

The last few decades have seen an increased focus on mathematics learning and language learning in kindergarten (Sommer, 2015). The increased political focus on mathematics risks shifting early childhood education from a social pedagogical tradition focusing on play toward a school-preparatory tradition with specific learning outcomes (Lange, 2019). In digital apps, valued mathematics is often comprised of numbers and number understanding (Papadakis, Kalogiannakis, & Zaranis, 2018; Veraksa, Balaguer, Christiansen, & Meaney, 2021), i.e. mathematics that can be seen as falling under the category of school mathematics (Christiansen & Meaney, 2020). A comparative study of frequently downloaded digital apps in Moscow, Catalonia and Norway found that apps were unlikely to support children's number understanding in a manner compatible with the respective curricula, as they did not focus on play (Veraksa et al., 2021).

Nilsen (2018) found that digitally available apps will not lead to the children's learning of the expected learning outcome programmed into the app. A linear set-up where children can guess their way to the one correct answer turns the game into a guessing game, where children interact with the app to get stardust instead of solving the game's intended tasks. The design of digital apps for learning mathematics influences the way children take part in the activities. Apps with a strong developmental structure reduce the children's participation and promote directed dialogues (Palmér, 2015), which indicates that apps created for learning mathematics should be made in a way that allows children to explore. Lembrér and Meaney (2016) found that when children play digitally, unintended technical hiccups, where the game is not functioning as planned, can create spaces in which to explore, providing spaces for the playing-exploring child (Nilsson et al., 2018). Digital play can also draw on the non-digital as well as on the digital, and in doing so facilitate a fluidity across the boundaries of time and space (Marsh, Plowman, Yamada-Rice, Bishop, & Scott, 2016), where

children can explore phenomena otherwise unavailable for them, such as hairdressing or travelling. Some apps will also allow the players to record their voices and, after investigating how those apps can be used, it was found that one of their strengths is that the stories can be told and retold several times inside and outside of the kindergarten (Garvis, 2015), which can serve to support multilingual children's opportunities to share stories verbally.

Lafton (2019) found that children can engage with the material in a different way than intended, e.g. when a teacher plans for the children to play a digital game and the children then choose to engage with the material differently and transform the activity into play, not playing a game. Lafton's findings indicate that children can shape a situation and thereby make it more meaningful for their own participation. However, for children to be able to play the game this way, the game should be designed to be playful and not as a string of tasks the children need to solve (Christiansen & Meaney, 2020). Helenius et al. (2016) outline three different ways in which play and mathematics are often considered related to one another: as a vehicle for learning; a creativity component in problem-solving; and playing as being a mathematical activity in itself. Addressing the separation of formal and informal learning, Logan and Woodland (2015, p. 301) state that "Learning environments can extend and complement each other rather than competing- and digital games are one way of doing this". The findings from the presented research underline the relevance to investigate children's interactions with playful digital apps not focused on number understanding when aiming at promoting children's mathematical play.

In Norway, where this study is situated, the learning areas quantities, spaces and shapes (Ministry of Education, 2017) build on Alan Bishop's mathematical activities (Reikerås, 2008). Bishop (1988) described mathematical activities that he considered to be universal: playing, explaining, designing, locating, measuring and counting. According to him, these are cultural activities in the sense that they develop through people's taking part in them, and that they can be found in all cultures. Bishop's activities are found in everyday activities in Swedish kindergartens (Johansson, Lange, Meaney, Riesbeck, & Wernberg, 2012). Lange and Meaney (2013) found elements of these activities in playful digital games for children and opportunities for these games to support children's mathematics in the same way that mathematics is supported in a sandbox, as these playful games allow children to interact with the apps without there being one right way to solve a problem. I therefore consider Bishop's (1988) six mathematical activities an appropriate theoretical framework to identify multilingual children's mathematical engagement with digital apps.

THEORETICAL PERSPECTIVE ON MATHEMATICAL ACTIVITIES

To investigate what can be learned from multilingual children's mathematical and playful participation when they interact with different apps, I use Alan Bishop's (1988) theory of fundamental mathematical activities to analyse my data material. As Bishop did not investigate children's cultures, I also refer to Helenius et al. (2016), who extended and linked these mathematical activities to children's activities in kindergarten. According to Bishop (1988), the following six mathematical activities lie at the heart of developing mathematics:

Counting	includes different kinds of counting and associating an object with a number. Different cultures develop counting based on the needs within the culture.
Measuring	is, like counting, related to numbers, but focuses on comparing sizes and amounts.
Locating	includes actions and language related to a spatial environment.
Designing	means shaping something in a specific way. It is not the product, but rather the process of shaping something according to a plan and the relationships between an object's shape and purpose that can be considered mathematical.

Playing	is linked to hypothetical thinking and imagining something, especially "what if" scenarios.
Explaining	relates to answering 'why' and is considered what lifts human cognition from the level of simply experiencing the world to beginning to understand it. Explanations can be complex or as simple as labelling something into a category.

To come closer to children's everyday play, I needed a framework outlined from children's play. I will therefore also draw upon Helenius et al. (2016), who have elaborated on Bishop's activity playing and connected it to children's play. They do not argue that mathematics is always play nor that play is always mathematical, but did, however, find three features that supported children's "understanding of mathematical processes such as modelling, hypothetical thinking and abstraction" (Helenius et al., 2016, p. 153), which are features that Bishop (1988) describes as part of play.

Creative	relates to imagining the "what if" scenarios that Bishop (1988) identifies as a central part of *playing*. Creative features can be modelling a situation, posing and solving problems or a participant accepting or determining an altered reality as a part of playing.
Participatory	relates to children showing awareness that their participation is dependent on recognition among other children that they are acting according to negotiated rules.
Rule negotiation	relates to children participating by the implicit or explicit rules of the play. These rules can change through negotiation between the participants in the play. The boundaries of play and what aspects of reality can be suspended are decided during the negotiation of the rules (Helenius et al., 2016).

In the following, the term "mathematical play" refers to the mathematical activity of playing, which includes all three features (creative, participatory and rule negotiation). Mathematical activity refers back to the six mathematical activities of Bishop (1988).

METHODS

I have carried out a case study to investigate what can be learned from multilingual children's mathematical and playful participation when interacting with two different apps. Although a case study is a specific and limited phenomenon, the phenomenon must be investigated in connection with the context in order to get a solid understanding of it (Yin, 2013). The data used for this article are comprised of video observations of two children from a single kindergarten playing "TocaBoca Kitchen" and "Toktok Klær". In the following, I will provide a presentation of the kindergarten and the children who are part of the study. Then I will explain how the material is collected and how I have analysed it.

Participants

The kindergarten is located in a larger Norwegian city. In Norway, kindergarten is voluntary, but all families have a right to a place from the time their child is one year old. 93.4% of all children between the ages of 1-5 attend kindergarten (SSB, 2022a), and 19.3% of the children have a minority language background (SSB, 2022b). The data were collected in a kindergarten where several teachers had approached my university expressing their interest in how multilingual children interacted with apps, as they had already been using ICT in their teaching for several years. The children in the study are two five-year-old boys who are multilingual, meaning that they are in the process of learning more than one language (Gujord, 2017). Most often they take part in physical play, such as climbing

and boisterous play, where not a lot of verbal language is used. The children involved expressed an interest in using tablets and being filmed. In addition, they engaged with the apps in line with how most of the other children in the kindergarten did.

The Digital Apps

During the first meeting that my supervisor and I had with the staff at the kindergarten, we asked the staff to try out different kinds of apps made for play and to discuss them. Afterwards, they said they saw a mathematical potential in some of the apps that they had initially thought looked "not mathematical" and "not worth" using in the kindergarten. They decided to download some of the apps and the tablets then had two main categories of apps available to the children: apps that focus on children's play and apps that focus on specific learning content. In the empirical material for this article, two apps are used: TocaBoca Kitchen and Toktok Klær, neither of which had a specific mathematical focus. TocaBoca Kitchen is an app where one prepares and serves food to either a boy, a girl or a monster. This app is developed by a large commercial app developer and, according to the creators, it is made for play (TOCA BOCA, 2020). Toktok Klær is an app that belongs to the Toktok universe developed by Cappelen Damm Undervisning, one of Norway's largest professional environments for teaching aids and textbooks (Cappelen Damm Undervisning, 2021). Within the app, children can choose to dress up either a boy or a girl. According to its creators, it was made to be playful while also enriching learning (Cappelen Damm Undervisning, 2021). Neither of the apps are labelled "mathematical" by the developers and they are both made to be playful.

Video Observation

Communication and language play an important part in children's mathematics learning (Palmér, 2015) but children who are in the process of learning a new language might use less verbal language as a natural part of their language learning (Bligh, 2014). In order to expand acknowledgement of expressions of mathematics beyond the purely verbal, I must also focus on the children's actions and therefore chose to record video observations of the children to facilitate review. The recordings were done over a two-month period, during which I spent a total of fourteen half-days with the children, and video recorded them on the last eight of those days, giving the children some time to get comfortable with a new adult (Corsaro, 2003). I took a non-participatory approach in the observations, and though children today are usually accustomed to being video recorded, the presence of a camera is likely to affect the situation to some degree (Raudaskoski, 2015). The observations were recorded with one hand-held camera. While recording I was sitting next to the children pointing the camera towards the children so that I could see their screens, hand movements and sometimes their facial expressions.

Ethics

This study has been approved by the Norwegian Centre for Research Data (NSD) (project number 51645) and follows NSD's ethical guidelines. Parents have provided written and informed consent on behalf of their children after receiving information in either their mother tongue or another language they know well. The children received information about the project from me and their teachers both individually and in groups. I did the observations in a room in the kindergarten which the children normally used for playing. All children and staff in the kindergarten could enter or leave this room as they wished, just as they could when I was not there recording. However, the staff informed the children that those who were interested in being filmed could enter the room I was in. I always asked the children before I started recording. I was also prepared to turn off the camera if ever the children looked uncomfortable, which they can show in subtle ways (Flewitt, 2005). For instance, I was prepared to turn off the camera if any of the children seemed to hide from

the camera or turn away from it, if someone who should not be recorded entered the room to play or if they simply asked me not to record. On some occasions when I was unsure of their willingness to participate, I stopped recording. The children who entered the rooms I was in usually expressed an interest in being recorded, such as by asking if I could record, sitting so the camera would capture them and checking that the camera was rolling. To keep the children anonymised, I have not named them.

ANALYSIS

The material involving the two children who are the focus of this article consists of 35 minutes collected over three different play episodes during which the children interacted with digital apps. The examples presented here are from one play session which was chosen because it includes both play and non-play, and because it is a somewhat long episode where the children engage with each other uninterrupted. The video data were then transformed into written text by first transcribing their verbal utterances and then adding in their actions, a description of what is happening on the screen and screenshots, inspired by Cowan's (2014) representation of multimodal data, in this case a mix between tabular- and timeline layout.

The multimodal data were analysed based on Helenius et al.'s (2016) features that facilitate mathematical play and Bishop's (1988) mathematical activities explaining, counting, measuring, locating and designing. The process of data analysis was carried out in three stages: first, I coded the data according to being mathematical play or not; second, I coded the mathematical play situations to identify other mathematical activities (counting, measuring, designing, locating and explaining); the third stage was to identify how the activities were related to what was going on in the app (for instance, if the children were modelling a situation). I have placed the transcribed material into a table (e.g. Table 1) including verbal dialogue, the actions of the child, screenshots of what is happening in the app, and the mathematical activities that took place in accordance with Bishop and/or Helenius et al.

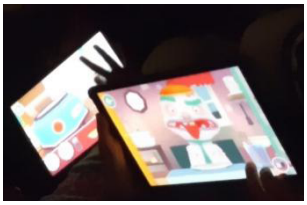
Verbal dialogue	Actions	Screenshots	Analysis
C1: He liked it! He liked it! He liked all of it!	C2: Feeds the smoothie to the monster, which drinks, pauses and sticks his tongue out.		The surprising/funny feature of the monster sticking his tongue out is promoting the children's participation in smoothie-making. Creative – modelling a situation. Negotiating rules by suggesting that the monster likes the food when he sticks his tongue out.

Table 1: Example of Analysis

FINDINGS

In the following, I will illustrate how Bishop's (1988) fundamental activities play a part in the children's playing by presenting two examples. The first example illustrates how the children's play can be classified as mathematical play and how other mathematical activities are present. The second example illustrates that not all the apps the children used were found to promote mathematical engagement. These two examples are from the same play situation and were chosen because they are representative of how the children engaged with these two digital apps.

The context for these two examples is as follows: it is 9:30 in the morning and three children are in the kindergarten's library, a room filled with bookshelves and mattresses and pillows on the floor. It is free-play time, and the children have chosen both to engage with tablets and to be video recorded in the room where I have already positioned myself on a chair with my hand-held camera. Installed on the tablet is a wide range of apps that they can freely choose from. They have turned the lights off because it is "more secret". The two children who are the focus of this article are sitting on mattresses next to each other and open up TocaBoca Kitchen. Along with them in the room is another child who is lying on the floor 1.5 metres away. They each have their own tablet and are free to choose what they want to do with it.

Example One: "Did you take this much?"

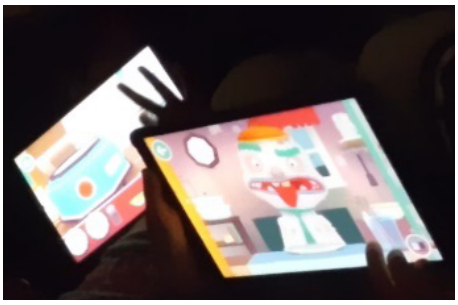


Fig. 1. Screenshot of the monster sticking it's tongue out

C2 feeds smoothie to the monster, which drinks, pauses and sticks his tongue out (see Figure 1).
C1: "He liked it, he liked it! He liked all of it!"
C2: "Wow, look!" and continues to prepare the smoothie.
C1, who is also preparing the new smoothie using the same ingredients, asks: "Did you take this much?"
C2: "No, not that much." He feeds the new smoothie to the monster, who sticks his tongue out again. "C1, Look! Does he like mustard, does he like mustard?"
C1: "I don't know."
C2 adds some mustard to the smoothie and feeds it to the monster, who spits the smoothie back out.
C2: "Can you… will you make good food?"
C1: "You need to know… he doesn't like carrots."

The two boys start holding unprepared food in front of the monster, who reacts in different ways: by saying "mmm", "yeiks" [a milder Norwegian form of "yuk"], licking his mouth, turning his head away, or with no change in expression. As the children hold food in front of the monster, they decide whether the food is good or bad based on the monster's reaction. They save the good food on a plate so they can put it in the smoothie. According to the children, the monster sticks his tongue out when he drinks a smoothie he likes and says "mmm" when he sees food he likes.

This example includes all the three features- creative, participatory and rule negotiation -that, according to Helenius et al. (2016), are part of mathematical play. The creative feature involves modelling a situation, posing and solving problems and accepting or determining an altered reality as part of playing (Helenius et al., 2016). In this app the children can prepare food for and feed the monster, and the children model a situation where the monster has personal features, such as being able to like food and showing this by sticking his tongue out. The children also pose a problem: making food that the monster will like, so the situation is creative as well. The participatory element is linked to the children's awareness that their participation is dependent upon other children recognising that they are acting according to the negotiated rules (Helenius et al., 2016). The children are demonstrating this awareness in their dialogue when they both accept and create the personal features that they give the monster. The rule negotiation is about participating by the implicit or explicit rules of the play (Helenius et al., 2016). When the children interact with an app, they are always limited by what it is possible to do within the app. TocaBoca Kitchen is programmed so that the monster reacts differently to different kinds of food. From this, the children devise a

strategy to solve the problem of creating good food that will make the monster stick his tongue out: they place food in front of the monster and check his reaction. They create a rule by which the monster will say "mmm" if he sees good food and stick his tongue out if it tastes good. This rule sets the boundaries of the play and what aspects of reality can be suspended are determined during the negotiation of the rules. As all the features of mathematical play are present, the children are taking part in mathematical play.

The children employ relatively extensive spoken language, as they normally take part in physical activities using little verbal language. The children play on two separate tablets and although their play is driven forward by verbal language, their use of mathematical language is not extensive, and the mathematical activities are therefore not always easy to identify. However, three of the other mathematical activities Bishop (1988) describes (measuring, locating and explaining) appear within their mathematical play. Measuring and explaining are present as part of their verbal communication, while locating is present as a visuospatial activity when the children navigate within the app. The children measure by comparing amounts when C1 asks "did you take this much?" and C2 replies "not that much". Explaining can be as simple as labelling something (Bishop, 1988), and in this example the children label food as good or bad based on the monster's reactions, which is labelled as liking or disliking food. I thereby find that not only are the children taking part in mathematical play, but that the other five mathematical activities are also emerging from their mathematical play.

Example Two: Something Funny Needs to Happen

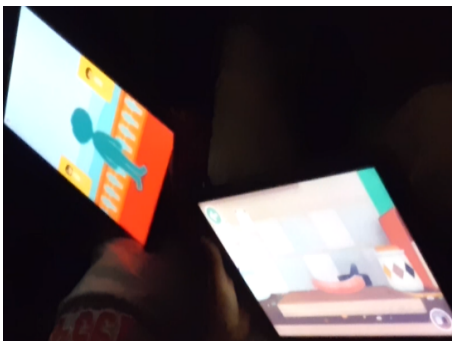


Fig. 2. Screenshot of Toktok Klær and TocaBoca Kitchen

After trying out a lot of different food, C1 feeds the monster a piece of meat, the monster eats the meat by chewing loudly and makes a neutral face afterwards.

C1: "When he ate meat, he did nothing."

C2: "What?"

C1 feeds the monster meat one more time and says: "Do you see, nothing!"

C2: "He did do something, he said hrm."

C1: "Yes, but he should do something funny."

C1 closes his app and says, "I will play Toca World". He opens Toktok Klær [Toktok Clothes] (see figure 2). In this app, he can choose a boy or a girl and put clothes on them.

C1: "I will be a girl." Both the children giggle.

C1 puts on different clothes, with the voice of the app saying what each piece of clothing is called. He changes clothes faster and faster by tapping his finger. Thirty-eight seconds after opening the app, he says "I will not play this. It's boring."

In this example, C1 says that the monster should do something funny and he labels the monster's "hrm" sound, as doing nothing. C1 also opens a different app, Toktok. The element of being able to choose a gender themselves (and even one that is not their own gender) for a child in the app, draws the children in and their giggling shows that this feature is amusing to them. When the children choose clothes, they could do so according to the (changing) weather on the picture which would be labelling clothes as summer clothes or winter clothes; this would serve as an act of explaining (Bishop, 1988). However, I did not find participation in mathematical play in the way Helenius at al. (2016) operationalise it. There were no interactions that illustrate the three features creative, participatory and rule negotiation. Although the children briefly explore the option of "what if" they

were a girl, as the app was dismissed as boring within a minute, no creativity evolves from it and the children do not negotiate rules for participation. The children closing the app after labelling it as boring is representative of how the children interacted with apps with limited room for exploration. Limited room for explorations curbs the need for verbal interaction and restrains the development of mathematical play.

DISCUSSION

In this article, I investigate what can be learned from multilingual children's mathematical and playful participation when interacting with two different apps. Four of Bishop's activities are found in the material with the two children's interaction with one of the digital apps, with mathematical play as an overarching and framing activity, and counting and designing not being present in the material. The element of surprise and of "something fun happening" seemed to draw the children into the play, while a focus on formal learning did not spark the children's interest and therefore also did not support their engagement in mathematical play. This is in line with Nilsen's (2018) suggestion that when children use learning-focused apps they might not learn what teachers might expect, but rather guess their way to the right answer without reflecting on the learning content. Helenius et al. (2016) outline three ways in which mathematics and play are related: play as a vehicle for learning mathematics, i.e. playing as a creativity component in problem-solving and playing as a mathematical activity in itself. In the examples I have presented, the relationship can be seen between all three: the children take part in mathematical activities while playing, and that playing can, therefore, be seen as a vehicle for learning mathematics. Their playing can also be seen as a creativity component when the children pose and solve problems such as how to create a smoothie that is just right to make the monster stick his tongue out and also to spit the smoothie back out. And their playing is mathematical in itself as it is both creative, participatory and they negotiate rules. However, *using* the play as a vehicle for learning will entail a risk of ruining the play, as can be seen in the example with Toktok Klær, where the app is said to be made to be playful (Cappelen Damm Undervisning, 2021), but the interaction around the app ends up being neither play nor mathematical. *Using* the play as a creative component in problem-solving is likely to involve the same risks. I would therefore argue that it is only when the children's play is an activity in itself that it is likely that the children will engage in other mathematical activities.

It is a common concern that digital tools made available for children can make them less social (McCarrick & Li, 2007). I find, however, that by using play-centred apps they can open for social activities. When the children chose apps that seemed to be meaningful to them, they used relatively much language given that they normally take part in activities that require little verbal language. As Petersen (2022) also found, the children started creating stories around the non-verbal digital content of the app. Although the TocaBoca Kitchen app did not provide opportunities to record the stories so they could be retold, such as the ones Garvis (2015) researched, the app still seemed to have the potential to support multilingual children's verbalisation. However, although mathematics is closely related to language (Lange & Meaney, 2018; Palmér, 2015) not all of the mathematical activities I have identified are connected to using verbal language; the children's participation in locating is non-verbal and linked to navigating in the app. The children do not develop activities linked to counting. This could be because the children are not interested in counting, but it could also be because the Toca Boca Kitchen app has few options for the children to engage in counting.

According to Palmér (2015), apps with a strong educational focus will reduce the children's participation. When the children use TocaBoca Kitchen, the negotiated rule of the monster sticking his tongue out when liking the food is very close to what is designed into the app: the children can make a rule for what the monster's action means and they can affect the monster's reaction by

what they feed it, but they cannot make the monster do something it is not programmed to. When the children use Toktok Klær, they simply close the app because "nothing fun happens", or in other words, it is dismissed as boring. Similar to Lafton (2019), who found that children can engage with materials in other ways than planned by a teacher (Lafton, 2019), I find that children can build on what is provided in the apps and create their own purpose and problems to solve, given that the app is designed in a way that will allow them to, and that it has a theme that is interesting to the children who interact with the app.

My findings indicate that apps made to involve children in mathematical activities need to have built-in space for exploration. Nilsson et al. (2018) finds that if children play and explore, the learning is inherent. I find that this is also the case when children engage in mathematical play. Instead of dismissing digital apps as something negative that will make children less social, inactive and delay their language development, my findings suggest that the apps have the potential to extend and complement ways to promote children's mathematical play. Apps with built-in space for playful exploration, in particular, have the potential to engage multilingual children in verbal negotiations.

SUMMARY

This study shows that apps might have the potential for engaging children in mathematical activities and can motivate multilingual children to use verbal language. However, the results indicate that choosing learning-centred apps might not be the best way to engage children in mathematical activities on digital surfaces. The notion of the playing-learning child should be replaced with the playing-exploring child (Nilsson et al., 2018) in the context of digital apps as well. These findings can support app developers in making apps that can promote and extend children's mathematical play, and they can also support teachers and parents in choosing apps that children can engage with in a way that is meaningful to the children themselves. The digital market is rapidly changing, and for future research, I would suggest looking at more ways for children to play and explore digitally and to see how children's explorations of an app might change or develop over time.

AUTHOR BIOGRAPHY

Silje Christiansen is a PhD student at Western Norway University of Applied Sciences, having previously been a kindergarten teacher in Norway. Her research interests include kindergarten mathematics, digital tools in kindergarten and multilingual participation in kindergarten. She is part of KINDknow – Kindergarten Knowledge Centre for Systemic Research on Diversity and Sustainable Futures. Her project is funded by the KINDknow centre and the Research Council of Norway.

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