The potential socio-political influences on kindergarten preservice teachers' evaluations of children's use of mathematical digital apps

Mona Karbaschi Vee and Tamsin Meaney

Children's use of digital tools is mandated as a requirement in Norwegian kindergartens but is also a source of public debate. To understand how preservice teachers make sense of what could be conflicting influences of their work in kindergartens, we analyse their descriptions of using mathematical digital apps with children. After an initial analysis using the Artefact-Centric Activity Theory, the results were discussed in relationship to potential socio-political influences on the preservice teachers' views about how digital technologies could or should contribute to providing mathematical learning opportunities. The kindergarten preservice teachers situated apps as providing the mathematical content to children, with the teacher's role to make the app understandable to the children. The kindergarten preservice teachers' view seemed to be affected by the curriculum and the public debate about using digital technology with young children. The results suggest a need for teacher educators to have explicit discussions about the impact of socio-political influences of digital technology with kindergarten preservice teachers.

In Norway, kindergartens, for children aged up to 6 years, are required to engage children with mathematical ideas (Ministry of Education and Research, 2017). In the curriculum, known as the Framework Plan, kindergarten staff are given the responsibility to use different working methods, so that children learn through play, experimentation, and everyday activities. One working method is digital practices, "digital practices in kindergarten shall encourage the children to play, be creative and learn" (Ministry of Education and Research, 2017, p. 44). This is in alignment with Plowman (2020), who described digital tools in early childhood education and care (ECEC) as contributing to a new form of play,

Mona Karbaschi Vee, *Western Norway University of Applied Sciences*
Tamsin Meaney, *Western Norway University of Applied Sciences*

as they provide opportunities for children to discover, make choices, and experience the impact of their decisions.

However, supporting children to engage in this kind of play may not be straight forward. Play involves children making their own decisions about what they want to do and how they want to do it and, thus, can be teacher-supported but not teacher-controlled (see for example, Lange et al., 2014). In play, children utilise their own initiative, often involving imagination and fantasy (Pramling Samuelsson & Björklund, 2023). They also negotiate and follow rules associated with the activity (Helenius et al., 2016), participating willingly and enthusiastically, by selecting objects, rules, and tools (van Oers, 2024). Digital play involves interactive and exploratory activities conducted through digital devices in which children can make choices about what they do. It can support and encourage children's mathematical thinking (Birklein & Steinweg, 2024), but this is more likely to occur when supported by interactions with the teacher (see for example, Lembrér & Meaney, 2016).

An OECD report on policies for young children's learning (Schleicher, 2019) recommended that educational institutions needed to evaluate their curricula and teachers their teaching practices "to ensure that ICT was used effectively to support learning and equip children with competencies that are important for the future" (p. 56). The report suggested that this could be achieved by linking what happens in educational institutions to how children use digital tools outside of those institutions. This could support reflecting on how digital tools can be incorporated into mathematical experiences in more playful ways (Christiansen, 2022). Although play is emphasised in the Framework Plan as important in kindergartens (Ministry of Education and Research, 2017), when it comes to digital play, few kindergarten teachers seem to utilise their play pedagogy in their work with children (Christiansen, 2022).

To support children's digital play, changes may be required to teachers' "pedagogical philosophy, professional learning processes, and confidence levels" (Dietze & Kashin, 2013, p. 3). Palmér (2015) noted that children's possibilities to learn with digital tools, "depend on the teachers' awareness of why they use the manipulatives and on their ability to use them effectively" (Palmér, 2015, p. 366). According to Palmér and Ebbelind (2013), the balance between teacher guidance and children's self-exploration is important for children's learning possibilities. Yet in Palmér's (2015) research, Swedish preschool teachers were more or less absent when children used digital apps suggesting that it would be unlikely that teachers were using digital tools in the ways suggested by the Framework Plan (Ministry of Education and Research, 2017).

Reflecting on whether and if they need to change their practices, kindergarten teachers are also likely to be influenced by wider societal debates about young children's use of digital tools. For example, concerns have been raised by some educators that digital tools could stifle children's learning and creativity (Danby et al., 2018; Stephen & Plowman, 2014). Time spent engaging with screens has also been highlighted as posing a risk to opportunities for play or for children to learn through play (Dietze & Kashin, 2013). Furthermore, Hu and Yelland (2017) found that when on practicum early childhood preservice teachers tended to adjust how they integrated digital tools, from what they had learnt in teacher education to what was expected by the preschool and their mentor teacher. This resulted in preservice teachers utilising more teacher-led rather than child-initiated activities, suggesting that teacher education courses may have limited influence on their practices. Therefore, a range of socio-political influences could affect the views of kindergarten preservice teachers (KPTs) on the use of digital tools in their work with mathematics with young children.

In contrast, although "the role digital technology plays in children's learning is largely unexplored" (Norén, 2018, p. 146), there are some indications that digital tools can have a positive effect. Dietze and Kashin (2013) suggested that technology can be an enhancement to children's play experience, rather than a substitute for active play. Digital tools provide different forms of play which can promote effective learning and development in ECE (Plowman, 2020). As well, earlier research with computers suggests that they can develop social and language abilities when KPTs made use of collaborative activities (Edwards, 2005). In mathematics education research, digital tools have been described as being more manageable for young children than physically manipulating concrete materials, when combining representations (Palmér, 2015). This is because digital technologies easily integrate visual presentations, animations and voice, which can support young children's learning. Children also have more control by being able to move 'things' on the screen, using their fingers, for example to make objects bigger or smaller, or by changing their colours. This kind of control is in alignment with children engaging in digital play.

For KPTs, with limited experiences with play pedagogy to draw upon, the integration of digital apps into their work with mathematics is likely to require considerable support to develop appropriate knowledge and skills. In a systematic literature review of research on how early childhood teacher education prepares preservice teachers to use digital technologies, Papavlasopoulou, et al. (2024) found that internationally there is little

focus on digital integration in teacher education and that there is a need for research that considers how this could be done more holistically.

In this article, we focus on digital apps as a digital technology frequently used in kindergartens (Vee, et al., 2024). In particular, we are interested in how practicum experiences might be affected by socio-political debates. Vee and Meaney (2022) suggested that there was a need for research which investigates the impact of KPTs' experiences with children in kindergartens on the ways that they use digital apps in their work with mathematics.

Socio-political influences

KPTs' views about mathematics and the learning potential of apps are not individually developed, but rather are affected by influences both from within and outside of the kindergarten environment and their teacher education. These influences are socio-political in that they are affected both by societal discussions and by political decision-making through policies such as the Framework Plan (Ministry of Education and Research, 2017). KPTs construct their choices about how to use digital apps in their mathematical work with children from the socio-political environment in which they live and work. For example, negative views about using digital tools in ECEC (Stephen & Plowman, 2014; Danby et al, 2018) could influence KPTs' understandings about what they should do and how. According to Skovsmose and Borba (2004), critical mathematics education provides opportunities to identify the socio-political issues that affect the mathematics provided to children, such as: their backgrounds; the communication pattern in the classroom; the organization of project work in mathematics education; the reliability of mathematics in practice; the distribution of resources; access to computers; and so on. To improve kindergarten teacher education in regard to integrating digital tools, there is a similar need to identify the socio-political influences on KPTs' use of digital apps in their mathematical work with young children.

Socio-political influences can include views about mathematics and how it should be learnt in kindergartens. For example, although the Framework Plan (Ministry of Education and Research, 2017) situates mathematics, or "quantities, spaces and shapes" as it is described, as having a value in young children's explorations, a shift towards valuing what is needed for schools could result in a more teacher-led approach and a focus on number understandings (Fosse et al., 2018). This is because the readiness-for-school approach focuses on the cognitive goals, considered necessary for success at school (Bennett, 2005), which can downgrade the

importance of play. Activities in this tradition are more often teacher-led and controlled (Christiansen & Meaney, 2020). In contrast, the traditional approach underlying Norwegian kindergartens is described as the social policy pedagogy tradition (Bennett, 2005). In this tradition:

> staff are trained to work in open framework contexts, and structural conditions support an active learning approach. The guiding national curriculum is flexible enough to allow staff to experiment with different pedagogical approaches, and adapt programmes to local conditions and demand. Again, Nordic guidelines are formulated on a consultative basis, and receive the critical analysis and consent of the major stakeholders before becoming statutory. (Bennett, 2005, p.11).

Christiansen (2022) suggested that kindergarten teachers might consider integrating digital apps, as a way to meet school expectations, because "educational" apps seem to be more appealing to kindergartens (see for example Lembrér 2021). These apps tend to present content in a linear manner, thus reducing children's possibilities to engage creatively. In contrast, other apps can provide alternative opportunities through "thinking big", by engaging children in exploration and innovation (Dietze & Kahin, 2013). According to Nikiforidou (2017), "digital games can promote learning when they are characterized by child-centred interactions, set within environments that have a meaning and interest for the children and are designed to match their abilities and desire to play and explore" (p. 254). Such apps would be more in alignment with the social policy pedagogy tradition (Bennett, 2005).

The shift to a more linear presentation of mathematics learning opportunities through apps can also be connected to a narrowing of views about what mathematics in kindergartens can include. Although the mathematics in the Framework Plan (Ministry of Education and Research, 2017) is based on Bishop's (1988) six mathematical activities – counting, measuring, designing, locating, explaining and playing – many kindergarten teachers value number understandings as the most important (Fosse & Lossius, 2017). In a previous study of KPTs' evaluations of apps for engaging children in mathematics, Vee (2023) also identified that most KPTs focused on number. In a systematic literature review of in-service and preservice teachers' work with mathematics in early childhood, Linder and Simpson (2018) highlighted that there was a limited focus on research on other mathematical content areas than number, suggesting that Norwegian kindergarten teachers are not alone in this focus. It may be that societal valuing of number understandings could influence KPTs' understandings about what kind of digital apps should

be made available to children, which then reinforces the preference to engage children with apps that present content in a linear progression and so reduce opportunities for exploration and creativity.

To provide appropriate teacher education courses, there is a need to understand what influences KPTs' choices for integrating digital apps into mathematical interactions with children. Therefore, our research question is: What socio-political influences potentially affect KPTs' evaluations of using digital apps to engage young children in mathematics?

To respond to this question, we analyse the assignments that KPTs wrote about their experiences of integrating digital apps into their work with mathematics during their practicum placement. In their compulsory assignments, the KPTs had to describe which apps they used, how they used them with children, and why.

Theoretical background

Artifact-Centric Activity Theory (ACAT) (see figure 1), developed by Ladel and Kortenkamp (2013), provides an appropriate way to consider the different aspects that KPTs could pay attention to in their evaluations. ACAT is based on Engeström's (1987/2014) activity systems, in which the artefact in the centre of interactions, mediating how the subject the child makes sense of the object, the mathematical content. ACAT provides insights into how the design of the app affects the mediation. By identifying how the KPTs describe the different nodes in the ACAT model, it is possible to infer some of the socio-political influences on their decision making.

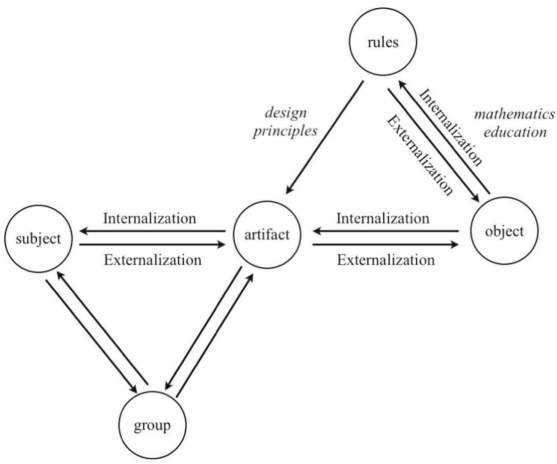

Figure 1. *The ACAT framework from Ladel and Kortenkamp (2013, p. 2)*

In the top right triangle in figure 1, the focus is on the relationship between: the artefact (the app); the rules which govern the kinds of interactions that are possible; and the object, the mathematical content (Ladel & Kortenkamp, 2013). The KPTs' descriptions of the apps provide information about the role that they considered the app would have in presenting mathematics to children. This provides insights into what they considered to be appropriate mathematics and how the apps should/would present it, such as in a linear manner or through exploration, and, thus, the potential socio-political influences on those choices.

In the triangle on the left-hand side, the focus is on how the child (subject) would make sense of (internalize) the mathematics that the app makes available to them (externalize). The group indicates how an individual child is expected to interact with an artefact, whether as an individual or as part of a wider group. The relationship between a teacher and child or between children can affect the child's interactions with the artefact and what learning opportunities are made available to them (Ladel & Kortenkamp, 2013). Socio-political influences can be inferred from identifying how the KPTs considered children should interact with each other and the teacher when using the apps.

Method

In this section, we describe the data collection and analysis and justify their choice against the requirements of the research question.

Data collection

The data were 17 KPTs' compulsory assignments, written as part of a compulsory course, "Language, text and mathematics", from their first year of teacher education. The KPTs were completing their teacher education part time and often already had experience of working with children in kindergartens. The assignments were analysed after the KPTs had completed all formal requirements of the course. The KPTs were aware that they were not obligated to provide their assignments and their choice to do so would have no impact on their grades.

The assignments had a limit of 1500 words and were written individually and submitted a week after they had completed six weeks of practicum. In the assignments, the KPTs had to describe their choice of one or more apps, their plans for using them as well as how children engaged with the apps, in one or more sessions in the kindergartens. The apps could be uploaded to tablets by KPTs or they could use apps, already available in the kindergartens where they did their practicums. To support the KPTs to make appropriate choices of apps to use with children when

they were on practicum, the KPTs were provided with the ACAT evaluation tool (https://prosjekt.hvl.no/latacme/ressurser/ressurser-app-evaluation-resources/). In this evaluation tool, the questions included: what is mathematical object of the app? How do children interact with the mathematical object, mediated by the app? How does the interaction develop? Is the app suitable for teaching and learning the mathematical object? How can the app be used in the group situation?

The apps discussed by KPTs were: Tella, Tell i vei, ABC Albert Åberg, Number Lines and Albert Junior. Table 1 uses information provided by the developers to briefly describe each app.

Table 1. *Information about the apps.*

The apps	KPT who used the app	Information about each app
Tella	9, 10, 11, 12, 13, 14, 15, 16, 17	TELLA is an educational game that children can learn simple mathematics by playing and trying their hand at it. It is intended for the age group 5 - 8 years, but is also suitable for those who are younger or older. (https://play.google.com/store/apps/details?id=no.mediesenteret.tella&hl=no)
Tell i vei	8	Learn the numbers 1-10 by counting the animals that hide on three different paths. They sometimes hide very well. You can choose from 6 different animals to count or listen to. (https://play.google.com/store/apps/details?id=com.peacore.Tellivei)
ABC Albert Åberg	2	Play with letters, sounds and words together with Albert Åberg. The app has been developed based on children's needs, and has no points, time limits or other elements that could lead to mistakes or stress. Children will play and learn with the app on their own terms and at their own pace, in kindergarten, at school or at home. (https://play.google.com/store/apps/details?id=com.groplay.abcalfons&hl=no)
Number line	5	An infinite number line to use in the classroom, with a simple design that allows for numerous maths games and challenges! (https://play.google.com/store/apps/details?id=design.blastoff.numberline&hl=en&gl=US)
Albert junior	1, 3, 4, 6, 7	Albert Junior is a learning platform that teaches younger children to count in a simple, fun and educational way. The content is specially designed for children aged three to nine and is based on the primary school curriculum. (https://play.google.com/store/apps/details?id=se.mralbert.junior&hl=en_US)

Data analysis

Each assignment was read carefully, with relevant comments being classified as being connected to one or more nodes of the ACAT model (Ladel & Kortenkamp, 2013). Table 2 provides an overview of the classification. The first row identifies each node. The second row describes the key aspects of each node, utilising Ladel and Kortenkamp's descriptions of the nodes. For example, when the KPTs wrote about children, these comments were considered to be about the Subject. The third row of table describe the potential socio-political influences on the comments which were related to the ACAT nodes, drawing on the discussion in the theory section.

Table 2. *Classification of KPTs' reports into different ACAT nodes*

	Object: Mathematics	Rules: How the app functions	Subject: Children	Group: Individual/group interaction
Key aspects of each node	Mathematical topics, such as number or measurement.	Explicit mentioning of design aspects of the apps.	Children's skills, abilities or needs.	Explicit mentioning of whether the children are expected to use the app individually or with others.
Socio-political influences on choices about these nodes	Curricula requirements about what mathematics children should engage with. Societal valuing of number understandings.	Curricular requirements about play and creativity. Societal expectations about linear learning about mathematics.	Curricular requirements about children being active in learning. Societal expectations about children learning passively through using apps.	Curricular requirements about the active role of the teacher. Societal expectations about children working individually on apps.

Once the points in the assignments had been classified according to ACAT, the socio-political issues that may have influenced the KPTs' choices about how to use digital apps with children for exploring mathematical understandings were then investigated (see table 2). This was done by identifying which aspects of mathematics were highlighted and how children were expected to engage with the app, either when the KPTs wrote about their planning or how they evaluated what the children actually did when using the apps in kindergartens.

Results and discussion

The results of the analysis are first discussed in relationship to ACAT's nodes (Ladel & Kortenkamp, 2013), beginning with the object node, before describing the potential socio-political influences that could have affected these views.

The object node identified the mathematics that the KPTs focused on. Eleven of the KPTs engaged children with apps to do with some aspect of number, although the aspect could differ. Six KPTs chose apps about shape and measurements as well as number understanding. The focus on numbers and shape were perhaps not surprising because the Framework Plan (Ministry of Education and Research, 2017) highlights "quantities, spaces and shapes" as the subject area. However, a focus on space concepts was missing, although earlier research identified these concepts in apps being used in Norwegian kindergartens (Christiansen, 2023). That the majority of KPTs focused on number can be connected to societal valuing, shown in previous research (Linder & Simpson, 2018) and for preparing children for school (Christiansen & Meaney, 2020).

In the ACAT model, rules of the app indicate how the mathematical understanding (object) is made available to the children (subject). In the compulsory assignments, some of the KPTs suggested that learning mathematics required the children to have possibilities to repeat tasks. For example, KPT17 wrote "the repetition in the app contributes to good learning and children experience mastery". KPT 12 also mentioned that was important for children to feel mastery, "through repetition I experienced that they had mastery over some tasks which make the children proud of themselves." In the earlier study of Vee (2023), other KPTs also highlighted the need for repetition, suggesting that children would work individually on apps. However, KPTs' valuing of repetition could restrict them seeing the value of children working together or with teachers and the possibilities for creativity, emphasised in the Framework Plan (Ministry of Education and Research, 2017).

In relationship to the need for repetition, many of the KPTs highlighted the importance of the apps having a learning progression. For example, KPT 1, 4, 10, 11, 13, 16 and 17 who used the Tella app or the Albert Junior app, with children, indicated that the app increased the difficulty of the tasks, which they considered important. However, KPT 1 and KPT 3 noted that this increasing difficulty required the children to have more explanations than the Albert Junior app provided. Without this explanation, the connection to the mathematical object was not clear, "it was difficult to understand what the children were going to do and what the purpose was" (KPT 3). Thus, the way the app presented the mathematical concept to be learnt had implications for the role of

the teacher. KPT8 wrote, "I repeat the task and explain to the children what they should do". Increasing the difficulty of tasks alongside a lack of explanation made it difficult for children to complete the tasks by themselves, which was problematic for the KPTs who seemed to expect children to engage with the app in this way. The KPTs, therefore, valued apps that the children could easily work out. KPT 8 who worked with the very young children felt that the "Tell i vei" app set up number understanding in an easy way, with the animals being shown for the children to touch. The children could then hear the app counting the animals and see the number symbols. The KPT justified choosing this app because of its simple setup and communication, which the children could understand and so could learn about numbers and counting. However, in evaluating how the children used the app, KPT 8 found that the children were more interested in the animal sounds, than learning to count. Although the design of the app could support children's possibilities to engage with mathematics, other aspects, such as sounds, could distract them and reduce their possibilities to learn. As Nilsen (2018) found the KPTs realised that the apps did not necessarily lead to children's learning the expected outcomes. They, therefore, seemed surprised when the children were not interested in learning mathematics, but more interested in exploring and discovering other things that the app made available, such as the sounds of animal, even though exploration with digital tools is highlighted in the Framework Plan (Ministry of Education and Research, 2017). This suggests that the KPTs were influenced by wider societal expectations that apps should "teach" children the required mathematics individually, rather than by curricular requirements about the need to engage creatively and through play with the mathematics in apps.

The KPTs negatively evaluated the design of apps which they considered did not engage children in mathematical learning. For example, KPT 5 and 9, who used two different apps, described how children could work out the correct answer from listening for the right sound, "the child also quickly realized that the app made a sound when the answer was correct, so if the child guessed wrong, he tried again until (the correct) sound was made" (KPT5). This suggests that the KPTs saw the design of the app, which focused on the children gaining a correct answer, rather than engaging with the mathematical idea, as affecting what could be learnt. These comments suggest that the KPTs did not value apps that might have supported the children to engage in digital play and creativity, even though this was required by the Framework Plan (Ministry of Education and Research, 2017), perhaps because this kind of exploration was in contrast to the kind of learning they expected children needed.

KPTs' few connections to play were about children engaging in problem solving, a connection noted in earlier research on non-digital activities (Fosse et al., 2020). KPT 2 described the tasks in ABC Albert Åberg as being about problem-solving, "The app is based on (letter) sounds and letters, but also has some mathematical problem-solving tasks. Here, numbers and mathematical thinking are presented in a playful way". KPT 2 considered the app to be playful, as the children could make cakes and decorate them, using measuring and counting skills. Nevertheless, they were concerned that the children engaged in the app, without recognising that it involved mathematics. This KPT seemed to be positive about the app contributing to a new form of play, where children could make choices, discover and learn from their decision making, but was uncertain about whether engaging with mathematical content and processes was sufficient for it to fulfil the requirements of the Framework Plan (Ministry of Education and Research, 2017).

In contrast, other comments which were classified as belonging to the rule node indicated that some KPTs did not think that aspects of the design of the app matched children's needs. Alongside the difficulties deriving from a lack of explanation, described earlier, there were also concerns that the app was not developmentally appropriate. For example, KPT14 highlighted that "the very youngest children needed help to complete the task in Tella app, but 5-year-olds could do the task by themselves". KPT 17 also noted that the children did not have the fine motor skills needed to control the Tella app, "Here it was too challenging for the 2-year-olds children. They would like to paint the number. When they remove finger off the screen or lose their 'grip', they had to start over". This KPT considered that the children lost motivation because of the design of the app. Similarly, KPT 11 mentioned that gripping of the items in the Tella app was difficult because "the children had to put their fingers in the middle of the objects to move them". As the children were unable to complete the tasks successfully, KPT 17 and 11 considered that they could not engage meaningfully with the mathematics. This reinforces the idea that the KPTs considered that the app should be engaging by itself so that the children would find mathematics interesting and motivating, and, thus, provide them with the possibility to learn. Although Nikiforidou (2017) had highlighted the need for apps to be child-centred for children so that they could play and explore with others, the KPTs instead seemed to expect that the app should provide both the engagement and learning for children so that it could be used individually. These views seemed to be informed by societal expectations about how apps should engage children, rather than the requirements of the Framework Plan (Ministry of Education and Research, 2017).

As well, expectations about how children should engage with the app affected the value KPTs gave to possibilities for collaborations with themselves as teachers or with the children's peers. Comments about this were linked to the group node of the ACAT model. For example, six KPTs (1, 4, 10, 11, 13,17) mentioned that one adult should hold the tablet so that the children could cooperate to find the right answer. These KPTs indicated that the teacher should lead the children to the right answer. This approach was in contrast to other KPTs who thought that the children should learn individually while using the app, discussed earlier. For example, KPT 5 described how children should work on the tablet by themselves and did not become involved unless the children asked for help. The same KPT suggested that for the children to work independently, the app, in this case the Number line app, should present the tasks with pictures and not with text or words because the children could not read. The KPT seemed to think that the children would "learn by doing" and did not need to communicate with others. Palmér (2015) had noticed that ECE teachers were more or less absent when children were using digital apps, suggesting that the expectation that children should use them on their own is widespread. This is in contrast to the requirements of the Framework Plan which emphasises that kindergarten teacher "shall be actively involved with children when using digital tools" (Ministry of Education and Research, 2017, p. 44).

Some of the KPTs (8, 11,14, 17) who worked with very young children (under 2 years old) suggested that every child should have their own tablet because the children were impatient for their turn on a shared tablet and so lost motivation. This indicated that they did not think it was possible for very young children to work in a group. For example, the KPTs who used the Tella app, which was described as being for older children, seemed reluctant to consider changing how they worked with the children or identify other ways that children could engage together, when using apps. KPT 2 was the only KPT who highlighted the possibility for children to work in groups of 2-3, as well as working individually, perhaps because they had highlighted a connection to play, something not raised by the other KPTs.

Although the design of app may have provided opportunities for collaborations between children and with the teacher, the KPTs' views about how mathematics should be learnt and how apps should be used seemed to reduce their willingness to look for these opportunities. In their reflections, the KPTs focused more on what they considered the app should provide for children to learn from, with the teacher's role to just explain what the app required the children to do. Although concerns have been raised about the use of digital tools in kindergartens to do with lack of

social interaction and screen time (Danby et al., 2018), it seemed the KPTs' expectations that children would work on them individually was not something that they could see past to identify how to overcome these concerns when using apps with young children.

Conclusion

In this paper, we have identified potential socio-political influences on KPTs' evaluations of children's use of apps to engage with mathematical ideas. The ACAT framework provided insights into how they saw the app (artefact) mediating children's interactions with the mathematical content (object), through its design (the rules) and linked to the role of the teacher and potentially peers. The KPTs' descriptions show that the ACAT nodes are connected, not just within each triangle but also across the triangles. For example, it seemed that the KPTs expectations about the design of the app, connected to the rule node, was affected by both the valued mathematical content (the object) for young child and the role the teachers saw themselves and other children as having when engaging with apps. From the KPTs' descriptions of how they implemented apps on practicum, it seemed that they expected the apps to "teach" the children, with the KPTs having a minimal support role. Potential socio-political influences seem to be about expectations that number is the most valued content in mathematics and that children should learn mathematics individually and through repetition. These societal expectations seem to override their understandings about what the Framework Plan (Ministry of Education and Research, 2017) highlighted for how children should engage in digital play.

Although the assignment specifically asked the KPTs to consider how apps could engage children with mathematics through play, there were few comments about play and creativity in their reflections. The provision of learning possibilities depends on teachers' awareness (Palmér 2015). Therefore, if play and creativity are to be valued, in alignment with the Framework Plan (Ministry of Education and Research, 2017), it is clear that teacher education needs to provide KPTs with other experiences with apps, either by choosing different apps or by having different expectations of what the children could do and their own roles as teachers.

However, a focus merely on incorporating kindergarten play pedagogy into experiences with digital tools in mathematics teacher education courses is unlikely to result in improving the likelihood that the requirements in the Framework Plan about the use of digital tools will be fulfilled. This is because the socio-political environment influences how

the wider society determines what is valuable mathematics for kindergarten children, how it should be learnt and how children should engage with digital apps. Our analysis using ACAT highlighted the different aspects of young children engaging with mathematics apps which were identified by KPTs in their evaluations. This provided insights into the potential socio-political influences on their expectations of how children should engage with apps and the role of the teacher in those engagements.

These wider socio-political views about what mathematics children need to learn and how they should engage with apps may have contributed to the majority of them focusing on children learning about numbers and counting by individually engaging with apps. This seemed to lead to the KPTs highlighting as important mathematics for children to learn (number and counting), through individually repeating tasks. It may be that the recent pressure on Norwegian kindergartens for children to learn mathematics in order to be prepared for school (see Lange & Meaney, 2018) may have reduced the KPTs' possibilities to feel that it was appropriate to choose apps which provided more opportunities for play and creativity. Lembrér (2021) noted that some kindergarten teachers seemed reluctant to see entertainment apps as providing the same possibilities for children to engage with mathematical ideas as educational apps, such as Tella, even if the entertainments apps were already familiar to the children. Using what was familiar to children from home was one of the recommendations in the OECD report for improving children's digital competencies (Schleicher, 2019). As Björklund et al. (2018) wrote, teaching mathematics is not only about counting, adding or measuring "it is rather about expanding the play and helping children to understand the surrounding world, thus to mathematize" (p. 471). Identifying potential socio-political influences indicates that teacher educators may need to not just present alternative ways to use apps to engage children in mathematical ideas, but to have explicit discussions about the impact of socio-political pressures. Without these discussions, it may that the readiness-for-school tradition becomes more evident in kindergartens' work with mathematics.

Acknowledgement

Funding for this project was provided by Western Norway University of Applied Sciences, Kindknow, Kindergarten Knowledge Centre for Systemic Research on Diversity and Sustainable Futures (Research Council of Norway project 275575) and University of Stavanger's project DiCoTe: Increasing professional Digital Competence in ECTE with focus on enriching and supporting children's play with coding toys (Research Council of Norway project 326667).

References

Bennett, J. (2005). Curriculum issues in national policy-making. *European Early Childhood Education Research Journal*, 13(2), 5–23. https://doi.org/10.1080/13502930585209641

Birklein, L. & Steinweg, A.S. (2024). I can do it on my own?! Evaluation of types of implementation of digital game-sased learning in early mathematics education. In H. Palmér, C. Björklund, E. Reikerås & J. Elofsson (Eds) *Teaching mathematics as to be meaningful – foregrounding play and children's perspectives.* Springer. https://doi.org/10.1007/978-3-031-37663-4_5

Bishop, A. J. (1988). *Mathematical enculturation: A cultural perspective on mathematics education*. Kluwer.

Björklund, C., Magnusson, M. & Palmér, H. (2018). Teachers' involvement in children's mathematizing– beyond dichotomization between play and teaching. *European Early Childhood Education Research Journal*, 26(4), 469–480. https://doi.org/10.1080/1350293X.2018.1487162

Christiansen, S. F. (2022). 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? *Transdisciplinary journal of cultural participation*, 9(2), 1–12. https://doi.org/10.2478/tjcp-2022-0009

Christiansen, S. F. (2023). Supporting one-year olds' digital locating: The mediating role of the apps and the teacher. In H. Palmér, C. Björklund, E. Reikerås & J. Elofsson (Eds.) *Teaching mathematics as to be meaningful-foregrounding play and children's perspectives: results from the POEM5 Conference, 2022* (pp. 39–54). Springer.

Christiansen, S. & Meaney, T. (2020). Cultural meetings? Curricula, digital apps and mathematics education. *Journal of mathematics and culture*, 14(2), 71–90.

Danby, S. J., Fleer, M., Davidson, C. & Hatzigianni, M. (2018). Digital childhoods across contexts and countries. In S. J. Danby, M. Fleer, C. Davidson & M. Hatzigianni (Eds.), *Digital Childhoods Technologies and Children's Everyday Lives* (pp. 1–14). Springer. https://doi.org/10.1007/978-981-10-6484-5_1

Dietze, B. & Kashin, D. (2013). Shifting views: exploring the potential for technology integration in Early Childhood Education Programs. *Canadian Journal of Learning and Technology*, 39(4), 1–13. https://doi.org/10.21432/T25P4Z

Edwards, S. (2005). Identifying the factors that influence computer use in the early childhood classroom. *Australasian Journal of Educational Technology*, 21(2), 192–210. https://doi.org/10.14742/ajet.1334

Engeström, Y. (1987/2014). *Learning by expanding: An activity-theoretical approach to developmental research* (2nd ed.). Cambridge University Press.

Fosse, T., Lange, T., Lossius, M. H. & Meaney, T. (2018). Mathematics as the Trojan horse in Norwegian early childhood policy? *Research in Mathematics Education*, 20(2), 166–182. https://doi.org/10.1080/14794802.2018.1473162

Fosse, T., Lange, T.,& Meaney, T. (2020). Kindergarten teachers' stories about young children's problem posing and problem solving. In I. Erfjord, M. Carlsen & P. S. Hunderland (Eds.). *Mathematics Education in the Early Years* (pp. 351–368). Springer International Publishing. https://doi.org/10.1007/978-3-030-34776-5_21

Fosse, T. & Lossius, M. H. (2017). "I find that pleasurable and play-oriented mathematical activities create wondering and curiosity" Norwegian kindergarten teachers' views on mathematics. In E. Norén, H. Palmér, A. Cooke, (Eds.), *NORMA 17: Eighth Nordic conference on research in mathematics education* (pp. 21–30). Swedish Society for Research in Mathematics Education.

Helenius, O., Johansson, M. L., Lange, T., Meaney, T., Riesbeck, E. & Wernberg, A. (2016). What is play as a mathematical activity for preschool children? In T. Meaney, O. Helenius, M. L. Johansson, T. Lange & A. Wernberg (Eds.) *Mathematics Education in the Early Years - Results from the POEM2 Conference, 2014* (pp. 139–156). Springer. https://doi.org/10.1007/978-3-319-23935-4_8

Hu, X. & Yelland, N. (2017). An investigation of preservice early childhood teachers' adoption of ICT in a teaching practicum context in Hong Kong. *Journal of Early Childhood Teacher Education*, 38(3). https://doi.org/10.1080/10901027.2017.1335664

Ladel, S. & Kortenkamp, U. (2013). An activity-theoretic approach to multi-touch tools in early maths learning. *The International Journal for Technology in Mathematics Education*, 20(1), 3–8.

Lange, T., Meaney, T., Riesbeck, E. & Wernberg, A. (2014). Mathematical teaching moments: Between instruction and construction. In C. Benz, B. Brandt, U. Kortenkamp, G. Krummheuer, S. Ladel & R. Vogel (Eds.), *Early mathematics learning: Selected papers of the POEM 2012 conference* (pp. 37–54). Springer. https://doi.org/10.1007/978-1-4614-4678-1_4

Lange, T. & Meaney, T. (2018). Policy production through the media: the case of more mathematics in early childhood education. In M. Jurdak & R. Vithal (Eds.), *Sociopolitical Dimensions of Mathematics Education from the Margin to Mainstream* (pp. 191–207). Springer. https://doi.org/10.1007/978-3-319-72610-6_11

Lembrér, D. & Meaney, T. (2016). Preschool children learning mathematical thinking on interactive tables. In T. Meaney, O. Helenius, M. L. Johansson, T. Lange & A. Wernberg (Eds.) *Mathematics education in the early years - Results from the POEM2 Conference, 2014* (pp. 235–254). Springer. https://doi.org/10.1007/978-3-319-23935-4_13

Lembrér, D. (2021). *Sociocultural influences on parents' views about mathematics education for young children*. [Doctoral thesis]. HVL Open. https://hvlopen.brage.unit.no/hvlopen-xmlui/handle/11250/2828862

Linder, S. M. & Simpson, A. (2018). Towards an understanding of early childhood mathematics education: A systematic review of the literature focusing on practicing and prospective teachers. *Contemporary Issues in Early Childhood*, 19(3), 274–296. https://doi.org/10.1177/1463949117719553

Ministry of Education and Research. (2017). *Framework plan for the content and tasks of kindergartens*. Norwegian Directorate for Education and Training. https://www.udir.no/contentassets/7c4387bb50314f33b828789ed767329e/framework-plan-for-kindergartens--rammeplan-engelsk-pdf.pdf

Nikiforidou, Z. (2017). Digital games in the early childhood classroom: theoretical and practical considerations. In S. J. Danby, M. Fleer, C. Davidson & M. Hatzigianni (Eds.), *Digital childhoods technologies and children's everyday lives* (pp. 253–265). Springer. https://doi.org/10.1007/978-981-10-6484-5_16

Nilsen, M. (2018). *Barns och lärares aktiviteter med datorplattor och appar i förskolan* (Children's and teachers' activities with tablets and apps in preschool). [Doctoral thesis], Gothenburg University.

Norén, E. (2018). Agency, materiality, and mathematics learning in a preschool classroom. In U. Gellert, C. Knipping & H. Straehler-Pohl (Eds.), *Inside the mathematics class* (pp. 145–166). Springer. https://doi.org/10.1007/978-3-319-79045-9

Palmér, H. (2015). Using tablet computers in preschool: How does the design of applications influence participation, Interaction and dialogues? *International Journal of Early Years Education*, 23(4), 365–381. https://doi.org/10.1080/09669760.2015.1074553

Palmér, H. & Ebbelind, A. (2013). What is possible to learn? Using Ipads in teaching mathematics in preschool. In A. M. Lindmeier & A. Heinze (Eds.) *Proceeding of the 37th Conference of the International Group for the Psychology of Mathematics Education. Mathematics Learning Across the Life Span* (Vol. 3,pp. 425–432). PME.

Papavlasopoulou, S., Undheim, M., Meaney, T. & Esmaeelib, S. (2024). Early childhood pre-service teachers' preparation for using technology with children: a systematic literature review. *European Journal of Teacher Education*, 1–18. https://doi.org/10.1080/02619768.2024.2341935

Plowman, L. (2020). *Digital play*. University of Edinburgh. https://www.de.ed.ac.uk/sites/default/files/2020-07/Digital%20Play%20-%20Plowman%202020.pdf

Pramling Samuelsson, I. & Björklund, C. (2023). The relation of play and learning empirically studied and conceptualised. *International Journal of Early Years Education*, 31(2), 309–323. https://doi.org/10.1080/09669760.2022.2079075

Schleicher, A. (2019). *Helping our youngest to learn and grow. Policies for Early Learning*. OECD Publishing.

Skovsmose, O. & Borba, M. (2004). Research methodology and critical mathematics education. In P. Valero & R. Zevenbergen (Eds.), *Researching the socio-political dimensions of mathematics education: issues of power in theory and methodology* (pp. 207–226). Springer. https://doi.org/10.1007/1-4020-7914-1_17

Stephen, C. & Plowman, L. (2014). Digital play. In L. Brooker, M. Blaise & S. Edwards S (Eds.), *SAGE Handbook of Play and Learning in Early Childhood* (pp. 330–341). SAGE.

van Oers, B. (2024). The development of mathematical thinking in young children's play: the role of communicative tools. In H. Palmér, C. Björklund, E. Reikerås & J. Elofsson (Eds) *Teaching mathematics as to be meaningful – foregrounding play and children's perspectives*. Springer. https://doi.org/10.1007/978-3-031-37663-4_1

Vee, M. (2023). How do beginning preservice kindergarten teachers' evaluations of mathematical apps provide insights into their understandings about bildung (danning) for young children? *Nordisk Barnehageforskning*, 20(2), 51–69. https://doi.org/10.23865/nbf.v20.268

Vee, M., Lembrér, D., & Meaney, T. (2025, February 4–8). *Norwegian and Swedish early childhood preservice teachers' views on digital technologies for supporting mathematics explorations*. Paper presented at 14th Congress of European Research in Mathematics Education (CERME14), Bolzano, Italy.

Vee, M. K. & Meaney, T. (2022). Kindergarten preservice teachers evaluating mathematical apps. In G. A. Nortvedt, N. F. Buchholtz, J. Fauskanger, F. Hreinsdóttir, M. Hähkiöniemi, B. E. Jessen, J. Kurvits, Y. Liljekvist, M. Misfeldt, M. Naalsund, H. K. Nilsen, G. Pálsdóttir, P. Portaankorva-Koivisto, J. Radišić & A. Wernberg (Eds.), *Bringing Nordic mathematics education into the future: Proceedings of Norma 20, The Ninth Nordic Conference on Mathematics Education, Oslo 2021* (pp. 249–256). Swedish Society for Research in Mathematics Education.

Mona Karbaschi Vee

Mona Karbaschi Vee is lecturer of mathematics education at Faculty of Education, Arts and Sport, Western Norway University of Applied Science. Her research is with digital technologies and young children. Along with Tamsin Meaney, she is developing resources that can be used in kindergarten teacher education to support the use of apps to engage young children with mathematics through play.

Mona.Karbaschi.Vee@hvl.no

Tamsin Meaney

Tamsin Meaney is Professor of mathematics education at Faculty of Education, Arts and Sport, Western Norway University of Applied Science. Her research is wide ranging, with a particular interest in digital technologies and young children, including on the implications to do with social justice. Along with Mona Karbaschi Vee, she is developing resources that can be used in kindergarten teacher education to support the use of apps to engage young children with mathematics through play.

Tamsin.Jillian.Meaney@hvl.no