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How do beginning preservice kindergarten teachers' evaluations of mathematical apps provide insights into their understandings about *bildung* (*danning*) for young children?

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Abstract

In this article, evaluations of apps from kindergarten preservice teachers were analysed in relationship to their understandings about children's cultural formation. The Artifact-Centric Activity theory, a theoretical model based on Cultural-Historical Activity theory, was used in this study to identify how kindergarten preservice teachers considered that the digital games could engage children in mathematics. This analysis gave insights into what the kindergarten preservice teachers considered to be appropriate mathematics for young children and how they should learn it, which can be contributors to children's cultural formation. The results of this study give insights into how teacher education could be changed so that kindergarten preservice teachers could include other aspects in evaluating apps, such as connections to play and creativity, in alignment with the requirements of the Framework Plan. Making the kindergarten preservice teachers aware of the need for the inclusion of such foci is likely to affect kindergarten children's potential cultural formation.

Keywords: *Artifact-Centric Activity theory; cultural formation; kindergarten preservice teachers; mathematical apps*

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Introduction

In this article, I investigate how preservice kindergarten teachers (KPTs) evaluate digital apps that provide possibilities for children to engage with mathematics. My aim is to understand how KPTs' app evaluations provide insights into what they consider child's cultural formation, known in Norwegian as *danning*,[1] could or should be. *Danning* is a philosophical concept, which describes the holistic process of an individual's continuous becoming, or formative development, facilitated through goal-oriented educational practice (Ødegaard, 2019). In 2005, *danning* was mentioned for the first time in a policy statement for Norwegian kindergartens in reference to quality standards. *Danning* was later included in the 2006 Norwegian *Framework Plan for Kindergartens* (Ødegaard, 2019). In a summary of previous research, Sjöström et al. (2017) maintained that *Bildung*, in Germany and Scandinavia places the responsibility on teachers to transform knowledge into meaningful content for children. Therefore, it is important to understand KPTs' choices about the content they make available to children through mathematical digital apps and how they connect the content to pedagogical considerations. These choices give insights into KPTs' understandings about children's *danning* and how it should be developed. To analyse KPTs' evaluations of mathematical apps in regard to children's *danning*, I use the Artifact-Centric Activity theory (ACAT) (Ladel & Kortenkamp, 2013). The findings from the analysis of the KPTs' evaluations provide insights into how the KPTs relate opportunities for children's *danning* to their work in kindergartens.

Sjöström et al. (2017) emphasised that *Bildung* (*danning*) is relevant at both individual and societal levels. This is because children are active participants in their own learning and development, within the human relationships of a given culture (Grindheim, 2020, p. 69). The structural features of a society influence individual members, such as children, by providing opportunities to become active contributors to that society (Corsaro, 2014). Therefore, society provides the parameters that determine what kind of human beings children can become, while at the same time children can contribute to changing society as they grow and develop. As Klafki claims, "the child opens up to the world, and the world opens up to the child" (Klafki, 2016, p. 17).

Since 2006, *danning* has been mentioned in successive iterations of the *Framework Plan for Kindergartens* (Ministry of Education and Research, 2017). As kindergartens are places where children develop and learn, including about how they relate to the society they live in, kindergartens can be considered places in which *danning* occurs (Ødegaard, 2019). The Framework Plan sets out the opportunities for children's development and learning.

According to Ødegaard (2019), the Framework Plan should be seen as going beyond the Anglo-Saxon discourse about the importance of "learning," while at the same time

1 *Danning* is a Norwegian term related to the German concept of *Bildung*, and can be translated into English as cultural formation. Other translations are formative development and becoming. Following the work of Ødegaard (2019), I decided to use the Norwegian term, *danning*, in this article.

embracing equality for all children and leading to sustainable values, by being value-oriented towards both fellow human beings and nature. *Danning* can include children learning to value having agency to make decisions, so that they can contribute to their society. As a result, children can be educated to be citizens who act as thoughtful, brave, and responsible individuals within a society. This is in line with recommendations for *Bildung* (*danning*) to be part of a school's curriculum, so that "school should encourage students to become free, responsible citizens, with a developed individuality – cognitively, morally, as well as aesthetically" (Sjöström et al., 2017, p. 170). The Framework Plan can, thus, be seen as supporting children's exploration and social and cultural formation in kindergarten as well as opening up for practices that may prepare children for school learning (Hedegaard, 2020).

How children engage with the world contributes to their *danning*. In Norwegian kindergartens, there is a strong emphasis on play and on children learning through play, which will contribute to opportunities for *danning*. For example, exploration and curiosity are described as helping children to identify problems they want to solve and to make decisions about how to solve (Christiansen & Meaney, 2020; Hedegaard, 2020). Yet it is not always easy for kindergarten teachers to know how to implement some of the Framework Plan's requirements to do with academic subjects and pedagogical practices, so that children can learn through play. For example, in summarising previous research, Wager and Parks (2014) stated that "teachers do not do as much as they could to make connections between mathematics and play" (p. 220).

The mathematical goals in the Framework Plan are described in the learning area "Quantities, spaces and shapes," and "this learning area is about discovering, exploring and creating structures and helps children to understand relationships in nature, society and the universe" (Ministry of Education and Research, 2017, p. 53). Fosse et al. (2018) identified that engaging with mathematical ideas connected to problem-solving, reasoning, and rational thinking, highlight the importance of children having control. This could be considered as being in line with the Framework Plan's emphasis on the importance of children's own interests and being active in their own learning (Ministry of Education and Research, 2017).

In the 2017 Framework Plan, digital practices are described as one of the working methods to be used in kindergartens, "staff shall use books, games, music, digital tools, natural materials, toys and equipment to inspire children's mathematical thinking" (Ministry of Education and Research, 2017, p. 54). As well, "digital practices in kindergarten shall encourage the children to play, be creative and to learn" (Ministry of Education and Research, 2017, p. 44). Alvestad and Jernes (2014) reported that using technology in kindergartens, in Norway, was connected to the children's learning about making their own choices and critical thinking. This is an important part of *danning*, as it is about making the children aware of their rights and choices in becoming democratic citizens with regard to the media within a consumer society (Alvestad & Jernes, 2014, p. 6).

It is important to consider what opportunities for *danning* are made available to children when mathematical ideas are introduced through digital tools in kindergartens. For example, not all digital games support children engaging with mathematical ideas through play (Christiansen & Meaney, 2020). Christiansen and Meaney (2020) evaluated digital apps that focused on numeracy and visuo-spatial reasoning skill. They identified that the design of the apps could, but did not always, stimulate children's creativity as well as motivation for problem-solving (Christiansen & Meaney, 2020). This could have affected children's possibilities for *danning*, by learning how to experience, interpret, understand, and act in the world. In another study, Moyer-Packenham et al. (2019) examined twelve different digital mathematical games and found that the design features of apps influenced children's learning. They identified features such as progressive hints, audio feedback, and unlimited attempts in the digital games as contributors to increasing learning outcomes (Moyer-Packenham et al., 2019).

In contrast, apps that focused on teaching mathematics to children could reduce the opportunities for children to engage in creativity and problem-solving (Christiansen & Meaney, 2020). The kind of cultural formation or *danning* available to children will depend on whether a digital app emphasises children's opportunities for playing, creativity, or for following set rules to get the correct answer.

In this paper, I focus on *danning* as cultural formation or continuous becoming (Ødegaard, 2019), which is influenced by the choice of meaningful content (Sjöström et al., 2017), to do with "Quantities, spaces and shapes." *Danning* is also influenced by the individual-societal connection and how human relationships are considered (Grindheim, 2020).

The choice of digital tools that kindergarten teachers make is likely to influence a child's possibilities for *danning,* even if it is only one small contribution to the experiences that children experience. Aarsand (2019) demonstrated how a teacher's choice of digital tools and tasks influenced how children interacted with the tools and what they learned. However, different digital tools create different conditions for children's participation. To make appropriate choices about what apps to provide to children, kindergarten teachers need to determine which ones best support children to play, be creative, and learn about mathematical ideas. This has implications for teacher education as KPTs may need support to develop their digital competencies. In Norway, previous research noted that preservice teachers considered that they were not made aware of how to use digital resources in kindergartens (Alvestad & Jernes, 2014).

KPTs' pedagogical choices about what app to use in their future work are also likely to influence children's opportunities for *danning*, including the value placed on children's learning through play (Christiansen & Meaney, 2020) as well as their own decision-making. Therefore, teacher educators need to know what KPTs pay attention in order to develop appropriate experiences which can enrich KPTs' knowledge and skills when evaluating digital apps for kindergarten children. Therefore, the research question is, how do beginning

KPTs' evaluations of mathematical apps provide insights into their understandings about *danning* for young children?

Artifact-Centric Activity Theory

Artifact-Centric Activity theory (ACAT) can indicate which aspects KPTs focused on when evaluating apps at the beginning of their teacher education course. The ACAT framework was developed by Ladel and Kortenkamp (2013) for designing digital resources, but was later further developed so that it can also be used to assess digital apps (Larkin et al., 2019). The ACAT framework was based on Engeström's (1999) theory of human activity systems. The nodes in this framework (see Figure 1) provide a basis for determining how the KPTs' evaluation of apps can be connected to their views on possibilities for children's *danning*.

ACAT identifies how the interaction between the subject, the child, and the object, the mathematics, is mediated by the artifact, in this case the digital app (see Figure 1). Rules describe how each app functions, based on their design principles. The group node within the ACAT model denotes how an app might be used, for example, in the classroom, with a particular emphasis on expected interactions with the apps that children could have either individually or in groups. The artifact node can be described as the mediator between the subject and the object. The artifact is connected both to the object, in that a digital game externalises the mathematical content, and to the subject, in that it determines what children can experience.

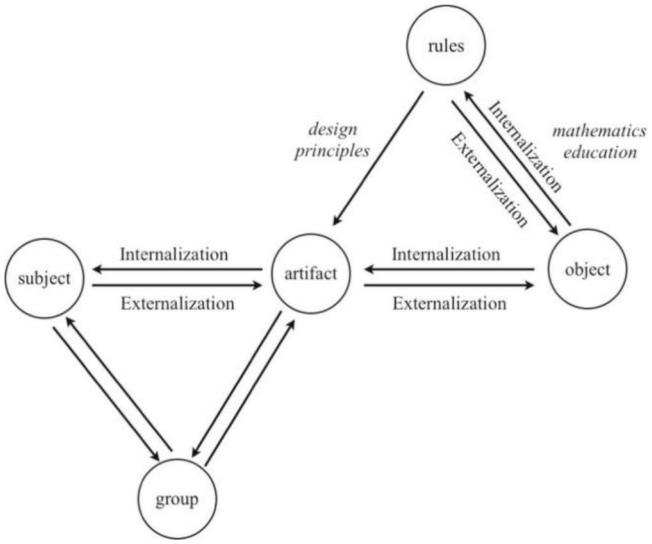

Figure 1. Artifact-Centric Activity theory model (Ladel & Kortenkamp, 2013, p. 3).

The app connects the two triangles (Ladel & Kortenkamp, 2013). In the top right triangle, the focus is on the relationship between the artifact, the app, the rules which govern the way the app works, and the object, the mathematical content (Ladel & Kortenkamp, 2013). The potential mathematical learning available to children is dependent on the app's design.

For example, the rules can include if, and how, feedback is given which can support children continuing engaging with the content of the app.

In the triangle on the left-hand side, the focus is on how the child (subject) would make sense of (internalise) the mathematics from playing the app (externalise). The group node, in the lower left triangle, indicates that an individual can interact with the artifact as part of a society, represented by the teacher or other children. KPTs may have expectations about how the artifact could or should be used with a group or individually, based on their understandings about societal relationships and expectations. For example, the relationship between a teacher and child could affect the child's interactions with the app, while the app could affect the relationship between the teacher and the child, by encouraging the child to want to talk to the teacher. The support provided by the social interaction will affect the internalisation/externalisation process.

As ACAT is based on activity theory (Ladel & Kortenkamp, 2013), there is a connection to *danning*. Cultural historical activity theory has been used to understand children's *danning* in early childhood education and care, particularly in Norway (Grindheim, 2020; Hedegaard, 2020; Schei & Ødegaard, 2020). This is because as Birkeland (2019) stated, "research needs to identify societal conditions, demands and value orientation as well as traditional institutional practices in concrete, everyday activity settings" (p. 54). ACAT, as a version of activity theory, also provides opportunities for undertaking research on KPTs' evaluations as everyday activities within traditional institutional practices which provide insights into what they consider as important for children's *danning*.

As *danning* is connected to children's opportunities for personal development, the nodes in ACAT can be connected to *danning*. For example, children's interactions with others or by themselves with the app provides information about the group node of ACAT. Ladel and Kortenkamp (2013) developed ACAT when designing an app to support children's understanding of numbers for counting and for different representations of numbers. In incorporating meaningful content—number understandings—into the app by having children explore different representations of numbers. Although these methods of exploration may not be considered as fostering creativity, they did give children control over their exploration. Thus, apps have the possibilities to provide children with opportunities to be active participants in their own learning through, for example, providing problem-solving situations. The rules node indicates how the design of app provides opportunities for children to be creative or learn through structured tasks as it contributes to the externalisation of the mathematical object.

Moyer-Packenham et al. (2019) used ACAT to identify how the design of an app influenced children's learning, by focusing on internalisation and externalisation. They described how some design features of an app can bring mathematics to an explicit level of awareness for a child (Moyer-Packenham et al., 2019). Thus, the apps (artifact) could contribute to the mathematical meanings gained by the children. The way that children

were expected to learn could influence the ways they saw for being competent members of society, by engaging with the apps individually or with others, thereby affecting a child's possibilities for *danning*.

Christiansen and Meaney (2020) used ACAT to determine how the design of two different apps influenced the mathematical engagement of young children in Norwegian kindergartens. In their analysis, they demonstrated that the interaction between children and apps, which was supported by the designs of the apps, shaped children's interaction with mathematical ideas and creativity (Christiansen & Meaney, 2020). The designs contributed to children's *danning* in that in one app there were possibilities for children's exploration and creativity in relation to problem-solving situations, while in the other app the focus was on completing a set of the tasks.

Therefore, ACAT seemed useful in analysing KPTs' evaluations of apps to identify what they considered valuable for children's *danning*, by identifying what they highlighted as important mathematical content for children to learn and how it should be learned by children. This provides opportunities to consider how they made sense of the need to incorporate creativity and play into the use of digital tools as required by the Framework Plan (Ministry of Education and Research, 2017).

Method

In this section, I describe the data collection and data analysis used to identify the KPTs' views on children's *danning* when using these mathematical apps. These indicate how ACAT was used to identify how the KPTs viewed young children's possibilities for *danning* from engaging with mathematical apps.

Data Collection

The data were collected from 13 groups of KPTs (two to five people in each group) as part of a three-hour workshop on mathematics and play in a first-year course, "Language, Text and Mathematics". This was part of the regular workshop provided to KPTs on playing as a mathematical activity (Bishop, 1988). The data can be considered as coming from a naturalistic setting and not part of an intervention. As such, the data provided baseline data about KPTs' valuing of mathematics and how it could be learnt from apps and was appropriate for responding to the research question.

The KPTs engaged with apps, on tablets, for about one hour. Five digital games had been uploaded by the mathematics teacher educator, who was a colleague. The teacher educator chose apps of various qualities, in order for the KPTs to discuss what would be a high-quality app that could provide kindergarten children with learning opportunities through play. The teacher educator asked the KPTs to evaluate the apps according to

whether their use in a kindergarten would be in line with the aims of the Framework Plan, with its emphasis on play (Ministry of Education and Research, 2017). They are first year students in kindergarten teacher education. They were familiar with the concept of *danning* from the pedagogy component of the "Language, Text and Mathematics" and as a part of *danning* and didactic practice course.

In this article, I focus on the KPTs' evaluations of two apps: Bimi Boo and Tella. These apps were the ones that most groups evaluated (8 groups tested Bimi Boo, 10 groups tested Tella). Both apps presented a range of mathematical ideas. Bimi Boo is a commercially-designed app for children aged 2–6 for learning numbers from 1 to 20 (http://bimiboo.net/app/numbers/). Tella was designed by a set of government agencies, with the lead role being taken by staff at our institution (Western Norway University of Applied Science). The Tella website (http://tella123.org/#/om) describes the app as developing a sense of quantities and then numbers, before introducing children to simple addition and subtraction. All the tasks are done in a specific order. Originally aimed at children aged 5 to 8 years with learning needs in mathematics, it has also been promoted as being suitable for younger children.

With the consent of the KPTs, 13 groups were recorded using a screen recorder app, which simultaneously recorded the video and audio discussions via a tablet. The KPTs determined how long they recorded their interactions. The audio recordings were then transcribed. Eight groups discussed Bimi Boo from 2 minutes 4 seconds to 8 minutes 40 seconds. Ten groups discussed Tella from 2 minutes 42 seconds to 11 minutes 15 seconds.

Data Analysis

The transcripts were read carefully and then the comments made by the KPTs were classified as being related to one or more nodes of the ACAT model (Ladel & Kortenkamp, 2013). The original classification according to ACAT was done in collaboration with a colleague and presented as a conference paper (Vee & Meaney, 2022). Table 1 provides an overview of how I operationalised ACAT to the data by identifying key aspects connected to each of the nodes, in comments made by KPTs. The second column lists the key aspects of each node. These key aspects were based on Ladel and Kortenkamp's (2013) descriptions of the nodes and checked against how the KPTs discussed the different apps. For example, when the KPTs talked about children, these were considered to be comments connected to the subject. When they talked about the mathematical focus of the app, this was classified as being related to the object. When they talked about how the apps engaged the children with mathematics, these comments were classified as being about the rules node. When the KPTs talked about how children could play with apps by themselves or with others, including adults, I classified these comments as being related to the group node. The third and fourth columns provide examples of comments made by the KPTs from the transcripts about to the two apps.

Table 1. Classification of KPTs' comments into different ACAT nodes.

The ACAT nodes	Key aspects of each node in KPTs' discussions	Examples from discussions about the Bimi Boo app	Examples from discussions about the Tella app
Subject: Children	Explicit mention of children's skills, abilities or needs	• Some difficult tasks for children • Relevant for younger children	• For older children • Children can misunderstand aspects of some tasks
Artifact: Apps	Explicit mention of aspects of the design of the apps	• Attractive app • Not just guessing by trying things • Could have more variety	• Exciting app • Too much mathematics • Progressive app • Interesting
Object: Mathematics	Explicit mention of mathematics in the app	Number, quantity, writing number symbols, one-to-one matching and cardinal numbers	Number, size comparisons (bigger/smaller), ratio, quantity, sorting, classification and order
Rules: How the app functions	Explicit mention of design aspects of the apps	• Positive about parental control • Could be more flexible. • Feedback • Some difficult tasks • Positive with repetition	• Positive with repetition • Some wrong explanations • Feedback • Boring as children cannot advance • Could have more variety in the tasks
Group: Individual/ group interaction	Explicit mention of whether the children can play individually or not	Children can play it individually	Should be used together with an adult

Once the data was classified according to the different nodes of the ACAT framework, then how the comments could be connected to KPTs' views about children's *danning* was identified. This was done in a similar way to that of the ACAT nodes. The descriptions of *danning* from earlier research in the earlier sections were used to identify key aspects. The descriptions of those key aspects were then checked against the comments made by KPTs. Table 2 provides an overview of how I operationalised aspects of *danning* in the KPTs' discussions. The first column provides lists the key aspects of *danning*. The second column describes the key aspects and the last column provides examples from KPTs' discussions about the key aspects of *danning*.

Table 2. Aspects of 'danning' from KPTs' comments.

Aspect of *danning*	What is the relation to *danning*?	Example from KPTs' discussions
Meaningful content	It is about the valued knowledge that children should have to be competent members of society.	The app is about learning number comprehension The app is about learning size, order, sorting
Active in their own learning and development	*Danning* as a continuous becoming	Being motivated to engage in a difficult task (draw a number or place objects in the right order)
Learning from their own actions and motivations	Exploration and curiosity	Need for repetition, explanation and feedback
Supported to make their own decisions	The children are aware of their own rights and choices	Flexibility in apps in moving between tasks and levels of difficulty.
Learning to co-operate, human relationships	It is about the connection between an individual to the social environment and human relationships	Children's interaction with app (play the app individually or with help of an adult)

Results and Discussion

In this section, I use the nodes from ACAT to structure the results from analysing the KPTs' evaluations of the two apps. Comparing the points made about the two apps in relationship to each node is then used to discuss the kind of *danning* the KPTs seemed to be indicating were available to children from engaging with the mathematical apps.

Object

The object is the mathematical content. When the KPTs discussed the mathematics in the apps, they focused on number comprehension, such as counting and quantitative reasoning. Although they did not discuss it explicitly, the KPTs could have considered that number comprehension as being important because of the goal in the Framework Plan about "numbers, quantities and counting" (Ministry of Education and Research, 2017, p. 53). The emphasis on number learning in the apps could reinforce the KPTs' views about the importance of number comprehension for young children's *danning*.

What the KPTs could identify depended, not only on what the apps made available, but also on what the KPTs considered to be mathematics. Despite mathematics in the *Framework Plan for Kindergartens* (Ministry of Education and Research, 2017) being based on Bishop's (1988) six universal mathematical activities, most KPTs restricted their discussions about mathematics to understandings about numbers in their evaluations. Previous research has also shown that kindergarten teachers tended to focus on numbers (Johansson, 2015) and so it could be a cultural expectation that young children should be taught to count in early childhood institutions. Although the KPTs were asked to reflect on the relationship between the apps and play, the KPTs did not mention problem-solving or playing, even though Bishop's (1988) mathematical activity of playing has been linked to problem-solving (Fosse et al., 2020). Similarly, the KPTs could have made connections to locating in Bimi Boo, for example when they placed things inside the basket or items of clothing on the characters in the app. However, they did not mention these aspects as being about mathematics.

In their discussions, the KPTs considered that the Tella app provided young children with experiences to do with order, sorting, size, quantities, and counting, such as finding the biggest and the smallest items and ordering visual representations of items, according to size (see for example, Figure 2). One KPT in Group 17 stated, "It is about size and numbers. Measurement, volume and comparison." Group 15 stated, "It is about largest and smallest, sorting, number and number words."

With Bimi Boo, most of the groups identified the mathematical object as being about cardinal numbers, number representations and numeral recognition, including how to write numerals. Group 10 stated, "It is about number comprehension and writing numbers." Similarly, Group 3 stated, "It is about numbers and quantity, cardinal numbers and number symbols."

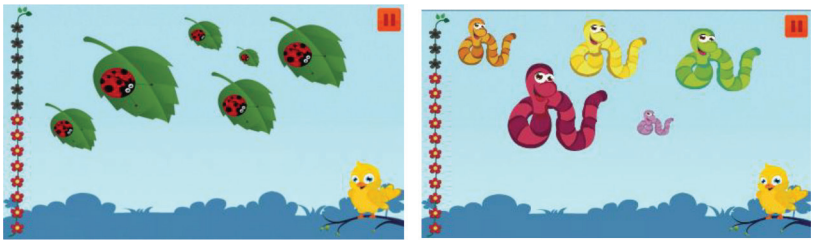

Figure 2. Screenshot of choosing the smallest and biggest object.

Such statements indicate that the KPTs focused on number comprehension, choosing to evaluate apps with this focus. This can be related to children's *danning*, if the KPTs did so because they valued this as knowledge children needed to be a competent member of society. As Meaney and Christiansen (2020) described, potential interactions between children and these apps are likely to shape children's interaction with mathematical ideas. Yet, most groups did not discuss the development of number comprehension beyond completing small tasks (discussed in the section on Rules) and focusing on individual ideas. This limited focus on number comprehension could restrict children's possibilities for *danning*, by not highlighting other mathematical topics such as problem-solving or developing number comprehension beyond limited understandings. It may be that teacher educators need to challenge KPTs to recognise other mathematical activities (Bishop, 1988) that might be present when children engage with these apps and to show how number understandings are more than being able to count or write numerals.

Rules

Rules are about the design of apps and how they are expected to function. Moyer-Packenham et al.'s (2019) research indicates that the design features of an app influence the learning opportunities for young children. When the KPTs discussed how and in what way the app should present mathematics to children, they provided insights into what they considered would be appropriate for children's *danning* in regard to how they should learn. Sometimes, the KPTs discussed how the rules of a game could be improved to provide better learning opportunities. For example, in discussing both apps, some groups identified that improved feedback could help children to complete the tasks correctly. This is linked to the subject node and the need for children to be successful when doing mathematics. The KPTs considered that the children should receive explicit information about what they had got wrong and how to fix it. Repetition and explanations were considered to be positive design features in both apps. These discussions provide insights into how the KPTs thought children should engage with mathematical ideas, which was through direct instruction and repetition of tasks. Direct instruction and repetition do not provide children with opportunities to make decisions for themselves and to learn through play as required by the Framework Plan (Ministry of Education and Research, 2017).

In the Bimi Boo app, a member of Group 3 said, "There is no feedback if you make a mistake, this should be explained." In some groups, there were suggestions that Bimi Boo should be more flexible in how it responded to what a child might do. For example, in one task, the KPTs had to place a specific number of ribbons on a cat (see Figure 3). The KPTs found it frustrating when the ribbons had to be placed on the head and not on any other part of the cat. A member of Group 7 summarised the group's feelings by stating, "It could be more flexible."

Figure 3. Screenshot of the KPTs placing two ribbons on the cat's head.

In evaluating Tella, some groups also suggested that the rules for how to play the game could be more flexible. For example, when discussing how the children should "place things in the right order", a member of Group 17 stated, "it could be from largest to smallest" (see Figure 4). For them, this inflexibility was exacerbated by the fact that there was no explicit information about what was incorrect. As one member of Group 17 said, "We do not get feedback on why we made a mistake."

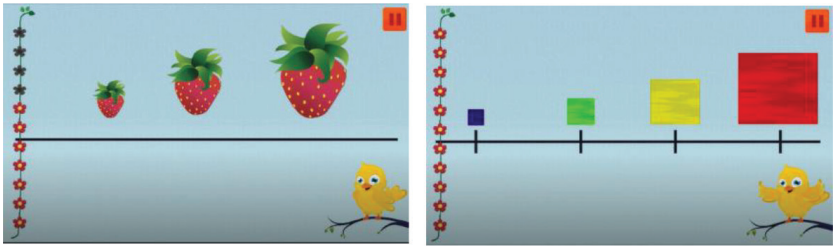

Figure 4. Screenshot showing "the right order".

The structuring of the tasks in Tella was also considered problematic, with the first-level tasks having to be solved before more advanced tasks could be attempted. As one KPT said in Group 10, "It's a pity we cannot advance." Related to this, some groups also described the tasks in the Tella app as being too similar and boring. They suggested that the children should have a range of choices about sizes and colours at the same level and should not have to wait till they reached the next level. They also felt that creating tasks involving only one small concept was not helpful for children's learning. Group 11 suggested that it would be better if related concepts were not separated, "It should be that you press the largest, press the smallest, press the pad colour, use slightly different terms, which is largest, which is smallest, in between." The KPTs noted that the design of the app focused learning on completing many small tasks, which was similar to what Christiansen and Meaney (2020)

had found in their research. The KPTs' evaluations indicated that they mostly valued young children making decisions and taking control in relation to the rate of their learning and the ordering of the tasks in the app. This is related to *danning*, in that it is about children becoming aware of their own rights and choices.

The KPTs generally considered the Bimi Boo app to be well designed, particularly due to its variation in tasks and the explanations provided to the children. Group 11 stated, "One of the best apps—very different every time." Group 9 highlighted the feedback, "Very nice that there is an explanation in the game." Group 10 described it as "very good and educational" because it did not just present facts that they had to be learnt, "It's not cramming—kids do it and learn it."

On the other hand, Tella was considered to present more abstract mathematical ideas, with the app instructing the children. For example, Group 5 stated, "It is very focused on mathematics," where mathematics, as discussed with the object node, was about comparisons and numbers. The KPTs considered that the Tella app provided limited possibilities for learning because the children had to work with mathematical ideas in a specific order. For example, Group 15 stated, "It's getting harder and harder." Similarly, Group 9 discussed how "It gets harder when more things appear." Some KPTs thought that the development of ideas went at an appropriate speed, "It works gradually with number comprehension" (Group 15). This suggested that the progression of tasks, as part of the design of the app, was seen by the KPTs to be connected with what children would be able to do on their own.

In their responses, the KPTs showed that they recognised how the rules of the different digital games could affect the children's opportunities for engaging with mathematical ideas. These discussions provided insights into how the KPTs thought that mathematics should be learned, through apps. Focussing on the structuring of the tasks indicates that the KPTs considered that children's possibilities for *danning* had to provide them with feedback on how to be successful so they could to be active in their learning. Providing small, manageable tasks was important to ensure children were successful, but if those tasks were too repetitive or easy, they could become bored. It may be that teacher educators need to encourage KPTs to understand how children's engagement with open, problem solving apps also give them opportunities to be successful but also engage in play as required by the Framework Plan.

Subject

The KPTs' discussions indicated that they saw the subject as being the child/ren, although at times they tended to merge their own needs into their understandings about children. For example, the KPTs frequently described both apps as being interesting for children. This seemed to be based on their understanding of what children could do or be interested in and how important it was for children to be successful in the tasks, in these two apps. This suggested that the KPTs considered that children needed to be motivated and active in their own learning as part of their development.

The KPTs described the Bimi Boo app as being most appropriate for younger children, but potentially boring for older children, as it was an easy game to play, with tasks being repeated at every level, with few new challenges. Group 19 described Bimi Boo as an app "For 2-year-old children, it's fine but for 3-year-olds it's boring," while one KPT in Group 3 stated that it was "boring after a while because there is nothing new, maybe that's why it's easier for the little ones."

The KPTs also identified that the children may not be able to trace the number symbols because they did not have the necessary fine motor skills. For example, a member of Group 3 stated, it is "intuitively difficult to draw the number inside the lines." In connection to *danning*, the KPTs seemed to consider that it was important for children to be successful in completing the tasks so they would be motivated to learn and engage with mathematics. For example, they talked about why they did not get any feedback when they made mistakes in both apps. In Group 3, one KPT said, "We must get feedback if we make a mistake." Similarly, in Tella, when the KPTs tried to place the items in the right order, "We do not get any explanation as to why we made a mistake" (Group 17). This suggests that the KPTs wanted to complete the tasks successfully and expected it also to be important for children to be successful, thereby motivating them to do more and to learn more.

The Tella app was described as providing children with opportunities for exploring through movement, colours and the different sizes of items. For example, Group 7 stated, "Things move and it does not get boring," while Group 11 said that "Movement and different sizes make it more exploratory." This suggests that the KPTs considered exploration and curiosity as helping children to learn through their own actions, which is in line with their descriptions of *danning* (Grindheim, 2020).

For KPTs, it was important that children should be successful in their interactions with apps. Being successful would contribute to their motivation for learning, exploration and curiosity. This could increase opportunities for children to learn through play by making their own decisions, also aspects that are considered to contribute to children's possibilities for *danning* connected to the Framework Plan (Ødegaard, 2019). Teacher educators may need to challenge KPTs in their pedagogical choices of apps that influence children's opportunities for *danning*.

Groups

The group node in the ACAT model relates to how an app might be used in the classroom, or in this case in a kindergarten, and focuses on the expected kinds of interactions children could have from engaging with apps either individually or in groups. Co-operation as part of this node can be related to *danning* as it provides a different kind of cultural formation than when children are expected to learn on their own. Comments that were categorised within the group node ranged from whether the KPTs considered the control of interactions with the app lay with the child or whether there was a potential role for adults

in controlling what happened in interactions with the app. This contributes to children's *danning* because it is about how their social environment and to human relationships are connected to their learning.

The KPTs considered that with the Tella app, adults would need to provide explanations, as the app was too difficult for younger children to play on their own. This point was summarised in Group 9, "The adults can explain to the younger children about what is smallest and what is largest." On the other hand, the KPTs considered that Bimi Boo was simple enough for children to play individually, "children can control the game themselves" (Group 3).

Underpinning these discussions, there seemed to be a view that the KPTs expected the children to use the app by themselves. If an adult was involved, it was to explain to the child what the app wanted them to do. In regard to *danning*, the KPTs seemed to expect children to become independent, responsible, and active on their own initiative, through playing digital apps. Teacher educators could broaden discussions about what the role of the adult could be when playing digital apps, as in the Framework Plan it is stated that staff shall be actively involved with the children when using digital tools (Ministry of Education and Research, 2017, p. 44).

Artifact

The artifact node focuses on the apps and how they acted as mediators between the object, the mathematical content and skills, and the subject, the children, with considerations of the rules and the group. For example, when the KPT identified how colour and movement in both apps make them interesting for children (see discussion about the Subject), they highlighted how the design of the app (the rules) contributed to children's engagement in mathematical ideas. Thus, the KPTs implied that they expected that as part of their possibilities for *danning*, children would learn that materials needed to be interesting in order for them to engage with mathematical ideas.

The KPTs indicated that number comprehension tasks in the apps needed to be small and manageable so that children would be successful. It also seemed that the KPTs assumed the children would play the apps by themselves, with teachers or adults only needed if the apps were too difficult for the children to understand by themselves. As a result, parental control, repetition, and feedback built into the apps were considered good design features that would support children to work individually and be successful. The KPTs' expectations about children working individually on the apps can be considered as providing opportunities for children's *danning*.

The KPTs considered it problematic if the children could repeatedly fail when they engaged with the apps, as this would create a negative feeling towards learning mathematics. The KPTs wanted feedback and repetition in the apps because they considered that children needed to be successful when they were learning.

Identifying how the KPTs' comments related to the different nodes in ACAT theory provided a way of understanding what they valued as possibilities for how mathematics education could contribute to young children's *danning*. For example, how an app should teach children, what kind of ways children should interact with it and what kind of mathematics children should have experience with have the potential to contribute to children's *danning* (see for example definitions of *danning* in Ødegaard, 2019).

The Norwegian *Framework Plan for Kindergartens* indicates that digital tools should encourage "children to play, be creative and to learn" (Ministry of Education and Research, 2017, p. 44). However, possibilities for children's learning through play and being creative did not seem to feature in KPTs' evaluations of the different apps, even though they had been asked to focus on play in their evaluations. Teacher educators might need to have discussions about the design features of apps which support creativity and co-operation with KPTs to broaden understandings about how these aspects could be seen, or not, in children's engagement with apps. As it states in the current Framework Plan, for the mathematical goals, learning includes "discovering, exploring and creating structures that help children to understand relationships in nature, society and the universe" (Ministry of Education and Research, 2017, p. 53). Yet at the beginning of KPTs' teacher education, they may have different understandings about the range of opportunities for *danning* that could be provided to young children, through their engagement with mathematical apps.

Conclusion

The beginning KPTs evaluated the two mathematical apps by discussing how they thought children would engage with mathematics when using them. This provided insights into what they valued as possibilities for children's *danning*. Nevertheless, the KPTs' evaluation of these apps provides only a limited insight into what they considered might contribute to children's *danning*, based on their perceptions of how they expected children to engage with the apps. However, *danning* is a continuous process affected by multiple aspects (Ødegaard, 2019) and it is likely that KPTs would raise different aspects in other contexts.

Nevertheless, as baseline data about KPTs' views, this study can inform teacher educators, who like those at Western Norway University of Applies Sciences have limited time to support KPTs' development of understandings about children engaging with mathematics apps, about what to raise in their mathematics teacher education, such as the requirements of the Framework Plan, especially in regard to play and being creative. Without such a focus in the teacher education, KPTs may continue to struggle with how to include digital tools into their future work in kindergartens (Alvestad & Jernes, 2014). This would then

have implications for the possibilities for *danning* made available to children. Although only a small study, some of the finding might be relevant for other teacher education programmes.

These KPTs' focus on young children learning about quantities and numbers, as mathematics, could be broadened so that other mathematical activities, such as locating and problem solving, could be recognised in children's engagement with app. The KPTs' foci could also be expanded by considering how children could use the app with a group or with an adult. The KPTs indicated that the children should use the app individually which then requires the app to be at the right developmental level for the children. If the app could be used by groups or with an adult, different ways of engaging with the mathematical ideas would be possible and this would open up other opportunities for children's *danning*.

These results also indicate areas for future investigation. For example, it would be interesting to know whether the KPTs' views change during and after the use of these apps in kindergarten, based on the children's engagement with them. By identifying what children can do, rather than what they imagine they could do, the KPTs could gain more focused insights into the children's learning processes and, thus, into children's *danning*. Previous research (Hauge et al., 2018) has shown that interacting with kindergarten children may also help educators to understand how their theoretical and practical knowledge can be combined to improve the children's pedagogical mathematical knowledge. This could lead to providing both additional and a wider range opportunities for young children's *danning*.

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