



**HAL**  
open science

## An arithmetical word problem-solving intervention for disadvantaged French kindergarten children

Marie-Caroline Croset, Sébastien Caudron, Laure Mondelain, Ahmed Zaher,  
Hamid Chaachoua, Karine Mazens

► **To cite this version:**

Marie-Caroline Croset, Sébastien Caudron, Laure Mondelain, Ahmed Zaher, Hamid Chaachoua, et al..  
An arithmetical word problem-solving intervention for disadvantaged French kindergarten children.  
2024. hal-04652839

**HAL Id: hal-04652839**

**<https://hal.science/hal-04652839>**

Preprint submitted on 18 Jul 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# An arithmetical word problem-solving intervention for disadvantaged French Kindergarten Children

Marie-Caroline Croset<sup>1</sup>, Sébastien Caudron<sup>2</sup>, Laure Mondelain<sup>1</sup>, Ahmed Zaher<sup>2</sup>, Hamid Chaachoua<sup>1</sup> & Karine Mazens<sup>2</sup>

<sup>1</sup>Université Grenoble Alpes, CNRS, LIG, 38000 Grenoble, France

<sup>2</sup>Université Grenoble Alpes, CNRS, LPNC, 38000 Grenoble, France

## Abstract

Previous research has shown the importance of conducting early interventions in mathematics in disadvantaged children. Solving arithmetical word problems is a field in which children particularly fail. In this study, preschoolers from disadvantaged French public schools (N= 101;  $M_{age} = 5-6$ ) were taught strategies for using fingers to solve arithmetic word problems and compared with a control group. The intervention consisted of collective rituals based on learning fingers patterns and 7 sessions spread over 4 weeks, for about 20 minutes, focusing on explaining how to use the fingers to solve problems. The results showed that the intervention has a significant post-test impact on the targeted transformation problem-solving skill and that children with lower performances in problem solving at pre-test benefited more from the intervention. The intervention had also indirectly benefited the other problem-solving skills. However, there was no intervention effect on the arithmetic addition task. Our research highlights that an intervention focused on explicit teaching of finger strategies for problem solving can be successfully implemented into ecological learning contexts, especially in disadvantaged areas.

## Keywords

Problem solving, Priority education, Kindergarteners, Preschool mathematics instruction, Finger patterns

International assessments in mathematics such as Timss 2019 or Pisa continue to place France below the European average as well as that of the other OECD countries (DEPP, 2020). In response to this low ranking, French education policies have engaged mathematics education researchers to develop collaborative research with teachers and to test the effectiveness of teaching sequences into real-life learning context (Villani & Torossian, 2018). Arithmetic word problem solving is one of the least successful fields of mathematics in the 1<sup>st</sup> and 2<sup>nd</sup> grades in French national assessments: in 2021, 32.7% of children entering 1<sup>st</sup> grade were considered to be in difficulty (MENR, 2021). This rate rose to 51.3% in 2<sup>nd</sup> grade. This domain is particularly marked by social inequality: the performance gap between the proportion of 1<sup>st</sup> grade children enrolled in priority education (public school network defined by geographical areas with families with a low socio-economic level, on average - see below in method section) with a satisfactory mastery of problem solving and those enrolled outside non-priority education is 19.7%, surpassing all the other domains assessed. It therefore seems important that teaching of this domain be introduced even before entering 1<sup>st</sup> grade, especially for disadvantaged children enrolled in priority education. This raises several questions. How should problem solving be taught at such an early age? How should we go about finding an effective means to solving the problem that can be taught by the teachers themselves?

## Arithmetic word problems

### What is an arithmetic word problem?

Word problem solving seems to be considered a key skill in mathematics (for an overview of the research literature on word problem solving, see Verschaffel et al., 2020). Word problems are arithmetic problems that tell stories without any formal mathematical symbolism of the mathematical operation (addition, subtraction, multiplication or division). Word problems are not, however, authentic problems of everyday life: the modelling of the problem, e.g. the numerical information or the operations to be used, are simply easier to deal with. To be more precise, a word problem can be defined as “a text (typically containing quantitative information) that describes a situation assumed as familiar to the reader and poses a quantitative question, an answer to which can be derived by mathematical operations performed on the data provided in the text.” (Greer et al., 2002, p. 271). In the additive field, 3 classes of problem can be distinguished according to the semantic structure of the additive terms involved: combine (“There are 4 boys and 7 girls. How many children are there altogether?”), change/transform (“There are 3 tokens, I add 2. How many tokens are there now?”) and compare (“Tyler is 5 years old. Mila is 3 years older than Tyler. So How old is Mila?”) (Riley et al., 1983; Vergnaud, 1982). These classes of problem do not have a simple correspondence with the mathematical operations. Depending on what the question is about (the number of boys, the number of girls or the number of children) or the nature of the action of the change (an increase or a decrease), the problem can be modelled by addition or subtraction. “There are 3 tokens, I add 2. How many tokens are there now?” or, “I have a number of tokens. I lose two. Now, I have 5. How many did I have at the beginning?” can be modelled by addition while, “There are 3 tokens. I lose 2. How many tokens are there now?” or, “I have a number of tokens. I add two more. Now, I have 5. How many did I have at the beginning?” can be modelled by subtraction. Several studies have highlighted the relevance of this semantic structure, both in terms of the difficulty of the problems and the strategies used by children to solve them (see Verschaffel & De Corte, 1997 for a review).

### Why teach arithmetic word problem solving?

The learning objective of word problem solving depends on the grade level at which the problem is proposed. Thus, if mathematical formalism has already been introduced, proposing a problem to children may have as its objective to give practice at applying what has just been taught. Working on word problems before teaching mathematical formalism can serve two major learning goals. The first is to make sense of a mathematical operation. This is the case of “Realistic Mathematics Education”, which advocates a “bottom-up” approach (Van den Heuvel-Panhuizen, 2000). The aim of the teaching here is to help children to make the transition to more formal mathematical activities in which conventional symbols make sense to them (Gravemeijer et al., 2000). A second goal may be to confront children with problems that are considered complex for their age, in the sense that children cannot solve them in a routine way. Whatever the objective, how to teach word problems effectively remains problematic (Verschaffel et al., 2020, p. 4, 5).

### How should we teach arithmetic word problem solving in pre-school?

In order to give meaning to mathematical operations, Fagnant (2013) stresses that word problem solving should be taught before the introduction of formal symbols of operations concerning either written forms (+, −, ×, ÷) or verbal forms (plus, minus, times, divided by). Children need to understand that the use of mathematical symbols is equivalent to the concrete actions. Indeed, Fagnant suggests that children's informal strategies, such as using manipulatives or fingers, could serve to give meaning to these operations. In the French system, this would require

that this teaching should take place before grade 1 (children aged about 6 years old) when the symbolism of addition and subtraction is introduced.

The semantic structure of the problem and the nature of the question have an impact on a child's performance. Transforme and combine problems are more successful, especially when the question is about the final state and the whole rather than compare problems (Riley et al., 1983, p. 162-164). Problems of the same semantic class, whether solvable by addition or subtraction, should be taught in parallel and not separately since their treatment involves concepts and procedures of several closely connected types (Fagnant, 2005; Vergnaud, 1982, 1992)

The simulation of situations, at first physically with a tangible manipulation and then mentally, favours the learning of arithmetic operations and the understanding of symbols. Levine and her colleagues (1992) showed that, as early as age 4, children are able to solve problems by simulating with materials (without the possibility of simultaneously seeing the two addends of the problem). To solve word problems, children use various strategies such as tapping their feet, decomposing numbers or using their fingers (Siegler & Shrager, 1984). These strategies involving physical gestures seem to appear spontaneously very early on the child's development (for a review of the role of gestures in learning arithmetic, see Goldin-Meadow et al. (2014)). Thus, the use of a physical simulation of the word problem on the one hand and the use of tangible material on the other will favour the transition to conceptualization, in other words from quantity (concrete magnitude) to the symbolic code of numbers.

### Fingers, a relevant number representation tool for solving problems

Finger use as a relevant intermediary between quantity and the symbolic codes has been suggested by different authors, in particular because fingers have the specificity of being sensori-motor representations (e.g. Andres et al., 2008; Butterworth, 1999; Di Luca & Pesenti, 2011). Fingers can help mainly in two domains: A deeper understanding of the concept of number and arithmetic learning.

Quantities can be represented by fingers as counted units (i.e. raising fingers one at a time). In this case, fingers tend to take on an ordinal meaning. This means that the obtained collection is a concrete representation where each unit is present and can be manipulated. In this regard, the raised fingers are an analogical code of quantity which makes it more concrete than the number-word or the Arabic code. Fingers thus have the same function as materials (Levine et al., 1992): they are a collection of tangible units. Quantities can also be represented as patterns (i.e. raising fingers simultaneously to design a set). In this second case, fingers generally take on a cardinal meaning. The fingers represent a composite set of units, being used as a new code. By using this same representation to represent quantities of different collections (cars, marbles, etc.), the child gradually moves away from a tangible representation and enters into a process of abstraction. Thus, fingers allow a representation of the cardinality of a set and give meaning to quantities by being a link between the quantity's magnitude and the symbolic code.

Beyond helping to have a deeper understanding of the concept of number, the fingers also support arithmetic. Even if finger counting is not a necessity for performance in arithmetic (Lafay et al., 2013) and inter-individual differences are strong (Guedin et al., 2018), researchers have looked at the possible relationship between finger use and performance in arithmetic. In a longitudinal study involving children from kindergarten to 2<sup>nd</sup> grade, Jordan and her colleagues (2008) found a relationship between finger use and calculation performance, but only in younger children. Dupont-Doime and Thevenot (2018) added that children who use their fingers in addition tasks are the ones who have a higher working memory capacity. These results have been completed in a longitudinal study showing that children who use their fingers the most at age 5 use them the least at age 7 and that 7-year-old

children who use their fingers have a lower working memory capacity (Poletti et al., 2022). Despite these correlational studies, there is no evidence of a causal relationship between finger use and performance in arithmetic (Guedin et al., 2018). These authors have argued for the promotion of finger use in arithmetic tasks in the early school years. Specific finger strategies should be explicitly taught to children who have difficulties in discovering and implementing them (Dupont-Boime & Thevenot, 2018, p. 41). What about today's teacher representation and practice about finger-counting? Two recent studies (in Turkey, Mutlu et al., 2020, and in France, Poletti et al., 2023) show that preschool teachers are mostly positive and explicitly teach finger counting strategies. Historically, this positive attitude has not always been present, as it was thought that counting on fingers could prevent children from reaching more mature strategies (Boaler & Chen, 2016).

Siegler and Shrager (1984) and Baroody (1987) described different finger use in children learning arithmetic. In simple additions, the two main strategies were “*counting all*” and “*counting on*”. For an arithmetic problem such as  $3+2$ , counting all means representing the first addend “three” on the first hand (counted by raising fingers one-by-one or as finger patterns), then representing the second addend on the second hand, and at the end counting out, one by one, all the raised fingers to determine the total. Variations may exist: e.g., children can represent the first addend and then, complete the first hand before using the second hand. It is useful, for example, if the second addend is greater than 5 (e.g.  $2+6$ ) or if the addition consists of more than two addends (e.g.  $2+4+3$ ). In this case, the reading of the cardinality may be facilitated by recognition of the finger pattern obtained. “*Counting on*” means starting from the first addend (3 in the example of  $3+2$ ) and adding the second addend by counting out “four, five” and raising corresponding fingers. Björklund and her colleagues (2019) have also observed different strategies of using fingers for subtraction by preschoolers. They focused their results on a Transform problem where the question was about the final state (“If you have 10 candies and eat six of them, how many are left?”). They identified three main strategies depending on whether the numbers involved (in the previous example, 10, 6, 4) were represented with finger patterns or by counting fingers one by one. They found that the most common way was not to count fingers as single units, but to structure the part-part-whole relationship with finger patterns.

Researchers have noted the lack of interventional studies and encourage researchers to investigate the effectiveness of training in the use of fingers (Berteletti & Booth, 2016; Costa et al., 2011; Fayol, 2012, Chap. I; Gracia-Bafalluy & Noël, 2008). To our knowledge, only two studies have evaluated the efficiency of a school intervention based on finger training (Ollivier et al., 2020; Orrantia et al., 2022). Ollivier et al.’s program was based on the development of fine motor skills and on an explicit knowledge of how fingers can represent and decompose numbers. This was aimed to lead 5- to 6-year-old children to counting on their fingers and thus performing better in calculation tasks. The results were encouraging as they showed that children improved compared to those in the control group, who also worked on decomposing numbers using cubes or tokens but without perceptual training of fingers. However, as two skills were trained (finger gymnastics and the decomposition of numbers), future studies are needed to better understand what is efficient in the program. Almost at the same time, the team of Orrantia and colleagues (2022) started testing the effectiveness of teaching finger use as a representative of symbolic code. They have shown into real-life learning context that an intervention aimed at training finger patterns to represent numbers improves children’s understanding of cardinality. These two studies show that teaching the use of fingers to represent number improve both a deep understanding of numbers and word problem solving.

## The Current study

The main purpose of our research is to evaluate the impact of a problem-solving program into real-life learning context. Kindergarten schools in priority education network (with most disadvantaged background) have been targeted to test this intervention, since problem-solving is a mathematical domain particularly marked by differences in learning due to social inequality (MENR, 2021). As described in the previous section, the use of fingers seems to be a good way of representing the numbers involved in word problems. Few studies have investigated the effectiveness of such instruction. Ollivier et al. (2020) have revealed that training children to represent quantities with their fingers has a positive impact on problem solving. Orrantia et al. (2022) have shown that by receiving training on how finger patterns represent numbers, children can develop a better understanding of cardinality. These authors have shown that teaching how to represent numbers on one's fingers seems to be effective. However, to our knowledge, no study has yet been conducted on the effectiveness of explicit teaching *on the ways of using one's fingers* to solve word problems. In support of this line of thought, Björklund's study (2019, p. 21) suggests that, "Finger use for problem solving is not necessarily a 'natural' phenomena that all children engage in spontaneously".

Our research question is, therefore, whether performances in problem solving can be improved in kindergarten children by explicitly teaching them different ways of how to use their fingers to solve problems. We would only teach the transformation problems where the question concerns the final state and instead vary the nature of the action of the transformation (increase, decrease). Our research compares a teacher-implemented intervention program, in which strategies for using fingers to solve transformation problems are taught, with a "business as usual" group within a population of disadvantaged kindergarteners (for more details, see Control group section). The children's mathematical skills (core skills tasks on understanding numbers, word problem solving and arithmetic tasks) were tested before and after experiment. We hypothesize that children who have learned how to use their fingers to solve word problems will manage to solve transformation problems where the question is about the final state (directly targeted by the intervention) better than those who have received conventional instruction (the "business as usual" group). This is why, even though the intervention focuses on a single type of problem (transformation with question on the final state), we have evaluated the children's performance on other types of problem (compare problems or transform problems where the question is about the initial state or the transformation itself): children could also indirectly benefit from the teaching of explicit problem-solving strategies. Finally, as fingers can also be used to solve arithmetic tasks, we can assume that the children in the intervention group would show an improvement on addition tasks.

## Method

### Participants

The sample used in the experiment consisted of 130 children, aged from 5 to 6 years, enrolled in 12 kindergarten classes in 5 French public preschools. In France, schools are free of charge and the attribution of places depends almost exclusively on the family's place of residence. The social position index (SPI), a measure of student social status (Rocher, 2016) has been constructed as a weighted average of characteristics including types of diploma, cultural practices, material conditions and parental involvement in their children's schooling. This guiding scale varies for French schools between 49.6 and 155.6, with an average of 103 in 2022. In 2022, 11% of all French schools were identified as meeting the conditions for the "Priority Education Network with a low SPI. Schools in

this network benefit from special teaching conditions, in particular a class size of about 12 children. The five schools involved in our research all belong to this “Priority Education Network”, are characterised by a low SPI (69.80; 73.5; 75.4; 88.3; 101) and thus benefit from small class sizes. Within the priority education networks, a distinction is made between the PEN+ (reinforced priority education network), which concerns neighbourhoods with the greatest concentrations of social difficulties that have a strong impact on academic success, and the PEN, which are more socially mixed but still encounter more significant social difficulties than schools located outside the priority education system. In our research, the classes belonging to the PEN and PEN+ were identified in order to control any potential effect of schools that had been assigned to one network or the other.

The experiment was approved by the local school boards. Parental consent was obtained for each participating child and each child gave his/her assent to participate in the experiment. Of the original sample of 130 children, 16 did not participate in the study because they were absent at the pre- or post-test sessions, 7 children were absent from at least two training sessions, and 6 were considered as outliers based on their results. The final sample comprised 101 children (58 girls and 43 boys). The children ranged in age from 63 to 76 months ( $M = 70.2$  months, mean age 5 years and 10 months,  $SD = 3.28$ ). The classes were divided into experimental and control groups in order to balance the numbers of participants and priority education network membership: in the interventional group, 3 classes belonged to the PEN and 3 classes belonged to the PEN+; This same organisation applied to the control group. Participants from the two groups did not differ with respect to age, gender, and for their repartition in PEN and PEN+ classes (Table 1). Data were collected at the end of their kindergarten year, from May to June 2022.

	<i>Non Intervention group</i>	<i>Intervention group</i>	<i>Statistics Non intervention vs. intervention group</i>	<i>Total sample included</i>
Sample size	52	49	101	101
Mean age (SD)	69.8 months (3.1)	70.7 months (3.4)	$t(99) = 1.48$ ; $p = 0.14$	70.2 months (3.3)
Girls / Boys	31 / 21	27 / 22	$\chi^2 (N=101) = 0.21$ ; $p = 0.65$	58 / 43
Priority Education Network membership:	3 / 3 classes 28 / 24 children	3 / 3 classes 25 / 24 children	$\chi^2 (N=101) = 0.08$ ; $p = 0.78$	6 / 6 classes 53 / 48 children
PEN / PEN+				

Table 1. Characteristics of the study populations: by subgroups and in total.

## Procedure

Development of the learning sequence involved collaboration between researchers and 4 teachers who were not part of the experiment. This work led to the production of a booklet for teachers and a 4-hour training course for them. Twelve teachers volunteered to participate in the experiment. These twelve teachers did not participate in the prior collaborative work. Six of them underwent the training course and went on to carry out the sequence in their own classroom. At the end of the intervention, the training course was followed by the remaining 6 teachers, those in the control group (Figure 1). The 4-hour teacher training focused on 4 points: the importance of conducting problem solving in kindergarten, the existence of different strategies for using fingers to solve transformation problems, the automation of canonical finger configurations until patterns are acquired and, finally, on how the training sessions should be implemented.

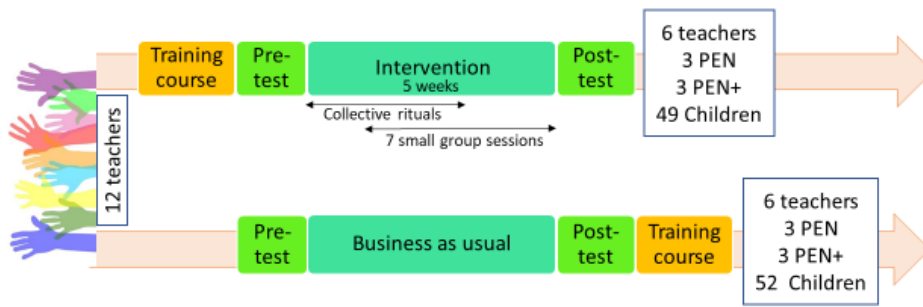


Figure 1. Outline of the research method

### Control group

The non-intervention group was “business as usual”: the teachers continued to work as they were used to doing with a duration of activities on numbers equivalent to that of the experimental group. Between the pre-test and post-test, the teachers in the control group offered 7 small group sessions on numbers and about ten ritualised short sessions for working on numbers. The non-intervention group teachers were not informed of the purpose of the intervention. They were unaware that the intervention was about word problem solving even if they knew that the intervention was about “numbers” (as opposed to geometry, for example). These teachers taught number skills as they were used to. Thus, these 7 sessions could focus on core competencies (“Give me” tasks, “How many” tasks, verbal chain, number Comparison, etc.) but also on problem solving, if this was part of their curriculum.

### Intervention

The intervention started each morning with the whole class gathered together as usual for fifteen minutes followed by small group sessions. This took place four times a week for three weeks. The teaching sessions were conducted in small groups of about 4 children for about 20 minutes. Each child attended 7 sessions spread over 4 weeks (about 2 sessions/child/week). These started one week after the beginning of the ritual.

#### *Collective rituals: verbal numerical chain & the “Lucky-Luke” game*

The ritual was as follows: for 5 minutes, the verbal numerical chain was worked on according to an established progression over a 10 days spread for 3 weeks. This covered counting from 1 to a given number, counting from a given number to another number and then counting backwards. During the next 10 minutes, finger work was proposed with the “Lucky-Luke” game (see Appendix 1). The aim of this game was to automatize the verbal number code via a finger pattern (*decode a verbal code with fingers*) and vice-versa (*code a finger pattern*). A finger configuration for each number was chosen during the training course in line with the most commonly used representations in France (Berteletti & Booth, 2016). The structure of the learning sequence content was as follows: first, in incrementing numbers in order (for example, the children had to show 1 then 2 then 3 with their fingers), then the numbers in disorder (the children had to show 2 then 1 then 3 with their fingers), and then as quickly as possible. The name “Lucky-Luke” refers to a comic strip in which a cowboy has to shoot faster than his shadow. The numbers increased with an interleaving of values so that the numbers were reworked regularly. The organisation and content of these two rituals are presented in Appendix 2.

#### *Training sessions*

After a week of this daily ritual, the sessions on transformation problems were introduced (see Appendix 3). These sessions were built on two principles.



First, there was a gradual withdrawal of simulation using tangible materials. Based on Levine's study (1992), each training session started with simulated problems and the necessity of abstraction was ensured by not letting the child see the composite of the addend. To achieve this, an opaque box was presented to the children. The teacher placed tokens in the box, adding or removing them without the children being able to see inside. The teacher then systematically asked the same question: "How many tokens are there in the box?" and then "How do you know?" so that the pupils could justify their answer. During each session, 7 transformation problems were played using the box. The children did not have access to the tokens, only the teacher handled them. The tokens were only used to simulate the verbal problem. Children were encouraged to use their fingers to find out how many tokens were in the box. As by age 5, children succeed in solving word problems without physical simulation, the training sessions ended with 1 or 2 verbal problems without the teacher handling any materials.

Secondly, making strategies explicit. The teacher encouraged each child to use his/her fingers by linking the action(s) to the Lucky-Luke game. The children's different strategies for solving the problem were discussed and praised. The answer was validated by opening the box. Three strategies for modelling addition were taught during the sequence: one which consists in putting the two quantities of tokens onto the two hands (e.g. 4 on one hand and 2 on the other), a second which consists of putting a quantity on one hand (e.g. 4 on one hand) and then completing that hand with the second quantity (we obtain 5 fingers raised on the first hand and one finger raised on the second hand). The interest of this second strategy was explained to the pupils: not only could they recognise the final configuration worked on during the Lucky-Luke ritual ("we can see that you have 6 on your fingers!") but it is also possible to add several terms as proposed in the learning sequence. A third strategy was then proposed: to have a term in one's head and then use one's fingers to "count on". A fourth strategy using fingers was taught focusing on subtraction: use one's fingers to represent the higher number and then lower the number of fingers corresponding to what needs to be removed. For each problem the teacher explained how the children could use their fingers to answer the question in word problems. Each session was organised as follows: 7 problems in which the teacher used tokens, followed by 1 or 2 problems given orally only. During the sessions, a strategy using the fingers to solve the problems could be explained to the children. The chronology of strategies and the choice of verbal problems are presented in Appendix 3.

### Outcome Measures

The children were tested twice in a quiet room in their respective preschools: once one week before the intervention and once one week after the intervention. The tests were administered individually by graduate students in sessions of approximately 25 minutes. The test assessed overall math skills: Eight tasks on core competencies (T1-T8), two tasks on problem solving (T9 & T10) and one task on arithmetic (T11), see Table 2 for details of the items.

	<i>Description</i>	<i>Items in this order</i>	<i>Score max</i>
<i>Core competencies</i>			
T1. TVerbalChain	<i>Verbal numerical chain.</i> The child was asked to count as high as possible as (s)he could. After a mistake or when (s)he had counted to 100, the task was stopped. The resulting score was the number reached by the child therefore between 0 and 100.		100
T2. TNumId	<i>Numeral identification.</i> The child was presented with 20 flashcards in succession with numbers on them and asked,	4, 2, 5, 0, 3, 9, 7, 6, 8, 10, 12 18, 25, 30, 43,	20

	“What number is this?”. The task was stopped after 3 consecutive mistakes. The maximum score possible was 20.	75, 80, 94, 128, 432	
T3. TDecodeFingers	<i>Production of a number using the fingers.</i> The child was told a number and asked to raise, as quickly as possible, the number of fingers corresponding to the number announced.	3, 1, 5, 2, 10, 4, 6, 8, 7, 9	10
T4. TCodePatterns	<i>Recognition of canonical finger shapes.</i> The child was shown photographs of canonical finger shapes on a computer screen for 1500 msec. (S)he was asked to say the number of fingers raised as fast as possible. The canonical finger shapes are those used in large parts of Europe (Berteletti & Booth, 2016): raising the right thumb for one, the index finger for two and continuing following the order of the fingers and using the fingers of the other hand in the same way.	2, 5, 1, 10, 3, 6, 4, 9, 7, 8	10
T5. TGiveMe	“Give me” tasks. The child was asked to put a number of tokens into a cup. The task had potentially 6 items of increasing difficulty. First, the two most difficult items were presented to the child. If both items were executed successfully, the task was stopped and a score of 6 points given. If the child made a mistake on one of the two items, the previous 4 items were presented. One point was awarded for each successful item.	3, 2, 5, 8, 9, 12	6
T6. THowMany	“How many” tasks. 6 cards were presented in succession to the child. Each one contained several identical animals: for example, 8 lions. Two questions were asked: “Can you tell me how many lions there are?” and then, to assess the cardinality principle, she was asked to conclude “how many lions?”. 1 point was given for each correct answer. As in the previous task, the 6 items were of increasing difficulty with the two most difficult items being initially presented to the child. If both items were completed successfully, the task stopped and a score of 12 points was given. If the child made a mistake on one of the two items, then the next four items were introduced.	4, 6, 5, 7, 6, 8	12
T7. TComparison	<i>Number Comparison Fluency.</i> The child was presented with 40 pairs of single-digit numbers. (S)he had to cross out the larger of each pair of numbers in two minutes. This task is taken from the 1 <sup>st</sup> grade national assessments <sup>1</sup> . All correct items were scored as 1, giving a maximum of 40.		40
T8. TUseNumbers	<i>Spontaneous use of numbers.</i> The child was presented with 3 fixed quantities of bottles in succession. (S)he then had to take the right quantity of corks to close each bottle. While taking the corks, a flap made the collection of bottles invisible. So, to succeed in this task, the child had to count the number of bottles and take the corresponding number of corks. All correct items were scored as 1, giving a maximum of 3.	6, 8, 9	3
<i>Problem-solving</i>			
T9. TTransformPb	<i>Arithmetical transformation problem-solving.</i> The child was read 6 transformation problems. A second reading was possible, at the child’s request or if the child did not answer. The problems concerned the final question after transformation. Three items were modelled by addition and the other three by subtraction. The task stopped after 3	2+1=?; 4-2=?; 3+5=?; 10-3=?;	6

<sup>1</sup> <https://eduscol.education.fr/2295/evaluations-des-acquis-et-besoins-des-eleves-au-cp>

	consecutive errors. All correct items were scored as 1, giving a maximum of 6.	2+1+1=?; 8-2-1=?	
T10. TOtherPb	<i>Other problem-solving.</i> The child was given 6 problems. As in the previous task, the problems were read. A second reading was possible, at the child's request or if the child did not answer. Two items were Compare problems, two Transform problems with a question about the transformation and two Transform problems with a question about the initial state. The task stopped after 3 consecutive errors. All correct items were scored as 1, giving a maximum of 6.	5-3=?; 9-2=?; 8-4=?; 10-2=?; 6-3=?; 3+2=?.	6
<i>Arithmetic</i>			
T11. TAdd	<i>Addition tasks with Arabic digits.</i> 10 single-digit additions were presented. A visual support was offered to the child with the arithmetic sentence on a computer screen. They were also read out loud by the experimenter. For example, "3 plus 2, how much is that?" The task stopped after 3 consecutive errors. One point was awarded for each item successfully solved. Thus, the score could range from 0 to 10.	2 + 1; 1 + 3; 3 + 2; 3 + 4; 0 + 8; 6 + 3; 3 + 5; 7 + 3; 2 + 3 + 2; 3 + 2 + 4.	10

Table 2. Outcome Measures

### Statistical analyses

Descriptive statistics are reported as the mean (standard deviation - SD) calculated at pre-test and post-test in the non-intervention and intervention groups for each different outcome measured. An independent sample t-test was used to compare the two groups on the pre-test scores, in order to check equivalence between groups at the baseline. Only a marginal difference between the non-intervention and intervention groups was reported at Pre-test on the *TAdd* ( $t(99) = 1.94$ ;  $p = 0.055$ ; *Cohen's d*=0.39). The other t-test indicated that the groups were equivalent on the different outcome measures at pre-test (all  $p > 0.05$ ).

Because participants were maintained in their respective classes (with different teachers), generalized linear mixed models (GLMM - *lmer* function of *lme4 R-package*, using a Restricted Maximum Likelihood (REML) algorithm for the estimation of the random effects) were used to assess the effects of the intervention (see for example Hilbert et al. (2019) for a description of the advantages of the GLMM method in comparison to other alternative statistical analysis methods in a context of intervention testing design with repeated measures). This statistical analysis strategy to assess the effect of an intervention in the educational domain is similar, for examples, to the one used by Lassault et al. (2022) or even by Boggio et al. (2023). All outcome measures (T1-T11) were standardized ( $M = 0$ ;  $SD = 1$ ) prior to the analysis. This allowed to standardize all slope coefficients, in order to makes them appropriate effect size measures in these mixed effect models (Lorah, 2018). This GLMM procedure was primarily applied to problem solving variables, allowing us to test our hypotheses directly. Indeed, a significant intervention effect was expected on *TTransformPb* with better post-test scores at this task hypothesized in the intervention group than in the control group. Moreover, whereas the intervention targeted transformation problem-solving, we also wanted to assess a potential intervention effect on the adjacent problem-solving skills evaluated by the *TOtherPb*. For each of these two outcome measures, the following mixed model (1) was fitted to predict the post-test scores ( $POST-PbSolv_{ij}$ , of each  $i$  schooler placed in the  $j$  class) by using the pretest score measured in the same problem solving task ( $PRE-PbSolv_{ij}$ ), the pretest score measured in the *TAdd* task, using intervention

(INTERVENTION: 1 for the intervention group and 0 for the control group), and the school PEN network (SCHOOL NETWORK: 1 for PEN+ and 0 for PEN) as fixed effects and class / teacher as a random effect ( $u_{0j}$ ):

$$\text{POST-PbSolv}_{ij} = \beta_0 + \beta_1 \text{PRE-PbSolv}_{ij} * \beta_2 \text{INTERVENTION}_j + \beta_3 \text{PRE-TAdd}_{ij} * \beta_2 \text{INTERVENTION}_j + \beta_4 \text{SCHOOL NETWORK}_{j+} u_{0j} + \varepsilon_{ij} \quad (1)$$

In this model (1),  $\beta_0$  corresponds to the intercept and other  $\beta_k$  are the standardized slope coefficients; these latter enabled us to estimate the effect sizes for the different predictors. An interaction term between  $\text{PRE-PbSolv}_{ij}$  and  $\text{INTERVENTION}_j$  predictors was included to take into account that the baseline level of a child at Pre-test (on the same problem-solving outcome variable) could interact with the intervention effect. In the same way, the pre-test scores in the  $TAdd$  ( $\text{PRE-TAdd}_{ij}$ ) were added as predictor (fixed effects) with the concomitant inclusion of an interaction term between  $\text{PRE-TAdd}_{ij}$  and the intervention factor. Indeed,  $TAdd$  assessed a calculation skill and this latter could have a potential relation with the problem-solving outcome variables. Moreover, a statistical marginal difference was observed between the non-intervention and intervention groups in terms of  $TAdd$  pre-test scores, indicating the need for close monitoring during the analysis of intervention effects. Therefore, since the variables were standardized, the model estimated the intervention effects at post-test by controlling: (1) baseline differences at pre-test on the problem-solving outcome variable ( $TTransformPb$  or  $TOtherPb$ ); (2) baseline differences at pre-test on the  $TAdd$  arithmetic task and, (3) differences due to school networks.

Although arithmetic (T11) and mathematical core competencies (T1-T8) were not directly targeted by the intervention, we want to check whether this latter would have (or not) an impact on these corresponding outcome measures. To that end, the following more simple mixed model (2) was fitted to predict the post-test scores ( $\text{POST}_{ij}$ , from each  $i$  schooler placed in the  $j$  class) by the pretest scores ( $\text{PRE}_{ij}$ ) using intervention (INTERVENTION: 1 for intervention group and 0 for control group) and school PEN network (SCHOOL NETWORK: 1 for PEN+ and 0 for PEN) as fixed effects and class / teacher as random effect ( $u_{0j}$ ):

$$\text{POST}_{ij} = \beta_0 + \beta_1 \text{PRE}_{ij} * \beta_2 \text{INTERVENTION}_j + \beta_3 \text{SCHOOL NETWORK}_{j+} u_{0j} + \varepsilon_{ij} \quad (2)$$

Therefore, this model (2) was similar to model (1), at the exception that pre-test scores in the  $TAdd$  was not entered in this model (2) (of course except for  $TAdd$  post-test scores).

Results of the different fixed effects of the models are reported with the estimates (standardized  $\beta$  slope coefficients – reflecting effect size), the 95% confidence interval of the estimates ( $CI$ ), the  $t$ -value and the associated  $p$ -value. Conditional ( $cond R^2$ ) and marginal ( $marg R^2$ ) determination coefficients and intraclass correlation coefficients ( $ICC$ ) were used to assess the model performances and the influence of random effects.

## Results

### Descriptive results

Means (and standard deviations) calculated for both the Non-intervention and the Intervention groups at Pre-Test and at Post-Test are reported in Table 3. The descriptive results for the Intervention group indicate that scores for all of the eleven mathematical tasks improved from the pre-test to the post-test. To a lesser extent, mathematical performances were also better at Post-test than at Pre-Test for the Non-intervention group, except for  $TDecodeFingers$  and  $TOtherPb$  (with a not significant decrease of mean score at post-test).

**Table 3.** Outcome measures results. Means (standard deviations) at pre-test and post-test calculated for the different outcome measures in the No Intervention and in the Intervention groups.

	No Intervention (n = 52)		Intervention (n = 49)	
	Pre-test	Post-test	Pre-test	Post-test
<b>Core competencies</b>				
TVerbalChain	49.27 (28.99)	50.81 (28.60)	50.59 (27.95)	57.14 (25.44)
TNumId	13.48 (3.29)	13.62 (3.22)	12.78 (3.37)	13.45 (3.49)
TDecodeFingers	9.65 (1.10)	9.63 (0.89)	9.45 (1.24)	9.84 (0.47)
TCodePatterns	9.10 (1.38)	9.27 (1.22)	8.82 (1.51)	9.31 (1.12)
TGiveMe	5.62 (0.80)	5.79 (0.54)	5.65 (0.69)	5.69 (0.62)
THowMany	11.44 (1.53)	11.62 (1.29)	11.39 (1.40)	11.84 (0.62)
TComparison	31.08 (9.99)	33.31 (9.59)	29.71 (10.80)	33.24 (8.69)
TUseNumbers	1.71 (1.16)	2.04 (1.08)	1.92 (1.20)	2.31 (0.87)
<b>Problem Solving</b>				
TTransformPb	2.56 (2.38)	2.88 (2.37)	3.22 (2.04)	4.53 (1.88)
TOtherPb	1.50 (1.89)	1.17 (1.80)	1.53 (1.68)	2.04 (1.96)
<b>Arithmetic</b>				
TAdd	5.38 (3.72)	6.02 (3.72)	6.69 (2.99) †	6.92 (3.34)

† marginal difference between No intervention and intervention groups at pre-test ( $p = 0.051$ ). All other differences at pre-test were no significant (all  $p > 0.13$ ).

### Intervention effects on problem solving tasks

**Arithmetical transformation problem-solving task (TTransformPb).** A significant effect of the intervention was expected for the problem-solving tasks, and more especially on arithmetical transformation problem-solving performance (TTransformPb). The test of model (1) showed a significant effect of the intervention on the TTransformPb post-test scores ( $\beta_{\text{INTERVENTION}} = 0.43$ ;  $CI = [0.04; 0.83]$ ;  $t = 2.17$ ;  $p = 0.033$ ). This indicated that TTransformPb scores of children in the Intervention group showed greater improvement at post-test than those of children in the Non-intervention group (Figure 2). TTransformPb scores at post-test were also (not surprisingly) significantly predicted by performances on the same task at pre-test ( $\beta_{\text{PRE-TpbSolv}} = 0.63$ ;  $CI = [0.41; 0.84]$ ;  $t = 5.79$ ;  $p < 0.001$ ).

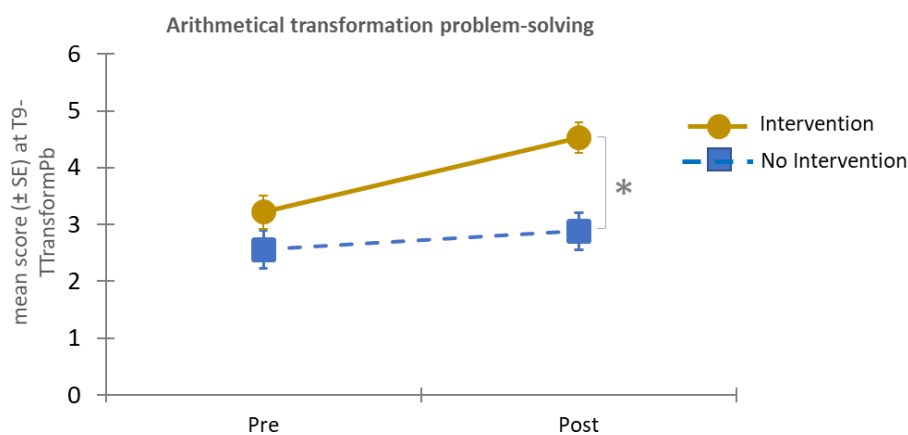


Figure 2. The intervention has a significant post-test impact on the score for transformation problems (taking into account pre-test differences in solving transformation problems and in arithmetic).

Moreover, a significant interaction appeared between intervention and TTransformPb pre-test scores ( $\beta_{\text{PRE-TpbSolv} \times \text{INTERVENTION}} = -0.33$ ;  $CI = [-0.64; -0.02]$ ;  $t = 2.14$ ;  $p = 0.035$ ). The negative slope coefficient of this interaction effect's estimates indicated that children with lower performances in arithmetic transformation problem

solving at pre-test benefited more from the intervention (on the task *TTransformPb*) than children with higher *TTransformPb* pre-test scores (Figure 3). Although initial levels in the arithmetic task (*TAdd*) predicted only slight (and not significant) the *TTransformPb* scores at post-test ( $\beta_{\text{PRE-TAdd}} = 0.14$ ;  $CI = [-0.06; 0.34]$ ;  $t = 1.35$ ;  $p = 0.181$ ), the better the children were on addition tasks with Arabic digits (*TAdd*), the greater the intervention effect was in post-test on the *TTransformPb*, as indicated by the significant interaction between *TAdd* pretest scores and intervention ( $\beta_{\text{PRE-TAdd} \times \text{INTERVENTION}} = 0.32$ ;  $CI = [0.01; 0.63]$ ;  $t = 2.02$ ;  $p = 0.046$ ). The school network effect was not significant ( $\beta_{\text{SCHOOL NETWORK}} = 0.00$ ;  $CI = [-0.40; 0.41]$ ;  $t = 0.02$ ;  $p = 0.98$ ). The good fit estimation parameters for the Model (1) applied to the *TTransformPb* post-test scores indicated a *marg R*<sup>2</sup> = 0.58 and a *cond R*<sup>2</sup> = 0.66 with an ICC = 0.19.

**Table 4. Parameter estimates for the problem-solving dependent variables analysing with generalized linear mixed Model (1).** Results of the different fixed effects of the models are reported with the estimates (standardized  $\beta$  slope coefficients – reflecting effect size) and the 95% confidence interval of the estimates (between brackets). Asterisks indicates the level of significance, and the significant fixed effects are reported in bold characters. Intraclass correlation coefficients (ICC) are reported for the random effects. Marginal (*Marg R*<sup>2</sup>, in italic) and Conditional (*Cond R*<sup>2</sup>) determination coefficients assesses the Model (2) performances.

Problem-solving dependent variable (post-test)	Fixed Effects (Model 1)						Random effects	Goodness of fit
	Pre-test score	Intervention	Pre-test x Intervention interaction	TAdd pretest score	TAdd pretest score x Intervention interaction	PEN / PEN+ School network	ICC	<i>Marg R</i> <sup>2</sup> / <i>Cond R</i> <sup>2</sup>
<b>TTransformPb</b>	<b>0.63</b> <sup>***</sup> [0.41 ; 0.84]	<b>0.43</b> <sup>*</sup> [0.04 ; 0.83]	<b>-0.33</b> <sup>*</sup> [-0.64 ; -0.02]	0.14 [-0.06 ; 0.34]	<b>0.32</b> <sup>*</sup> [0.01 ; 0.63]	~0.00 [-0.40 ; 0.41]	0.19	0.58 / 0.66
<b>TOtherPb</b>	<b>0.36</b> <sup>**</sup> [0.11 ; 0.61]	<b>0.36</b> <sup>*</sup> [0.02 ; 0.70]	-0.03 [-0.41 ; 0.34]	0.17 [-0.07 ; 0.40]	0.22 [-0.17 ; 0.61]	<b>-0.41</b> <sup>*</sup> [-0.76 ; -0.06]	0.03	0.43 / 0.45

\*p < 0.05; \*\*p < 0.01; \*\*\*p < 0.001. TAdd = Arithmetic addition task with Arabic digits. PEN = priority education network; PEN+ = reinforced priority education network; ICC = Intraclass correlation coefficients.

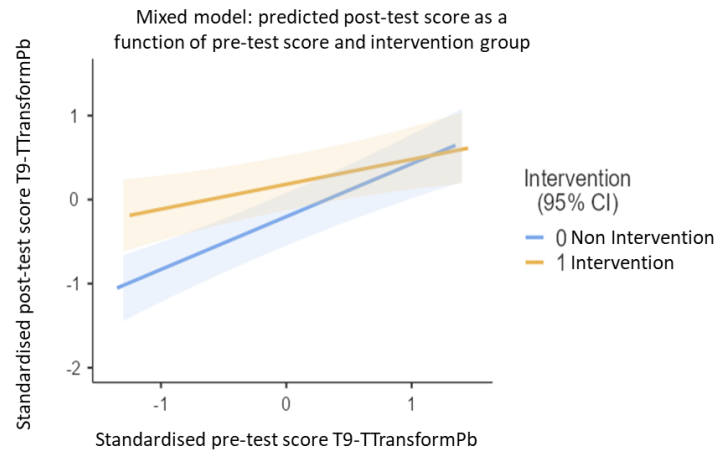


Figure 3. The lower the children's *TTransformPb* pre-test scores, the more they benefited from the post-test intervention.

**Other problem-solving task (TOtherPb).** As highlighted above, the intervention had a positive and significant impact on the targeted transformation problem-solving skill. Therefore, the question arises as to whether the intervention may have also indirectly benefited the other problem-solving skills. Considering the fitting with model (1) of the post-test scores at the *TOtherPb* task (*marg R*<sup>2</sup> = 0.43 / *cond R*<sup>2</sup> = 0.45; ICC = 0.03), the intervention effect was also significant ( $\beta_{\text{INTERVENTION}} = 0.36$ ;  $CI = [0.02; 0.70]$ ;  $t = 2.12$ ;  $p = 0.037$ ), with higher performances

at post-test on  $T_{OtherPb}$  for the intervention group than for the non-intervention group (while controlling the initial level). Although  $T_{OtherPb}$  post-test scores were significantly predicted by pre-test scores ( $\beta_{PRE-T_{OtherPb}} = 0.36$ ;  $CI = [0.11; 0.61]$ ;  $t = 2.88$ ;  $p = 0.005$ ), there was no significant interaction between intervention and  $T_{OtherPb}$  baseline level ( $\beta_{PRE-T_{OtherPb} \times INTERVENTION} = -0.03$ ;  $CI = [-0.41; 0.34]$ ;  $t = 0.17$ ;  $p = 0.87$ ) (Figure 4). Moreover, neither  $T_{Add}$  pre-test scores ( $\beta_{PRE-T_{Add}} = 0.17$ ;  $CI = [-0.07; 0.40]$ ;  $t = 1.43$ ;  $p = 0.16$ ) nor interaction between these latter and intervention factor ( $\beta_{PRE-T_{Add} \times INTERVENTION} = 0.22$ ;  $CI = [-0.17; 0.61]$ ;  $t = 1.12$ ;  $p = 0.27$ ) had a significant predictive effect on  $T_{OtherPb}$  post-test scores. However, it should be noted that the scores at post-test on this other problem-solving task were significantly lower for children from PEN+ schools ( $m_{PEN+} = 0.92$ ;  $SD_{PEN+} = 1.40$ ) compared to children from PEN schools ( $m_{PEN} = 2.21$ ;  $SD_{PEN} = 2.12$ ;  $\beta_{SCHOOL NETWORK} = -0.41$ ;  $CI = [-0.76; -0.06]$ ;  $t = 2.33$ ;  $p = 0.022$ ).

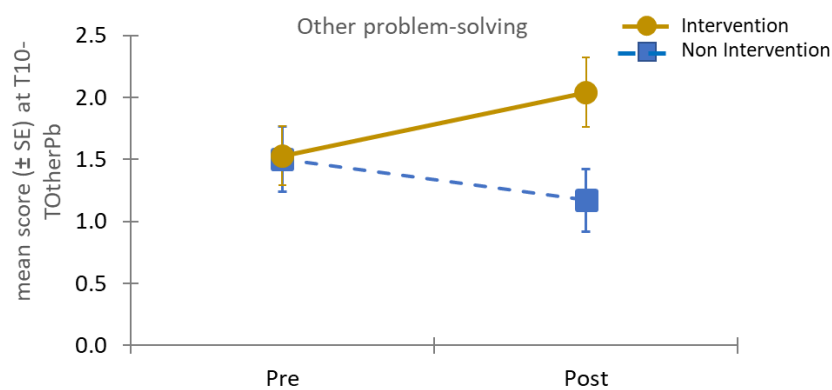


Figure 4. The intervention has a significant impact on the  $T_{OtherPb}$  scores (taking into account the pre-test differences in solving transformation problems and in arithmetic).

#### Intervention effects on the arithmetic addition task ( $T_{Add}$ )

Since the use of fingers can be an important support to “count all” or to “count on” and then for addition calculations, we could expect that the intervention would have an effect on the arithmetic task of addition with Arabic digits. It is therefore not surprising that the baseline level of performance predicted quite strongly the  $T_{Add}$  post-test scores ( $\beta_{PRE} = 0.58$ ;  $CI = [0.39; 0.78]$ ;  $t = 5.96$ ;  $p < 0.001$ ). In this context, both groups showed an improvement in this skill and there was neither an intervention effect ( $\beta_{INTERVENTION} = 0.01$ ;  $CI = [-0.32; 0.34]$ ;  $t = 0.06$ ;  $p = 0.96$ ), nor interaction between baseline level and intervention factor ( $\beta_{PRE \times INTERVENTION} = 0.14$ ;  $CI = [-0.17; 0.45]$ ;  $t = 0.92$ ;  $p = 0.36$ ) when tested with Model (2). Post-test scores on the  $T_{Add}$  task were significantly lower in PEN+ schools ( $m_{PEN+} = 5.40$ ;  $SD_{PEN+} = 3.87$ ) than in PEN schools ( $m_{PEN} = 7.42$ ;  $SD_{PEN} = 2.96$ ;  $\beta_{SCHOOL NETWORK} = -0.35$ ;  $CI = [-0.68; -0.01]$ ;  $t = 2.04$ ;  $p = 0.044$ ). Model (2) was fitted to  $T_{Add}$  post-test score data with  $margin R^2 = 0.47$ ,  $conditional R^2 = 0.49$  and  $ICC = 0.04$  (see Table 5 for details).

#### Intervention effects on core competencies ( $T1-T8$ ).

The basic tasks ( $T1$  to  $T8$ ) were not directly targeted by the intervention. Statistical GLMM analyses with model (2) applied to the post-test scores (see Table 5 for details) confirmed that intervention did not have any significant effect on any of these tasks, although almost all slope coefficient estimates were positive ( $\beta_{INTERVENTION}$  coefficient from 0.09 to 0.29), thus in the direction of larger improvements (descriptively) for the intervention group than for the non-intervention group (except  $\beta_{INTERVENTION} = -0.14$  for  $T_{GiveMe}$ ). Post-test scores were significantly

predicted by the baseline level at the same task (from  $\beta_{PRE} = 0.35$  to  $\beta_{PRE} = 0.90$ , all  $p < 0.05$ ; except for *TGiveMe*:  $\beta_{PRE} = 0.11$ ;  $p = 0.38$ ). This baseline level interacted with the intervention effect only for *THowMany* post-test scores ( $\beta_{PRE \times INTERVENTION} = -0.51$ ;  $CI = [-0.80; -0.21]$ ;  $t = 3.40$ ;  $p < 0.001$ , note a marginal interaction effect for *TDecode fingers*:  $\beta_{PRE \times INTERVENTION} = -0.34$ ;  $CI = [-0.70; -0.03]$ ;  $t = 1.84$ ;  $p = 0.07$ ; in all the other tasks:  $-0.2 < \beta_{PRE \times INTERVENTION}$  -values  $< 0.2$  and all  $p$ -values  $> 0.35$ ). No significant school network effect was reported for all of these core competency tasks ( $-0.37 < \beta_{SCHOOL NETWORK}$  -values  $< 0$ ; all  $p$ -values  $> 0.12$  in the other tasks).

**Table 5. Parameter estimates for the different core competencies and arithmetic dependent variables analysing with generalized linear mixed Model (2).** Results of the different fixed effects of the models are reported with the estimates (standardized  $\beta$  slope coefficients – reflecting effect size) and the 95% confidence interval of the estimates (between brackets). Asterisks indicates the level of significance and the significant fixed effects are reported in bold characters. Intraclass correlation coefficients (ICC) are reported for the random effects. Marginal (Marg  $R^2$ , in italic) and Conditional (Cond  $R^2$ ) determination coefficients assesses the Model (2) performances.

Dependent variable (post-test)	Fixed Effects (Model 2)				Random effects	Goodness of fit
	Pre-test score	Intervention	Pre-test x Intervention interaction	PEN / PEN+ School network	ICC	Marg $R^2$ / Cond $R^2$
<b>Core Competencies</b>						
<b>TVerbalChain</b>	<b>0.87</b> <sup>***</sup> [0.72 ; 1.02]	0.20 [-0.05 ; 0.44]	-0.09 [-0.30 ; 1.12]	-0.11 [-0.37 ; 0.14]	0.06	0.73 / 0.75
<b>TNumId</b>	<b>0.90</b> <sup>***</sup> [0.78 ; 1.03]	<b>0.14</b> <sup>†</sup> [-0.03 ; 0.31]	0.00 [-0.17 ; 0.18]	-0.03 [-0.21 ; 0.14]	~0	0.82 / 0.82
<b>TDecodeFingers</b>	<b>0.38</b> <sup>**</sup> [0.11 ; 0.65]	0.29 [-0.27 ; 0.85]	-0.34 [-0.70 ; 0.03]	-0.24 [-0.80 ; 0.33]	0.16	0.10 / 0.24
<b>TCodePatterns</b>	<b>0.64</b> <sup>***</sup> [0.39 ; 0.89]	0.15 [-0.20 ; 0.49]	-0.16 [-0.49 ; 0.18]	-0.13 [-0.49 ; 0.22]	0.01	0.32 / 0.33
<b>TGiveMe</b>	0.11 [-0.14 ; 0.36]	-0.14 [-0.60 ; 0.32]	0.12 [-0.28 ; 0.51]	-0.37 [-0.84 ; 0.10]	0.05	0.07 / 0.12
<b>THowMany</b>	<b>0.85</b> <sup>***</sup> [0.65 ; 1.04]	0.25 [-0.06 ; 0.55]	<b>-0.51</b> <sup>***</sup> [-0.80 ; -0.21]	-0.14 [-0.45 ; 0.16]	0.01	0.46 / 0.47
<b>TComparison</b>	<b>0.80</b> <sup>***</sup> [0.62 ; 0.97]	0.09 [-0.20 ; 0.39]	-0.07 [-0.32 ; 0.17]	-0.24 [-0.54 ; 0.06]	0.06	0.61 / 0.64
<b>TUseNumbers</b>	<b>0.35</b> <sup>†</sup> [0.08 ; 0.62]	0.22 [-0.16 ; 0.59]	-0.01 [-0.39 ; 0.36]	-0.17 [-0.56 ; 0.21]	~0	0.16 / 0.16
<b>Arithmetic</b>						
<b>TAdd</b>	<b>0.58</b> <sup>***</sup> [0.39 ; 0.78]	0.01 [-0.32 ; 0.34]	0.14 [-0.17 ; 0.45]	<b>-0.35</b> <sup>†</sup> [-0.68 ; -0.01]	0.04	0.47 / 0.49

<sup>†</sup> $p < 0.10$ ; <sup>\*</sup> $p < 0.05$ ; <sup>\*\*</sup> $p < 0.01$ ; <sup>\*\*\*</sup> $p < 0.001$ . PEN = priority education network; PEN+ = reinforced priority education network; ICC = Intraclass correlation coefficients.

## Discussion

The purpose of the present research was to test the effect of an early mathematical intervention on kindergarteners' progress in problem solving. We compare a teacher-implemented intervention program with a “business as usual” group within a population of disadvantaged kindergarteners. For this study, we have co-constructed 7 small group teaching sessions on the use of fingers to solve problems in kindergarten. These sessions were designed to incorporate finger pattern rituals and implement them in real-life learning settings. Public kindergarten schools within priority education networks, which operate in socially disadvantaged environments, were selected to pilot this intervention. This choice was made because problem-solving is notably impacted by learning disparities arising from social inequalities (MENR, 2021). While children in these schools do not exhibit specific cognitive profiles, they may encounter challenges with language skills, which are essential for problem-solving. It would be



valuable to ascertain whether such an intervention could yield benefits for kindergarteners from more privileged social backgrounds.

In a context of socially disadvantaged children with potential difficulties in word problem solving, we have obtained the result, as expected, that teaching strategies for using fingers to solve transformation problems (with question on the final state, *TTransformPb*) improve the targeted knowledge. Interestingly, while the children retained the core skills (without any further beneficial effects of the intervention), the intervention had a positive impact on other types of word problem solving (*TOtherPb*), including compare and all types of transform problems. As anticipated, these other problems were more difficult for all the children than the transformation problems with questions on the final state. However, contrary to our hypotheses, the children who benefited from the intervention did not make more progress on the addition task (*TAdd*).

Our study thus reinforces the results of previous studies that have shown a relationship between learning to represent numbers with one's fingers and problem solving (Ollivier et al., 2020; Orrantia et al., 2022). The originality of our study lies in the fact that we do not teach only representations of numbers with fingers, but that rather we teach how to use them to model a problem. As a result, although the children were able to assimilate the strategies taught and use them on untaught word problems, they did not particularly benefit from the intervention where symbolic calculation tasks (*TAdd*) were concerned. There are several possible reasons for this. Firstly, the fact that the children in the intervention group started with a higher calculation ability than the children in the control group needs to be taken into consideration. Secondly, although the children could use their fingers during the symbolic calculation tasks, this possibility was not specified in the instructions so, perhaps the children thought that it was forbidden. The symbolic addition task, which did not refer to quantities, could have posed a psychological barrier to using fingers as an analogic code? This is in line with what Björklund (2019, p. 23) noted: "The literature brings to the fore a strong view that children commonly use fingers when encountering arithmetic tasks and thus it was surprising to find that only in 44% of the observations in our study were fingers used in one or another way." We can therefore assume that children, especially those from disadvantaged backgrounds, do not spontaneously use their fingers and that explicit instruction of their use for each of the relevant situations is necessary. Thirdly, the control group worked maybe on calculation tasks. Interventions into real-life learning context inevitably raise questions about the fidelity of implementation of interventions (Fixsen, 2005). Within the intervention groups, implementation fidelity was assessed during a single visit across all 7 small group sessions. The implementation grid included elements such as the adequacy of the tasks in relation to those prescribed, an explanation of the strategy employed, validation or rejection of the children's answers by opening the box and showing the tokens and the link between the Lucky-Luke ritual and the training session. During this single visit, these items were found to be present in each experimental group. However, such a grid has not been used to observe the exact content taught in the control group which is why it is conceivable that the control group worked on the calculation task. Finally, a word problem involves two phases: modelling (by recognizing the operation involved) and calculation, this last a skill that is found in *TAdd*. This absence of benefits in symbolic calculation tasks, albeit that benefits to problem solving occurred, could mean that the pre-schoolers in the experimental group made particular progress in the modelling phase instead. This reveals another limitation of the study: the purely quantitative evaluation (successes or failures in the word problems). Beyond this binary aspect, there is a qualitative aspect which could have been interesting to study more closely, that of seeing if the fingers were used more frequently in the post-test than in the pre-test in the intervention group.

The overall aim has been to improve problem-solving performance in pupils at-risk. Mathematical skills are, in fact, cumulative because they build on knowledge acquired in previous years (Merkley & Ansari, 2016), making failure over the years all the more difficult to remedy. It is therefore important to intervene early. In France, as the national evaluations seem to indicate (MENR, 2021), one of the most unequally developed skills seems to be that of problem solving. This was the reason for setting up an intervention with disadvantaged children and it seems to have worked: children with lower performances in transformation problem solving at pre-test benefited more from the intervention (on the task *TTransformPb*) than children with higher *TTransformPb* pre-test scores. On the other hand, in a context other than the one targeted (on the task *TOtherPb*), these children appear to not continue using what they have been taught. One possibility would therefore be to enrich the current study with the explicit teaching of strategies for using the fingers for all types of word problem, as well as for calculation tasks. Furthermore, post-tests were conducted subsequent to the intervention. However, the question of whether the performance can be sustained over time remains unanswered.

Our study is a pilot study in the sense that it was designed to evaluate the effectiveness of a complete system comprising teacher training, teaching focused on problem solving and based on the use of fingers. Nevertheless, this approach has several methodological limitations that need to be considered. Firstly, the results of the experiment could be attributed more to the increased motivation of the teachers involved in the intervention group than to the experimental protocol itself. In fact, the teachers involved in the study had all volunteered and the drawing of lots to allocate the groups may have provoked mixed reactions. The informal feedback we received following the draw suggests that it is actually quite complex to determine whether teachers were disappointed to be allocated to the control group. Indeed, some teachers expressed a certain relief at the idea of not changing their practices. We also attempted to control for this effect by engaging control group teachers in subsequent training enriched with intervention results. Secondly, and crucially, we cannot distinguish the effect of problem-solving teaching from the effect of finger use. Although we can conclude that children performances improve when taught how to use their fingers to solve arithmetic problems, it is possible that this positive progression could perhaps have been achieved by using other representations of number. Given the immediate availability of fingers, as well as their dual nature as an analogical code and pattern, we thought it appropriate to consider them as a suitable medium for teaching problem solving. But now that we have observed that the device seems to influence learning, it would be appropriate to explore similar teaching methods using other representations, with the aim of determining the real impact of the specificity of fingers on learning compared with an unstructured external analogical code (e.g. tokens) or even a structured external analogical code such as dice constellations. Finally, the study has demonstrated an effectiveness in solving transformation problems as well as other arithmetic problems. All the proposed problems relied on the use of numbers as measures of quantities such as a number of cars, candies, among others. However, the link between the choice of analogical code and the type of problem should be studied. Specifically, when the number denotes a position (e.g., the 3rd box or the 5th rung of a ladder), are fingers still good tools for resolution? In such cases, it might be more advisable to opt for a more suitable ordinal system. For example, the number line allows both the representation of numbers to indicate a position (a given graduation) and to quantify (the number of intervals between the origin and the graduation). Thus, the comparative evaluation of the effectiveness of different analogical codes, as well as their relevance according to the type of problem, seem to be research axes to consider in further studies.

## Conclusion

Interventions that have been evaluated for their effectiveness prior to entry into 1<sup>st</sup> grade are still an underdeveloped practice (for a meta-analysis, see Nelson & McMaster, 2019). Although recent studies show that early numeracy intervention has a beneficial impact on learning and a particularly beneficial effect on Low-SES (Darnon & Fayol, 2021; Nelson & McMaster, 2019; Raudenbush et al., 2020), few studies have focused on problem solving in very young children. Yet, knowing how to solve mathematical problems is a skill that children are expected to master in the French curriculum, and is assessed from the first year of elementary school (1<sup>st</sup> grade). The results obtained show that learning problem solving is accessible from the age of 6, the disadvantaged areas included. This study has been intended to be a pilot study: an interventional study into real-life learning context carried out by the teachers themselves. The results are consequently encouraging, albeit that further studies are needed to better understand how to help children experiencing difficulties with problem solving. Although using one's fingers seems to be a good choice for modelling statements, studies contrasting an intervention based on the use of fingers with the use of another type of material (tokens, cubes, lines) need to be carried out. Further research is needed to identify the types of word problems and, more generally, the situations in which the use of fingers is relevant or even effective.

## References

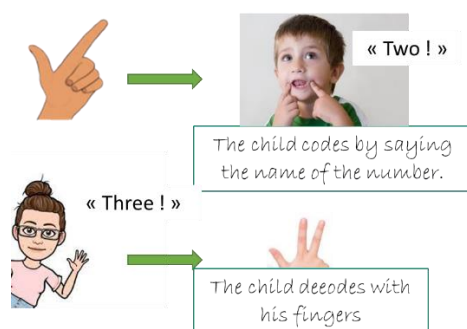
- Andres, M., Di Luca, S., & Pesenti, M. (2008). Finger counting: The missing tool? *Behavioral and Brain Sciences*, 31(6), 642-643. <https://doi.org/10.1017/S0140525X08005578>
- Berteletti, I., & Booth, J. R. (2016). Finger Representation and Finger-Based Strategies in the Acquisition of Number Meaning and Arithmetic. In D. B. Berch, D. C. Geary, & K. M. Koepke (Éds.), *Development of Mathematical Cognition* (p. 109-139). Academic Press. <https://doi.org/10.1016/B978-0-12-801871-2.00005-8>
- Björklund, C., Kullberg, A., & Kempe, U. R. (2019). Structuring versus counting : Critical ways of using fingers in subtraction. *ZDM*, 51(1), 13-24. <https://doi.org/10.1007/s11858-018-0962-0>
- Boaler, J., & Chen, L. (2016). *Why kids should use their fingers in math class*. The Atlantic. Retrieved from <https://www.theatlantic.com/education/archive/2016/04/why-kids-should-use-their-fingers-in-math-class/478053>.
- Boggio, C., Zaher, A., & Bosse, M.-L. (2023). ECRIMO, an app to train first graders' spelling : Effectiveness and comparison between different designs. *British Journal of Educational Technology*, 54(5), 1332-1350. <https://doi.org/10.1111/bjjet.13354>
- Butterworth, B. (1999). *The mathematical brain*. London, UK: Macmillan.
- Costa, A., Silva, J., Pinheiro-Chagas, P., Krinzinger, H., Lonnemann, J., Willmes, K., Wood, G., & Haase, V. (2011). A Hand Full of Numbers : A Role for Offloading in Arithmetics Learning? *Frontiers in Psychology*, 2. <https://www.frontiersin.org/articles/10.3389/fpsyg.2011.00368>
- Darnon, C., & Fayol, M. (2021). Can an early mathematical intervention boost the progress of children in kindergarten? A field experiment. *European Journal of Psychology of Education*. <https://doi.org/10.1007/s10212-021-00550-4>
- DEPP. (2020). *TIMSS 2019 – Évaluation internationale des élèves de CM1 en mathématiques et en sciences : Les résultats de la France toujours en retrait*. <https://www.education.gouv.fr/media/73349/download>
- Di Luca, S., & Pesenti, M. (2011). Finger numeral representations: more than just another symbolic code. *Frontiers in Psychology*, 2, 272. <https://doi.org/10.3389/fpsyg.2011.00272>

- Dupont-Boime, J., & Thevenot, C. (2018). High working memory capacity favours the use of finger counting in six-year-old children. *Journal of Cognitive Psychology*, 30(1), 35-42. <https://doi.org/10.1080/20445911.2017.1396990>
- Fagnant, A. (2005). The use of mathematical symbolism in problem solving : An empirical study carried out in grade one in the French community of Belgium. *European journal of psychology of education*, 20(4), Article 4.
- Fagnant, A. (2013). Opérations arithmétiques et symbolisations variées. Partir des démarches informelles des élèves pour donner du sens aux apprentissages. *Education et Formation*, 01, 23-38.
- Fayol, M. (2012). *L'acquisition du nombre* (Vol. 3941). Presses universitaires de France.
- Fixsen, D. L. (2005). *Implementation research : A synthesis of the literature*. National Implementation Research Network.
- Goldin-Meadow, S., Levine, S. C., & Jacobs, S. (2014). Gesture's role in learning arithmetic. In L. D. Edwards, D. Moore-Russo, & F. Ferrara (Éds.), *Emerging Perspectives on Gesture and Embodiment in Mathematics* (p. 51-72). IAP.
- Gracia-Bafalluy, M., & Noël, M.-P. (2008). Does finger training increase young children's numerical performance? *cortex*, 44(4), 368-375.
- Gravemeijer, K., Cobb, P., Bowers, J., & Whitenack, J. (2000). Symbolizing, Modeling, and Instructional Design. In P. Cobb, E. Yackel, & K. McClain, *Symbolizing and Communicating in Mathematics Classrooms*. Routledge.
- Greer, B., Verschaffel, L., & De Corte, E. (2002). "The Answer is Really 4.5" : Beliefs About Word Problems. In G. C. Leder, E. Pehkonen, & G. Törner (Éds.), *Beliefs : A Hidden Variable in Mathematics Education?* (p. 271-292). Springer Netherlands. [https://doi.org/10.1007/0-306-47958-3\\_16](https://doi.org/10.1007/0-306-47958-3_16)
- Guedin, N., Thevenot, C., & Fayol, M. (2018). Des doigts et des nombres. *Psychologie Française*, 63(4).
- Hilbert, S., Stadler, M., Lindl, A., Naumann, F., & Bühner, M. (2019). Analyzing longitudinal intervention studies with linear mixed models. *TPM-Testing, Psychometrics, Methodology in Applied Psychology*, 26(1), 101-119.
- Jordan, N. C., Kaplan, D., Ramineni, C., & Locuniak, M. N. (2008). Development of number combination skill in the early school years : When do fingers help? *Developmental Science*, 11(5), 662-668. <https://doi.org/10.1111/j.1467-7687.2008.00715.x>
- Lafay, A., Thevenot, C., Castel, C., & Fayol, M. (2013). The role of fingers in number processing in young children. *Frontiers in Psychology*, 4. <https://www.frontiersin.org/articles/10.3389/fpsyg.2013.00488>
- Lassault, J., Sprenger-Charolles, L., Albrand, J.-P., Alavoine, E., Richardson, U., Lyytinen, H., & Ziegler, J. C. (2022). Testing the Effects of GraphoGame Against a Computer-Assisted Math Intervention in Primary School. *Scientific Studies of Reading*, 26(6), 449-468. <https://doi.org/10.1080/10888438.2022.2052884>
- Levine, S. C., Jordan, N. C., & Huttenlocher, J. (1992). Development of calculation abilities in young children. *Journal of Experimental Child Psychology*, 53(1), 72-103. [https://doi.org/10.1016/S0022-0965\(05\)80005-0](https://doi.org/10.1016/S0022-0965(05)80005-0)
- Lorah, J. (2018). Effect size measures for multilevel models: Definition, interpretation, and TIMSS example. *Large-Scale Assessments in Education*, 6(1), 1-11.
- MENR. (2021). *Évaluations 2021 Repères CP, CE1*. Ministère de l'Éducation Nationale et de la Jeunesse. <https://www.education.gouv.fr/evaluations-2021-reperes-cp-ce1-326110>
- Mutlu, Y., Akgün, L., & Akkusi, Y. E. (2020). What Do Teachers Think about Finger-Counting?. *International Journal of Curriculum and Instruction*, 12(1), 268-288.
- Nelson, G., & McMaster, K. L. (2019). The effects of early numeracy interventions for students in preschool and early elementary : A meta-analysis. *Journal of Educational Psychology*, 111(6), Article 6.
- Ollivier, F., Noël, Y., Legrand, A., & Bonneton-Botté, N. (2020). A teacher-implemented intervention program to promote finger use in numerical tasks. *European Journal of Psychology of Education*, 35(3), Article 3. <https://doi.org/10.1007/s10212-019-00441-9>
- Orrantia, J., Muñoz, D., Sanchez, R., & Matilla, L. (2022). Supporting the understanding of cardinal number knowledge in preschoolers : Evidence from instructional practices based on finger patterns. *Early Childhood Research Quarterly*, 61, 81-89.
- Poletti, C., Krenger, M., Dupont-Boime, J., & Thevenot, C. (2022). The Evolution of Finger Counting between Kindergarten and Grade 2. *Children*, 9(2), 132. <https://doi.org/10.3390/children9020132>

- Poletti, C., Krenger, M., Létang, M., & Thevenot, C. (2023). French preschool and primary teachers' attitude towards finger counting. *Acta Psychologica*, 241, 104079. <https://doi.org/10.1016/j.actpsy.2023.104079>
- Raudenbush, S. W., Hernandez, M., Goldin-Meadow, S., Carrazza, C., Foley, A., Leslie, D., Sorkin, J. E., & Levine, S. C. (2020). Longitudinally adaptive assessment and instruction increase numerical skills of preschool children. *Proceedings of the National Academy of Sciences*, 117(45), 27945-27953. <https://doi.org/10.1073/pnas.2002883117>
- Riley, M., Greeno, J., & Heller, J. (1983). Development of children's problem-solving ability in arithmetic. In H. Ginsburg (Éd.), *The development of mathematical thinking* (p. 153-196). Academic Press.
- Rocher, T. (2016). Construction d'un indice de position sociale des élèves. *Éducation & formations*, 90, 5-27.
- Siegler, R. S., & Shrager, J. (1984). Strategy choices in addition and subtraction : How do children know what to do? In C. Sophian (Éd.), *Origins of Cognitive Skills : The 18th Annual Carnegie Mellon Symposium on Cognition* (1st edition, p. 229-293). Psychology Press.
- Van den Heuvel-Panhuizen, M. (2000). *Mathematics education in the Netherlands : A guided tour*. Ninth International Congress on Mathematical Education, Japan.
- Vergnaud, G. (1982). A Classification of Cognitive Tasks and Operations of Thought Involved in Addition and Subtraction Problems. In T. Carpenter, J. Moser, & T. Romberg (Éds.), *In Addition and subtraction : A cognitive perspective* (p. 39-59). Routledge.
- Vergnaud, G. (1992). Conceptual Fields, Problem Solving and Intelligent Computer Tools. In E. De Corte, M. C. Linn, H. Mandl, & L. Verschaffel (Éds.), *Computer-Based Learning Environments and Problem Solving* (p. 287-308). Springer. [https://doi.org/10.1007/978-3-642-77228-3\\_14](https://doi.org/10.1007/978-3-642-77228-3_14)
- Verschaffel, L., & De Corte, E. (1997). Word problems : A vehicle for promoting authentic mathematical understanding and problem solving in the primary school? In *Learning and teaching mathematics : An international perspective* (p. 69-97). Psychology Press/Erlbaum (UK) Taylor & Francis.
- Verschaffel, L., Schukajlow, S., Star, J., & Van Dooren, W. (2020). Word problems in mathematics education : A survey. *ZDM*, 52(1), 1-16. <https://doi.org/10.1007/s11858-020-01130-4>
- Villani, C., & Torossian, C. (2018). *21 mesures pour l'enseignement des mathématiques*. Ministère de l'Éducation Nationale et de la Jeunesse. <https://www.education.gouv.fr/21-mesures-pour-l-enseignement-des-mathematiques-3242>

### **Autour des gestes professionnels**

## Appendix 1. The Lucky Luke game



## Appendix 2. Progression of the collective rituals: The Lucky-Luke game and verbal numerical chain

Days	Lucky Luke game (10mns)	Verbal numerical chain (5mns)
<b>D1</b>	<b>Focus 1 to 5</b> <b>Code:</b> Order, Disorder <b>Decode:</b> Order, Disorder	- Count from 1 to 30 - Count from <b>2 to 10</b>
<b>D2</b>	<b>Focus 0 to 5 + speed</b> <b>Code:</b> Order, Disorder, speed <b>Decode:</b> Order, Disorder, speed	- Count from 1 to 30 - Count from <b>3 to 10</b>
<b>D3</b>	<b>Focus 5 - 6 - 7</b> <b>Code:</b> Order, Disorder <b>Decode:</b> Order, Disorder	- Count from <b>4 to 10</b> - Count down from <b>5 (with fingers)</b>
<b>D4</b>	<b>Focus 5 - 6 - 7 + speed</b> <b>Code:</b> Order, Disorder, speed <b>Decode:</b> Order, Disorder, speed	- Count from <b>5 to 10</b> - Count down from <b>8 (with fingers)</b>
<b>D5</b>	<b>Focus 8 - 9 - 10</b> <b>Code:</b> Order, Disorder <b>Decode:</b> Order, Disorder	- Count from 1 to 30 - Count from <b>6 to 12</b>
<b>D6</b>	<b>Focus 8 - 9 - 10 + speed</b> <b>Code:</b> Order, Disorder, speed <b>Decode:</b> Order, Disorder, speed	- Count from <b>7 to 12</b> - Count down from <b>9 (with fingers)</b>
<b>D7</b>	<b>Focus 5 to 10 + speed</b> <b>Code:</b> Disorder, speed <b>Decode:</b> Disorder, speed	- Count from <b>8 to 12</b> - Count down from <b>10 (with fingers)</b>
<b>D8</b>	<b>Focus 5 to 10 + speed</b> <b>Code:</b> Disorder, speed <b>Decode:</b> Disorder, speed	- Count from <b>9 to 12</b> - Count down from <b>10</b>
<b>D9</b>	<b>Focus 1 to 10 + speed</b> <b>Code:</b> Disorder, speed <b>Decode:</b> Disorder, speed	- Count from 1 to 30 - Count down from <b>10 (with fingers)</b>
<b>D10</b>	<b>Focus 1 to 10 + speed</b> <b>Code:</b> Disorder, speed <b>Decode:</b> Disorder, speed	- Count from <b>5 to 10</b> - Count down from <b>10</b>

« Order »: the numbers were given in integer order

« Disorder »: the numbers were given out of order

« Speed »: the children were challenged to give the answer as quickly as possible

« Code »: the teacher showed a canonical pattern of fingers and the children had to give the verbal code.

« Decode »: the teacher would say a verbal code and the children would draw a corresponding finger pattern

Appendix 3. Progression of the training sessions. Each session was organised as follows: 7 problems in which the teacher used tokens, followed by 1 or 2 problems given orally only.

S1	S2	S3	S4	S5	S6	S7
Simulated problems (with tokens): "I put $x$ tokens (the teacher shows them and puts them in the opaque box). Now I add $y$ tokens (the teacher shows them and puts them in the opaque box). Now I take out $y$ tokens (the teacher shows them and puts them in the opaque box). How many tokens are left in the box (the box is closed)?" or "I put $x$ tokens (the teacher shows them and puts them in the opaque box). Now I take out $y$ tokens (the teacher shows them and puts them in the opaque box). How many tokens are left in the box (the box is closed)?"						
$3 + 2; 3 + 1; 2 + 2;$ $1 + 5; 5 - 2; 4 - 3;$ $4 + 2$	$3 + 3; 5 - 3; 4 - 3;$ $2 + 1 + 2; 2 + 3 +$ $1$ $1 + 3; 4 + 2$	$4 + 3; 8 - 3; 9 - 2;$ $7 - 4; 2 + 5;$ $2 + 3 + 3; 5 - 2 -$ $1$	$8 - 4; 4 + 3; 6 + 4;$ $7 + 2; 4 + 5;$ $2 + 5 + 2; 6 - 2 - 2$	$8 - 4; 8 + 2; 5 + 3 + 1;$ $7 - 5; 6 + 1 + 2;$ $10 - 2 - 3; 9 - 3$	$9 - 4; 6 + 5; 4 + 3 + 5$ $8 - 8; 2 + 7 + 1; 10 - 5 -$ $1$	$10 - 6; 4 + 7; 6 - 1 - 5$ $7 - 6; 5 + 1 + 5; 9 - 2$ $- 3$
Word problems						
Tom has 3 sweets. Mathis gives him 2 more. How many sweets does he have now?	Sofia has 2 marbles. She wins 4 new ones at playtime. How many marbles does she have now?	The teacher brought 9 cakes this morning. She ate 3 of them at break time. How many do she have left?	Jeff has brought 7 small cars. He gives 4 to Adam. How many does he have left?	Malo had 3 marbles when he arrived at school. He earned 4 at the morning recess and 2 more at the afternoon recess. How many marbles does he have at the end of the day?	Noa has 5 marbles. He wins 6 at school. How many marbles does he have now? Tiago has baked 8 cakes. His dad ate 2 and his mum ate 3. How many cakes are left?	Lola has 5 markers. Her father gives her 2 and her mother gives her 4. How many does she have in total now? Liam has 10 sweets. He gives 7 to José. How many does he have left?
Explanation of finger use strategy						
I put the first addend on one hand. - If I add tokens, I can put the second addend on the other hand. - If I remove tokens, I can put my fingers down to find out what's left.	I put the first addend on one hand and then complete that hand each time tokens are added before using the second hand if necessary.	Reminder of procedures	I put 4 in my head (hand on head) and add 3 on my fingers. I lower my fingers 5, 6, 7. Or I put 4 in my head (hand on head) and open the fingers one by one and stop when the 3 is built.	Reminder of procedures	Reminder of procedures	Reminder of procedures

