PRESCHOOL TEACHERS' USE OF FINGERS IN EARLY NUMBER TEACHING

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In this paper, we present the ways in which fingers are used as representations in teaching the basic meaning of numbers to young learners, and what learning opportunities the different ways entail. This is done through an analysis of 38 video recordings from authentic Swedish preschool teaching situations. Three ways of using fingers as representations were identified in the observed interactions: Fingers as countables, as symbols, and as bridging tool. Different finger-use opened for different meaning to be discerned; cardinality as a novel notion was made discernible when fingers were used as bridging tool, connecting different quantities but also different modes of representation. The results provide empirical evidence for how *fingers are used as primary to* if *fingers are used in early number teaching.*

INTRODUCTION

In a growing body of studies, we and other researchers have investigated how the basic meaning of numbers, cardinality included, can be taught to the youngest learners in the education system (e.g. Björklund & Palmér, 2022; Paliwal & Baroody, 2020). This means, we direct our focus to learners, to whom numbers are truly novel concepts. In previous studies, we have found indications of the power of using fingers in teaching situations with novel number learners (Björklund & Palmér, 2022). Fingers can however be used in different ways, for example finger counting versus finger patterns, where different ways of using fingers offer different meaning to be discerned (Björklund, 2025; Roesch et al., 2024).

In this paper, we continue this strand of research by an explicit focus on how teachers use fingers as a mode of representation in teaching the basic meaning of numbers. As no representation is self-instructive, the meaning must be learnt, but the way a representation (such as fingers) is used may induce different ways of experiencing the meaning (Duval, 2006). This becomes particularly important to direct attention to in an early childhood mathematics education context, because of the dual complexity of number representations. That is, numbers are novel concepts to young children and so are representations through which numbers' meaning is to be explored. In the present study, the following research questions will be explored:

RQ1) In what ways are fingers used as representations in teaching the basic meaning of numbers to very young learners?

RQ2) What learning opportunities do the different ways of using fingers entail?

2026. In H. Krzywacki, M. Hähkiöniemi, E. Haataja, M.S. Hannula & P. Hästö (Eds.). *Proceedings of the 49th Conference of the International Group for the Psychology of Mathematics Education: Research Reports*, pp. 195-202. PME.

The research questions will be answered through an analysis of video recordings from authentic preschool teaching situations.

RESEARCH ON FINGER USE IN EARLY MATHEMATICS EDUCATION

Most research on finger use in early mathematics education has focused on whether children use their fingers or not and when they start and/or end using their fingers (Krenger & Thevenot, 2025). Finger-based interventions combining multiple finger representations have shown to significantly improve children's understanding of numbers and use of numbers in problem solving, suggesting that integrating diverse finger representations is an effective pedagogical approach for supporting early mathematical development (Frey et al., 2024; Jay & Betenson, 2017; Ollivier et al., 2020). As contextual factors have been shown to have impact on young children's spontaneous use of finger-based strategies in early numerical development, finger use may not be an automatic behaviour but rather shaped by environmental support (Roesch et al., 2024). Following this, we focus in this study on *how* fingers are used as representations by teachers with a focus on learning opportunities for young children.

In early childhood, when children are learning to use their fingers in numerical problem solving, there seem to be both more and less effective ways of using fingers. Some ways may support the child in completing a numerical task but will not support the child in their continued development of understanding the meaning of numbers, and how to use numbers effectively in problem solving (Neuman, 1987; Björklund et al., 2019). Finger counting (extending single fingers successively) is primarily associated with procedural counting skills, whereas finger number gesturing (extending fingers simultaneously to represent magnitudes, also called finger patterns) is more strongly related to an understanding of numerical magnitude (Roesch et al., 2024; Björklund et al., 2019). The difference lies in whether fingers are used as object representations ("one, one, one, one, one") or as summative symbols ("five together"). The latter is related to seeing number as consisting of composite units, emphasizing cardinality as a significant attribute of numbers, which is considered fundamental to developing arithmetic skills (Baroody & Purpura, 2017; Björklund et al., 2021). Furthermore, based on several studies of the relationship between number estimation and finger-use habits (Berteletti & Booth, 2016; Elgavi & Hamo, 2024), early experiences with gestures and finger-based strategies seem to create lasting neural connections between fingers and numerical representations that affect numerical processing and finger use when encountering quantities in tasks. This means, teachers should encourage and model ways to use fingers that help children to develop conceptual understanding of numbers (Krenger & Thevenot, 2025; Björklund, 2025).

METHOD

The empirical material in this paper is from a Swedish study on preschool mathematics. Preschool is a voluntary practice for 1–5-yearolds in Sweden with high attendance rate. In the study, activities that was earlier trialled and evaluated in a former project (see for example Björklund & Palmér, 2022; Palmér & Björklund, 2023), was now

implemented in 18 preschool groups. A guiding material was provided with example activities and background information about principles for learning about numbers in the early years. One important part of the activities was the use of representations, including fingers (Björklund & Palmér, 2025). Preschool teachers carried out the activities at their preschools as part of the regular pedagogical practice, capturing the interaction on video for research purposes. The teachers chose the number of children involved in the activities (varying between individual interaction and larger groups of up to 10 children), what kind of activity (enacting the example activities or planned by themselves) and the material they wanted to use in their teaching, resulting in a large variety of authentic preschool activities collected as data for analysis.

For this study, an analysis was done of all 38 video-documentations of the activities conducted by the preschool teachers. These recordings were made by the teachers themselves and uploaded to a secure online server to which only the teachers and the researcher had access. Data was collected from each preschool during one semester. Swedish ethical guidelines for research regarding information, consent and confidentiality were followed throughout the study (approved ethical review 2023-01344-01).

Analysis

Variation theory (VT) is used as framework for the analysis of what meaning of numbers that different ways of using fingers in numerical situations may offer children possibilities to discern. According to VT (Marton, 2015), learning means to discern aspects of a phenomenon that a learner has not previously discerned, that is, aspects brought to the foreground of the learner's awareness. Cardinality is one such aspect of the phenomenon numbers that is necessary to discern to handle numbers as describing magnitude. But when the learner encounters a certain situation, quantity or magnitude is perhaps not primary foregrounded because it is an abstract attribute and needs to be represented (see also Duval, 2006). When the phenomenon (for example the concept of numbers) is novel to the learner, necessary aspects are, in line with VT, discerned when features of that aspects are contrasted against an invariant background. Teaching numbers then means to facilitate the discernment of necessary aspects of numbers, which is made possible through carefully selected representations that are used in ways that liberate such discernment. In the current analysis, these theoretical conjectures have guided us in identifying what meaning of numbers that the use of fingers (as one kind of representation of numbers) make possible for children to discern. The result of the analysis informed by VT is thereby what learning opportunities different uses of fingers entail in terms of aspects made possible to discern (and not discern).

To answer RQ1, the video-documentations were categorized based on qualitatively different ways of how teachers used fingers. RQ2 is theoretical in the sense we conjecture what is made possible for children to discern when fingers are used in the different ways identified in the empirical data. Thus, even though the focus is on the teachers' use of fingers, the empirical video-documentations are essential in this

analysis, because the learners' response to the finger use may reveal what is actually made possible to discern from the offered representation.

RESULTS

Three ways of using fingers as representations were identified in the observed interactions: Fingers as *countables*, as *symbols*, and as *bridging tool*. These are described respectively (RQ1) and interpreted in terms of the aspects that are brought fore, and thus the learning opportunities they entail (RQ2).

Fingers as countables

In the observation data we see fingers used as countables, usually with the purpose of keeping track of counted objects.

> The teacher asks two children to choose a number of "stones" cut out of grey paper, as part of props included in a game that they are engaged in.
>
> Teacher: How many stones do you want? You can have one (extends her index finger) or two (extends also her long finger) or three (extends her ring finger) or four (extends her little finger, showing four fingers with thumb unfolded).

In the example above, the teacher uses her fingers to aid the counting. Each finger is made a single unit when she is extending it while saying a counting word. In doing that, no connection is made to the whole set, the counting words connection to the single fingers may rather be discerned as fingers given "names", as the cardinal attribute is not pointed out for the children. When fingers are unfolded one by one, and the set of fingers end up being shown at the same time (see also next category for contrast), the fingers could be perceived as a composed set of fingers "all together". But when, as in the example above, each finger is pointed out one-by-one, it is more likely that the fingers are experienced as representing single units, whereas the connection to the said counting word is not making the cardinality discernable.

Fingers as symbols

Fingers are observed to mediate cardinal meaning of numbers when they are used as symbols by the teachers, usually in combination with a counting word and also often connected to a set of objects that the teacher and the children are attending to. Both teachers and children show finger patterns with symbolic meaning, as in the following example.

> The teacher and two children have four papers with digits printed on them, faced down on the table. The girl turns one paper and gets a 4.
>
> Girl: Four! (shows four fingers on her right hand, thumb folded)
>
> Teacher: Four, good! (also shows four fingers, thumb folded). Can you go get four pieces of Lego blocks?
>
> Girl walks over to another table with a pile of Lego blocks, picks up some and returns to the teacher's table. In the meanwhile, the boy begins to turn over another paper.

Teacher: Wait just a second, we'll wait 'til she comes back with four Lego blocks (shows her four fingers in front of the boy). Are you coming with four pieces?

Girl puts *five* Lego pieces together while walking back to the table.

Girl: Four.

Teacher: Four pieces, this many (shows four fingers again)

In this example, several representations are used and connected, but what stands out is the consistent use of a finger pattern for the number four. The children in this example are probably aware of some cardinal meaning of numbers, but the teacher supports and generalizes this in their interaction. She uses the fingers as a pattern shown instantly where the set of four fingers are recognizable both as a group of similar objects, easy to see as constituting a set because the finger not included (thumb) is held down. At the same time, this finger pattern is an abstraction in the sense of "meaning four"; the girl does not count her fingers to make the finger pattern, she recognizes it instantly and the finger pattern is likely connected to the symbol 4 on the paper on the table; they share some similarity in meaning expressed through different modes of representation. Four seems to have some kind of cardinal meaning, which is expressed as she walks over to get *a number of* blocks, but the exact cardinal meaning is likely not discerned because she returns with more than four pieces of blocks. Connecting the different modes present in the situation (graphic symbol, verbal notion and finger pattern) is thus not a guarantee for cardinality meaning to be discerned even though the finger pattern may be seen both as a countable set of objects and as a symbolic expression for a phenomenon that is related to quantity.

The finger pattern for a number is in the observations usually shown in a canonical pattern, keeping fingers that are close to one another folded or unfolded, but there are exceptions, for example four is shown as two fingers (e.g., index and long finger) on both hands. The finger patterns are thereby not symbolic as in a static pattern representing a specific number (e.g., an image or icon), instead, it seems to be a symbolic representation carrying the meaning of cardinality as an attribute of numbers that is emphasized, particularly when different finger patterns are used by the same person for the same number.

Fingers as bridging tool

In some cases, teachers are using fingers as a bridging tool by keeping a finger pattern as reference point and comparing two sets of objects, sometimes represented through different modes, like a set of dots and a number of objects as in the example below.

The teacher sits with two children on the floor. They play a game where one child throws a dice and picks the same number of camels from a bag. They now see three dots on the dice facing upwards and are to determine if they have picked out three camels.

Teacher: How many camels do you have now?

Girl: One, two, three! (points with her index finger on each camel she picked out)

Teacher: Three (shows index, long and ring fingers simultaneously extended). Three camels (puts index, long and ring fingers on one camel each) and three dots (moves her finger pattern to the dice placing each finger on one dot).

In the example, cardinality is emphasized when the teacher agrees on the child's enumeration by saying the counting word out loud and showing the finger pattern for three; they have together determined that there are three camels on the floor. The teacher further connects the finger pattern "three" in a one-to-one correspondence with the three camels, then moves the finger pattern unchanged to the dots on the dice. In this way, it is made possible to generalize the cardinality as an attribute of numbers represented in different modes (words, manipulative, pictorial, fingers). The fingers play a significant role here also as the bridging tool, where fingers are both concrete objects that may be enumerated (three fingers) and an abstraction of the quantity, thereby generalizing by transferring the same pattern from one set to another.

Conclusion

In a single episode of interaction where fingers are used, there is rarely only one way of using fingers observed. The teacher or child may first point and count a number of objects, ending by showing the finger pattern of the total number of objects while repeating the last counting word. If a child seems unsure about the cardinality aspect, the teachers are observed to follow up the counting by saying the counting words once more but this time pointing one finger to each object (one-to-one) and thereby creating the finger pattern in the action, thus ending up connecting a finger pattern to both the set and the last uttered counting word. If applicable to the task at hand, the finger pattern is then used as a reference point to compare the number of objects in different sets. The fingers may in this way change the meaning they represent through the action.

An additional way of making use of fingers has deliberately been omitted in the analysis – gestures – because the meaning of the finger use is different in nature compared to the representational meaning found among the presented three ways of using fingers. That said, pointing and circling gestures are significant assets in early mathematics education, but because of the distinct differences in intentional meaning (e.g., directing attention to a set, in comparison to representing the set as a numerical phenomenon), these are discussed elsewhere (see Björklund & Palmér, 2025).

DISCUSSION

Previous research in early mathematics education has mainly focused on whether *children* use their fingers or not or when they start and/or end using their fingers (Krenger & Thevenot, 2025). Fingers used by *teachers* to mediate certain meaning has however not been an object for closer analysis. This should be of importance when discussing number learning in the early years when numbers are novel concepts and a careful use of mediating representations is critical. Two of our three identified categories – fingers as countables and fingers as symbols – are not new observations (e.g., Jay & Betenson, 2017; Ollivier et al., 2020). However, they are rarely

problematized in terms of the qualitatively different learning opportunities they might provide. The third category, fingers as a bridging tool, seems not to have been recognized to the same degree as a valuable means to teach cardinality. Based on our analysis, it seems plausible that fingers can work as bridging from more concrete representations (countable objects) to abstract representations (symbolic), while retaining and emphasizing the cardinal meaning.

Our observations are made of authentic interaction taking place in common preschool activities, which is a strength in the analysis by giving an insight to how fingers are naturally used to facilitate number learning. The intention was not to evaluate fidelity to the guiding material that was given to the teachers, but to identify the different ways of using fingers that teachers enacted when numbers were made the object of learning. An interesting finding is that fingers are often used in multiple ways in the same situation. Fingers change the meaning they represent through the activity, which adds more empirical evidence to earlier research claiming that it is not whether fingers should be used in early mathematics learning and teaching, it is *how* fingers are used that may have an impact on learning opportunities. However, more research in the early years would be needed to determine actual learning outcomes related to how teachers make use of fingers in teaching interaction with the youngest learners.

Acknowledgements

This study was financially supported by the Swedish Institute for Educational Research, grant no. 2022-00010.

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