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Effective numeracy educational interventions for students from disadvantaged social background: a comparison of two teaching methods

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ABSTRACT

The purpose of this study was to assess the effectiveness of explicit instruction, compared to constructivist instruction, in teaching subtraction in schools with a high concentration of students from a disadvantaged social background: eighty-seven second graders (mean age in months = 90.95, *SD* = 5.30). Two groups received explicit versus constructivist instruction during 5 weeks. Pre- and posttest analyses were conducted to compare the effects of the instruction type on subtraction skills taught through the partitioning subtraction method. Results showed that although all students progressed between both evaluations, those who received explicit instruction performed better. The findings from this study suggest that explicit instruction teaching is a promising approach in supporting the learning of mathematical knowledge for low-achieving students from disadvantaged social background. A larger scale study comparing the outcomes of children from different socioeconomic backgrounds would be needed to extend the applicability of the positive effects of this study.

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Explicit instruction; socioconstructivist instruction; students from a disadvantaged; social background; subtraction

Introduction

The purpose of any education system is to enable the greatest number of students to succeed. The results of international surveys indicate how successfully this goal is being achieved. According to the latest results of the Programme for International Student Assessment (PISA; Schleicher, 2019), France is the country within the Organisation for Economic Cooperation and Development (OECD) which is creating the highest level of educational inequality. Two significant elements are indicative of this. On the one hand, the proportion of low-performing students has increased steadily between 2003 and 2012. On the other hand,

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low-performing students systematically come from disadvantaged socioeconomic backgrounds. In other words, the students' socioeconomic background is a predictor of academic performance (OECD, 2016; Schleicher, 2019).

Forty years of research, mainly conducted in Anglo-Saxon countries, have shown that school plays a critical role in the achievement of students from disadvantaged social backgrounds. In France, results in mathematics are strongly correlated with the socioeconomic and cultural level of families, meaning that disadvantaged students have significantly poorer performance in this domain (Mullis et al., 2016; Schleicher, 2019). The role of schools is even more important since results are heavily influenced by the "teacher effect" (Bautier, 2006; Bressoux, 1994; Bressoux & Bianco, 2004; Felouzis, 1997). The crucial impact of this factor is illustrated in one of the biggest meta-analyses produced by Hattie (2012). Among the 138 variables affecting student achievement, the most influential are, according to their ranking: the teacher, the curriculum, and the teaching methods. Therefore, the teacher's pedagogical choices can be decisive for students' academic achievement.

Among the existing pedagogical orientations, two teaching methods have been frequently employed these last decades and have been the object of reforms in different education systems, that is, the constructivist-based instruction and explicit instruction. In France, the pedagogical orientations are given by the Ministry of Education authorities and followed in schools by the teachers. Since the 1970s, and until recently, they encouraged the systematic use of socio-constructivist methods (Doriath et al., 2013; Ministère de l'éducation nationale, 2002; Ministère de l'éducation nationale, de l'enseignement supérieur et de la recherche [MENESR], 2015). The aim of the present research is to compare the effectiveness of explicit teaching with the socioconstructivist teaching in acquiring subtraction mathematical skills among students from disadvantaged social backgrounds.

Two different teaching methods: socioconstructivist instruction and explicit instruction

The socioconstructivist method

According to the socioconstructivist method, students build their own learning as much as possible, that is, their interpretation of the world, with the teacher's support (Bächtold, 2012). The teacher's role consists in providing conditions conducive to the students' knowledge building. The teacher guides them in promoting active and individual learning rather than simply transmitting knowledge.

The constructivist approach, based on Piagetian developmental ideas, focuses on the learner's activity. New knowledge is built on previous knowledge but sometimes conflicts with later knowledge acquired. This creates cognitive conflicts, which must be solved (Piaget, 1975), generating dynamic balance and imbalance. Cognitive conflict and imbalance are in this sense crucial for learning. When other people are the source of conflict, one speaks of sociocognitive conflict (Doise & Mugny, 1997; Perret-Clermont, 1996). Sociocognitive conflict and its resolution are considered to be an essential learning mechanism, particularly in the classroom. Typically, for a given problem, students' different points of view emerge, generating cognitive conflicts. They are gradually resolved through exchanges, discussions, and negotiations. In this process, students move from dependency to independency through their mastery of knowledge (Vygotsky, 1985).

According to a constructivist view, learning new knowledge is built on the students' initial representations of the concept to be acquired. These representations serve as a starting point to building hypotheses. In the classroom, the socioconstructivist method corresponds to a form of process, which follows some distinct phases. The first consists of discovering a new piece of knowledge or competence through the presentation of a problem or a situation on which to reflect. The second, crucial for this approach, is a phase of research. Most of the time, it takes the shape of group work for students to exchange and confront their ideas in order to formulate hypotheses to test in the initial situation. The teacher's role is only to regulate the exchanges. The third phase consists of comparing the different groups' proposals, leading to the emergence of the sociocognitive conflict. The teacher "institutionalizes", employing written support, the most accurate ideas and solutions proposed by the groups. The lesson ends with a training phase in which the students apply their newly acquired knowledge or competence in different contexts.

The explicit teaching method

According to explicit teaching, learning new knowledge is based on the teacher's guidance and the examples provided. In addition, the learning content should be dealt with in a systematic and planned way, following a gradation from simple to complex and the use of particular, selected principles (e.g., Engelmann & Colvin, 2006; Gauthier et al., 2013; Rosenshine, 2012).

The principles of explicit teaching can be related to learning mechanisms theorized by behaviourism and cognitive theories. Classical (Pavlov, 1963), operant (Skinner, 1971), and observational learning (Bandura, 1977) describe laws that might explain many acquisitions. For instance, when neutral stimuli (e.g., the multiplication table) are related to an emotional response (e.g., stress), they may subsequently generate an emotional response because the individual assimilates not only the information but the conditions of its acquisition as well. The formulation of a minimum threshold of success in explicit teaching induces a positive feeling related to the learning content. Moreover, in explicit teaching, where feedback and automaticity are fundamental principles, any response produced by the learner must be followed by the teacher's feedback. Therefore, repeated association between responses (e.g., the results of multiplication tables) and reinforcers (e.g., feedback) leads to increased skills automaticity. This enables quick, effortless, and spontaneous reactions, leaving sufficient resources for more complex learning. Finally, observation of a competent model can also contribute to effective learning.

These principles are applied through the main phases of the teaching process. During the preparatory phase, clarifying the learning objectives and intended outcomes (i.e., specifying the expected behaviour of students at the end of the lesson), identifying key ideas (i.e., key concepts linking the knowledge), and determining prior knowledge are crucial.

In the classroom, conducting the lesson involves three steps: modelling, guided practice, and independent practice (Gauthier et al., 2013). Modelling takes place when the teacher makes explicit the connections between new and prior knowledge. During this stage, the teacher performs a task in front of students describing what they do when they perform the task. They use examples and carefully chosen counter-examples. They reason out loud and make the expert procedure explicit, using clear and concise language. The guided practice is crucial for the teaching process because it helps to check the students' understanding. In this respect, the teacher uses tasks similar to those performed during the modelling stage. They ask questions and give feedback as often as possible. To move on to the next stage, a sufficient number of exercises is recommended to ensure the mastery of 80% of the content. Once the threshold is attained, students move on to independent practice, which is a stage of training. Students must be given sufficient opportunities for the acquired skills to become automatic.

Cognitive psychology and recent neuroscience research provide support for the principles of explicit teaching. The role of encoding knowledge and skills in the long-term memory as well as the importance of constantly checking the students' comprehension are empirically supported (Brown et al., 2016).

Empirical support for evaluation of the efficacy of explicit and constructivism approaches

The evaluations of the efficacy of the two considered approaches are focused on different outcomes, and are rarely compared in the same studies.

Madden et al. (1999) evaluated MathWings, a programme designed to fit the standards of the National Council of Teachers of Mathematics in the USA, and based on the constructivist approach. Measures for six pilot schools in three districts show substantial improvement linked to the implementation of MathWings. The improvement was higher in high-poverty schools. However, this study did not include a control group, and the improvement in mathematical skills could be partially linked to a reading programme that was implemented at the same time in those schools. Moreover, the students spent at least 60 min in their mathematics class per day, and no information was given on the mathematics classes before the implementation of MathWings. In a longitudinal study, Carpenter et al. (1998) interviewed students (from first to third grades) from a socioconstructivist environment who used invented strategies before they learned standard algorithms; they demonstrated better knowledge of base-ten number concepts and were more successful in transferring their knowledge to new situations than students who initially learned standard algorithms. Dethlefs (2003) found a positive correlation between the constructivist-learning environment and self-efficacy, intrinsic motivation, attitudes, and learning strategies in secondary school students. In a study of mathematics learning in secondary school, it was shown that the way in which students participate in lessons (looking for a solution, comparing their own solution to that of their peers) shaped their knowledge of mathematics. In this perspective, the emphasis is placed on the student's capacity to recognize contexts in which the information is relevant (Gresalfi et al., 2009). However, these studies did not test the direct link between the constructivist learning environment and school achievement.

Concerning direct instruction, Chodura et al. (2015) show that this method is particularly efficient for teaching basic arithmetic skills in students who have difficulties with mathematics. Further, Kroesbergen et al. (2004) directly compare the explicit method and the socioconstructivist method in mathematics for low-achieving students, building on research that suggested that the socioconstructivist method benefits average and above-average students and only marginally benefits low achievers (Kroesbergen & Van Luit, 2003; Woodward & Baxter, 1997). They focused the study on the acquisition of multiplication skills. Their results show that the explicit method is more effective than the socioconstructivist method, and increases the students' ability to solve multiplication problems, although students improve skills with both methods. For them, the socioconstructivist method was less efficient because of the confusion that the presence of correct and incorrect solutions could create in low-achieving students.

Several studies showed that explicit instruction appears to be more efficient for students with learning disorders than the socioconstructivist approach. In a meta-analysis, White (1988) analysed the effect of direct instruction on special needs students (three of the 25 studies concerned mathematics skills). More than half of the results significantly favoured the direct instruction group and none of the negative measures for direct instruction was significant.

Based on an effect size of 0.40, considered as a threshold for a pedagogic intervention to be efficient (Cohen, 1988), three meta-analyses (Baker et al., 2002; Kroesbergen & Van Luit, 2003; Kunsch et al., 2007) ranked first the explicit methods and the direct instruction in mathematics for low-achieving students (Bissonnette et al., 2010). Accumulated evidence shows that the explicit teaching approach is effective; however, few studies have directly compared the respective effectiveness of the socioconstructivist and explicit teaching methods with regard to mathematics achievement. More research is needed in order to comment on the efficacy of the two pedagogical orientations with regard to low-achieving students.

Overview

This research compares the effectiveness of explicit teaching with socioconstructivist teaching in mathematics and, more specifically, concerns subtraction as a basic skill. It focuses on schools from the priority education networks in France, which have a concentration/high percentage of students from disadvantaged socioeconomic backgrounds. Many of them experience learning difficulties in general, and in mathematics in particular. The present study was conducted in Martinique. This French region is notable for having more than 50% of its students who come from disadvantaged backgrounds.

In this study, the effectiveness of explicit and socioconstructivist teaching methods is compared in the learning of subtraction using the partitioning method with second-grade students (7 years old). Two reasons motivated the choice of this learning content. First, the French National Mathematics Programmes require the acquisition of the subtraction skills at this particular education level. Second, the concept of numbers, as a basic concept in mathematical reasoning, is better understood if related to mathematical operations. For example, one genuinely understands what "8" means if one conceives it as the result of various operations (e.g., $4+4$, 2×4, $10-2$). For investigating the efficacy of the teaching method, we controlled for the subtraction technique and fixed it for all the classes (i.e., all the teachers taught the method of subtraction through partitioning). The hypothesis in this study is that students who receive explicit teaching in this method of subtraction progress more than students who receive socioconstructivist teaching.

Method

Participants

Ninety-four second-grade students participated in this research and were recruited from six public primary schools located in priority education networks in Martinique. The schools have a concentration of many students from low socioeconomic backgrounds (MENESR, 2015). Of those students, 87 met the participation criteria, including 49 girls and 38 boys aged between 82 and 104 months (mean age = 90.95, *SD* = 5.30). The students were from six different classes, all in priority education schools. One class per school was selected. The schools were selected from the most disadvantaged districts, on the basis of two schools per district. Schools and classes were randomly assigned to explicit or socioconstructivist teaching conditions. All the participants completed the pretest and posttest. Students with cognitive impairment, non-native Francophone students and students who did not take part in the two study sessions were excluded from analysis.

Design

The experiment had a pretest-intervention-posttest design. A 2×2 mixed experimental design (type of teaching method: explicit, socioconstructivist) with pretest and posttest measures evaluation was employed. Classes were randomly assigned to one of the two teaching method conditions, namely, 45 students in the explicit teaching condition (experimental group) and 42 students in the socioconstructivist teaching condition (control group). The two groups were well matched in terms of age and gender distribution. The study was conducted in regular classrooms/classes.

Materials and procedure

The experiment had three phases: the pretest, the intervention, and the posttest. The pre- and posttest enabled us to assess the students' performance before and after the intervention. The pretest helped to check the equivalence of the groups at the beginning of the intervention. The posttest measured the students' progress and the impact of the teaching method. The pre- and posttest were paper and pencil, strictly identical, and designed to take up to 45 min. Both the control group and experimental group were taught the subtraction technique (i.e., partitioning technique) at the same time, at the same pace, and in the same number of sessions. In terms of subtraction skills, the equivalence of the two groups was checked based on the pretest results. We expected no differences between the two groups. The intervention lasted for 5 weeks. The tests were taken in a regular classroom and administered by the first author and two research assistants. The instructions were fully standardized among classes and sessions to ensure the comparability of the experimental conditions. Before describing the three phases of the study, the notion of subtraction using the partitioning method is explained.

Subtraction techniques

A subtraction technique is a written technique of performing calculations consisting in lining up units, tens, and so forth, in columns when the calculation is too complex for the result to be found through mental calculation. In France, three main techniques are used to teach subtraction: the partitioning technique, the constant deviations technique, and the so-called "change unknown" technique. For second graders, the partition technique is most often used as it has the advantage of being easy to relate to the tens system acquired during the first grade, which is a fundamental prerequisite for learning subtraction. The principle is that numbers can be partitioned and recombined to make a ten, as our number system operates on base ten. Thus, if one has to calculate $52 - 39$, first one can convert 52 in 4 tens and 12 units. Therefore, the initial operation becomes $(40 + 12) - (30 + 9)$, which can be written as $(40 - 30) +$

(12 − 9). In this study, all the numbers are natural numbers and the partitioning technique was chosen and fixed for all the classes.

Pretest

The assessment of the subtraction competencies was completed through a test conceived by specialists in mathematics didactics and regularly used to evaluate the students in all the schools from the region in which the study took place. This assessment is used in schools as a predictor of students' acquisition of a series of basic competencies included in the students' record. Four exercises were designed to measure the baseline level of students in applying the partitioning technique of subtraction. The first exercise consisted in lining up, in a column, two subtractions whose result can be found without partitioning. For example, students had to write "52-12" as $\begin{array}{r} 52 \\ \underline{-12} \end{array}$ and calculate the subtraction result. The second exercise consisted of lining up, in a column, two subtractions with partitioning. For example, students had to write "52-39" as $\begin{array}{r} 52 \\ \underline{-39} \end{array}$ and calculate the subtraction result. The third exercise consisted of solving a cardinality subtraction problem (i.e., the numbers represent quantities). For example: "There is a bouquet of 35 flowers on the table. Dad removes 19 dead flowers from it. How many flowers are now on the table?" The fourth exercise consisted of solving an ordinality subtraction problem (i.e., the numbers represent ranks). For example: "The fireman is on the 57th rung of the ladder and steps down 29 rungs. On which rung is he now?" Students are expected to line up the subtraction in a column, conduct the calculation, and write a sentence that answers the question.

Students received instructions regarding the test content. They were told that they had to calculate operations and solve problems. The test would take 45 min maximum. Their goal was to do their best rather than be the first to finish. To facilitate the presentation and comprehension tasks, a test version similar to the paper version was displayed on the board. This served to help the researcher to explain the task. The researcher made sure that students understood that they had to solve four different problems and then place their responses in the appropriate places on the answer page. Moreover, in order to anticipate potential reading difficulties among students, the researcher read the instructions out loud twice to the class. On request, the researcher could provide students with extra reading instructions. Students were told to raise their hand when they thought they had completed the test.

Scores

The scores calculated are listed in Table 1. The maximum value of the score was 10 points. Points were awarded for both the final results of the operations and

Table 1. Types of exercises, instructions, and score calculation for the pretest and posttest.

Type of exercise	Instructions	Score calculation
Subtraction without partitioning	Line up in a column and calculate: 77 − 14; 96 − 55	– Lining up in a column: 0.25 point per subtraction – Writing the "−" sign and drawing the subtraction line: 0.25 point per subtraction – Finding the correct answer: 0.5 point per subtraction Maximum score: 2 points
Subtraction with partitioning	Line up in a column and calculate: 82 − 34; 51 − 28	– Lining up in a column: 0.25 point per subtraction – Writing the "−" sign and drawing the subtraction line: 0.25 point per subtraction – Finding the correct answer: 0.5 point per subtraction – Applying the partitioning technique 0.5 point per subtraction Maximum score: 3 points
Cardinality subtraction problems	Read each problem, line up the operation, and answer the following question: "There are 35 flowers in the bouquet on the table. Dad removes 19 dead flowers from it. How many flowers are now on the table?"	– Lining up in a column: 0.25 point per subtraction – Writing the "−" sign and drawing the subtraction line: 0.25 point per subtraction – Finding the correct answer: 0.5 point per subtraction – Applying the partitioning technique 0.5 point per subtraction – Formulating the correct answer: 0.5 point: reporting the correct answer 0.5 point: formulation of the sentence Maximum score: 2.5 points
Ordinality subtraction problems	Read each problem, line up the operation, and answer the following question: "The fireman is on the 57th rung of the ladder and steps down 29 rungs. On which rung is he now?"	– Lining up in a column: 0.25 point per subtraction – Writing the "−" sign and drawing the subtraction line: 0.25 point per subtraction – Finding the correct answer: 0.5 point per subtraction – Applying the partitioning technique 0.5 point per subtraction – Formulating the correct answer: 0.5 point: reporting the correct answer 0.5 point: formulation of the sentence Maximum score: 2.5 points

the procedures used. The items in the test had strong internal consistency (Cronbach's alpha = .80). The total score was obtained by adding the scores of four exercises: subtraction without the partitioning technique (Cronbach's alpha = .87); subtraction with the partitioning technique (Cronbach's alpha = .75); cardinality subtraction problem score (Cronbach's alpha = .78); ordinality subtraction problem score (Cronbach's alpha = .79).

Intervention

The experiment took place in real class conditions. In France, it is recommended to do 15 min of mental arithmetic exercises every day in all classes. Therefore, the first phase of the intervention consisted in carrying out the standardized mental arithmetic exercises with both the control and the experimental group students. For 3 weeks, the teachers used the same exercises and materials for both conditions. The purpose was to ensure that the students were taught the skill of mental subtraction with small numbers (i.e., up to 20), which is a necessary precondition for learning the subtraction partitioning technique. Two games requiring performing mental calculations were used. The first game consisted in placing a piece in the centre of a track (with numbers from 1 to 32) and rolling a dice to move the piece backward or forward. The goal of the game was to be the first to reach the arrival point of the track through a series of throws. For each throw, the player had to verbalize how the piece should be moved. For example, a student might say, "I'm on square 15. I have to go back 4 squares, so I have to put the piece on square 11". The second game consisted in putting a number of tokens (less than or equal to 20) in a box and then removing part of it (less than or equal to 5). The students had to say how many tokens remained in the box.

The subtraction partitioning technique was taught during the 2 weeks following the mental calculation training of the two groups. The length of the sequence, the number of lessons, and the material (strips and cubes respectively representing tens and units were identical for both groups).

Teachers in the control group did not receive training. They developed their own sequence according to the recommendations made by the researcher and the instructions for socioconstructivist teaching. Each lesson was built in accordance with the following sequence: the search for a solution to a simple subtraction problem through confronting different methods in order to find the right answer; the comparison of the different solutions proposed by the students in order to highlight the quickest and most effective; the institutionalization of the partitioning method; training phase. None of the teachers was familiar with explicit teaching. However, the researcher checked that the teachers were applying the correct instructions with the correct group through a classroom visit and with the sessions' preparation sheets.

Teachers of the experimental group were provided with a 3-hr training session. The goal of this training was to present the explicit teaching method and have the teachers become familiar with the sessions of the mathematical sequence that they were to implement. Similarly, the researcher checked whether the pedagogical material in the classes was adequate for the specificity of the subtraction sequence. Teachers then had the opportunity to review the sequence in detail and request any information or clarification that they needed. Regarding the control condition in the experimental group, the researcher checked that the teachers were applying the instructions they were given during the training, through a classroom visit.

The sequence was designed and prepared by the researcher, for use by the teachers in the experimental condition. It included eight sessions (see Table 2) following a progression from simple to complex and from concrete to abstract. Sessions 1 and 2 were planned for solving subtraction problems through manipulations. During Sessions 3 and 4, the same types of problems were proposed, except that their resolution was based on drawings. Session 5 was aimed at teaching the subtraction partitioning technique itself. Session 6 consisted in consolidation of the partitioning technique. Session 7 involved training exercises. Session 8 included the application of the subtraction technique to new problems.

Each session followed the three steps of a traditional classroom lesson: introduction, main activity, and conclusion. The main activity followed the steps recommended by the tenets of explicit teaching: modelling, guided practice, and independent practice. Table 3 illustrates the progress of a session (i.e., Session 4) by mapping the different stages and the teacher's action.

As in the experimental condition, the partitioning technique was taught to students in the control condition. This strategy is not necessarily the teacher's choice but is strongly recommended by programmes and academic authorities, as it is based on the properties of numbers learned in the previous grade level (1st year of primary school). Although variations among teachers might have occurred, typically the partitioning technique in the regular teaching should follow several steps. First, the lesson starts with a subtraction problem. Next,

Table 2. Training sequence for teaching subtraction with the partitioning technique in classes using the explicit teaching condition and including eight sessions.

Session	Goals	Content and tasks sample
1	Solve one cardinality subtraction problem with manipulatives	– Tom had 67 balls in his box. He lost 29 of them. How many are left in his box? – Using manipulatives
2	Solve one cardinality and one ordinality subtraction problem with manipulatives	– Magali plays on a track. Her pawn was on box number 48. It moved 25 boxes backward. On which box is Magali's pawn now? – Using manipulatives
3	Solve one cardinality and one ordinality subtraction problem using photo representations of manipulatives	– Same problems used in Sessions 1 and 2 – Visualizing the manipulatives without the possibility of manipulating – Solving problems through drawing
4	Line up the subtraction in a column applying the partitioning technique through photos of manipulatives representing the stages of a problem resolution already studied in previous sessions	– Same problems used in Sessions 1, 2, and 3 – Solving problems based on photos of the problem resolution stages – Lining up the subtraction in a column
5	Line up in a column and solve a subtraction based on a previously solved problem without the use of photos representing the stages of the problem resolution	– Same problems used in Sessions 1, 2, and 3 – Solving problems without photos of the problem resolution stages – Lining up the subtraction in a column
6	Line up a subtraction in a column and verbalize the partitioning technique application stages	– Exercises on lining up in a column
7	Calculate as many subtractions as possible in 30 minutes	– Exercises involving the application of the subtraction partitioning technique
8	Solve three subtraction problems using the partitioning technique	– New subtraction problems – Solve the problems using the partitioning technique mandatorily

Table 3. Sample of explicit teaching session phases (i.e., Session 4).

Session phases	Content
Introduction	
Presentation of the goal	"We're going to learn how to line up subtractions. To do this, we'll use the problem that we solved in Session 1."
Clarification of the goal	"At the end of the session, you should be able to put a subtraction in a column. For that, you can use the notes that you took during previous sessions."
Reactivation of previous knowledge	"How do we solve problems when we don't have manipulatives on hand?"
The lesson conduct	"If you don't know how to solve a subtraction mentally, you will put it in a column to find the answer. For instance, you might need to apply this technique when you pay something with a bill and you want to know how much change you should be given."
Modelling Practical interest of the learning (link with everyday life)	"I'll show you how to solve a problem using the photos we took. I write the number corresponding to the number constructed from the manipulatives next to the photos. Then I write the operation I have to do to solve the problem: 67 balls − 29 balls. I'll write the same thing only with numbers: 67 − 29. I put it in a column. For this, I write 67 first and then 29 below. The units must be one underneath the other, like the tens. Then I put the '−' sign on the side and on the same line as 29. Then I draw a horizontal line beneath the numbers. This is what I tell myself: I can't remove 9 units because there are only 7. Then I'll break a 'ten'. It now appears as 5 tens and 17 units. I can now remove 9 units from 17 units, which gives 8 remaining units. I can remove 2 tens from 5 tens, which gives 3 remaining tens." Each sentence spoken by the teacher is written and put in relation to the corresponding step of the partitioning technique.
Guided practice Resolution by students	"You'll work in pairs. You are to put the operation corresponding to the problem solved in Session 2 in a column on your slate. You are to explain everything you do to your friend. You have 15 minutes to do this. You'll have 2 extra minutes to prepare your answer if you are sent to the blackboard."
Institutionalization	"Make a poster to resume the subtraction put in a column." The teacher accompanies students to represent each step, resulting in a sentence connected to the operation put in a column, in the same manner as in the modelling phase.
Independent practice	"Put the operation corresponding to the following problem (i.e., a problem already studied in previous sessions) in a column and calculate it." Students receive feedback individually.
Conclusion	"What did we learn during this lesson?" "What is useful to be able to solve subtractions in a column?" "Tomorrow we'll learn how to solve new subtractions."

the students propose all sorts of possible solutions. Based on their responses, the correct responses are identified and the wrong solutions are analysed with the students. Students who have the correct solutions are invited to explain their strategy. While acknowledging that several solutions are possible, this validates, as common to the class, the solution based on the partitioning strategy.

Posttest

The posttest was identical to the pretest and was conducted, for all participants, on the day following the last session or immediately after the end of Session 8.

Results

To analyse the effect of the type of teaching method and evaluation of the performance change between the pre- and posttest, a variance analysis with mixed designs was conducted. The total score and the scores for the individual exercises (see Table 1) were analysed using mixed analysis of variance (ANOVA) 2 (type of teaching method: explicit, socioconstructivist) x 2 (evaluation: pretest, posttest) in the mixed experimental design. The evaluation was a within-factor as each participant performed the same test as a pretest and posttest. Sizes are reported for all effects (Cohen's *d* and eta squared η^2p). The effects are interpreted as small when $\eta^2p < 0.06$ or $d < 0.2$; in other words, when $0.06 < \eta^2p < 0.14$ or $0.3 < d < 0.8$; and great when $\eta^2p > 0.14$ or $d > 0.8$. Table 4 summarizes the means and standard deviations as a function of the type of teaching and the evaluation phase for each exercise. There was no statistically significant difference between the experimental group and control group on the pretest for both the total score and the individual exercise scores (*F*s <1).

Total score

The analysis of the total score revealed a strong statistically significant effect in the evaluation, $F(1, 85) = 228.31$, $p < .001$, $\eta^2p = .73$, in the sense that the students in both the control group and the experimental group made progress between the pretest ($M_{control} = 1.38$, $SD_{control} = 1.77$; $M_{experimental} = 1.26$, $SD_{experimental} = 1.27$) and posttest ($M_{control} = 5.73$, $SD_{control} = 3.13$, $d_{control} = 1.71$; $M_{experimental} = 7.06$, $SD_{experimental} = 2.76$, $d_{experimental} = 2.70$). The predicted interaction effect is significant, $F(1, 85) = 4.72$, $p < .05, = .05$ η^2p, and shows that scores increased between the two phases of the evaluation for both groups and more so for those in the experimental group (post-pre-test difference $d = 0.46$).

Table 4. Student means and standard score deviations on the pretest and posttest with the explicit teaching condition and constructivist teaching condition.

	Explicit teaching (*N* = 45)		Constructivist teaching (*N* = 42)	
Measures	*M*	*SD*	*M*	*SD*
Total score pretest	1.26	1.27	1.38	1.77
Total score posttest	7.06	2.76	5.73	3.13
Exercise 1 pretest	0.38	0.68	0.50	0.72
Exercise 1 posttest	1.64	0.59	1.49	0.65
Exercise 2 pretest	0.24	0.43	0.33	0.44
Exercise 2 posttest	2.15	0.98	1.71	1.03
Exercise 3 pretest	0.37	0.40	0.23	0.39
Exercise 3 posttest	1.57	0.89	1.39	0.98
Exercise 4 pretest	0.27	0.49	0.33	0.68
Exercise 4 posttest	1.71	0.85	1.14	0.93

Score for subtraction without the partitioning technique

The mixed ANOVA, applied to the subtractions without restraint scores, shows the statistically significant effect in the evaluation, $F(1, 85) = 148.30$, $p < .001$, $\eta^2 p = .64$ in that the scores of students in the control group and experimental group increased between the pretest ($M_{control} = 0.50$, $SD_{control} = 0.72$; $M_{experimental} = 0.38$, $SD_{experimental} = 0.68$) and posttest ($M_{control} = 1.49$, $SD_{control} = 0.65$, $d_{control} = 1.44$; $M_{experimental} = 1.64$, $SD_{experimental} = 0.59$, $d_{experimental} = 1.98$); however, the interaction effect was not statistically significant, $F(1, 85) = 2.19$, $p = .14$. This result suggests that students in the experimental group and control group progressed, but to a similar degree (post-pre-test difference $d = 0.3$).

Score for subtraction with the partitioning technique

The analysis revealed a statistically significant effect in the evaluation, $F(1, 85) = 187.62$, $p < .001$, $\eta^2 p = .69$, in that the scores of students in the control group and experimental group increased between the pretest ($M_{control} = 0.33$, $SD_{control} = 0.44$; $M_{experimental} = 0.24$, $SD_{experimental} = 0.43$) and posttest ($M_{control} = 1.71$, $SD_{control} = 1.03$, $d_{control} = 1.74$; $M_{experimental} = 2.15$, $SD_{experimental} = 0.98$, $d_{experimental} = 2.52$). The predicted interaction effect was statistically significant, $F(1, 85) = 4.66$, $p < .05$, $\eta^2 p = .05$. Scores increased between the two evaluation phases for both groups and more so for the experimental group (post-pre-test difference $d = 0.46$).

Cardinality subtraction problem score

The mixed ANOVA performed on the cardinality subtraction problem scores showed a statistically significant effect in the evaluation, $F(1, 85) = 134.82$, $p < .001$, $\eta^2 p = .61$, in that students in the control group and experimental group progressed between the pretest ($M_{control} = 0.23$, $SD_{control} = 0.39$; $M_{experimental} = 0.37$, $SD_{experimental} = 0.40$) and posttest ($M_{control} = 1.39$, $SD_{control} = 0.98$, $d_{control} = 1.56$; $M_{experimental} = 1.57$, $= 0.89$ $SD_{experimental}$, $d_{experimental} = 1.74$); however, the interaction effect was not statistically significant, $F < 1$ showing that the scores increased between the two evaluation phases for both groups, but to a similar degree (post-pre-test difference $d = 0.04$). Contrary to the hypothesis, the experimental group did not take more advantage of the learning sequence than the control group. This can be explained by the children being very familiar with the cardinal field (i.e., numbers representing quantities). Indeed, preschool mathematics is learned mainly in the cardinal field; however, explicit instruction provides a gain when the concepts are unfamiliar. The mixed ANOVA performed on the ordinality subtraction problem scores showed a statistically significant effect of the evaluation, $F(1, 85) = 112.18$, $p < .001$,

$\eta^2p = .57$, in that the scores of students in the control group and experimental group increased between the pretest ($M_{control} = 0.33$, $SD_{control} = 0.68$; $M_{experimental} = 0.27$, $SD_{experimental} = 0.49$) and posttest ($M_{control} = 1.14$, $SD_{control} = 0.93$ $d_{control} = 0.99$; $M_{experimental} = 1.71$, $SD_{experimental} = 0.85$, $d_{experimental} = 2.08$). The predicted interaction effect was statistically significant, $F(1, 85) = 8.57$, $p < .01$, $\eta^2p = .09$. Scores increased more between the two evaluation phases for the experimental group than for the control group (post-pre-test difference $d = 0.6$).

Discussion

In France, academic achievement is highly dependent on the students' socioeconomic characteristics, in the sense that the lowest performing students systematically come from disadvantaged socioeconomic backgrounds. Over the last decade, there has been an important amount of research aimed at identifying efficient pedagogical practices among students from disadvantaged social backgrounds. This study was thought to be a contribution to this field, which is based on the principle that the increase in academic performance should be based on changes in teaching practices. The effectiveness of two orientations in mathematics instruction was studied in the present research. The socioconstructivist orientation was compared to the explicit teaching orientation, given research results demonstrating and confirming its usefulness among students from disadvantaged social backgrounds (e.g., Baker et al., 2002; Chodura et al., 2015; Hattie, 2012; Kroesbergen & Van Luit, 2003). As is widespread in Canada and the United States, explicit teaching was shown to be particularly suited for learning new, complex, and structured concepts (Gauthier et al., 2013).

We believe this research to be important for three reasons. First, it contributes to the research field investigating the efficiency of teaching methods in mathematics, which is less developed than the reading and writing field (Baker et al., 2002). To our knowledge, there is no published research on teaching subtraction using the explicit method. Second, this research compares the effectiveness of the explicit instruction method and the socioconstructivist method in teaching subtraction to students who are known to be poor performers in this field. That is the case for most students in the priority education networks in France. Third, very little research directly compares the effectiveness of teaching methods on a specific student population. This is an important research approach to adopt in order to decide which teaching method might be the most suitable for a specific education context. The hypothesis we tested was that when priority education students learn subtraction through explicit teaching, they obtain better performance than when they learn it using a socioconstructivist method. The hypothesis was upheld.

Our results showed that students who learned through explicit teaching made more progress than students who learned through socioconstructivist teaching. These results are consistent with other research addressing the question of low performance students in mathematics. In this vein, Kroesbergen et al. (2004) directly compared the effectiveness of explicit teaching and socioconstructivist teaching. Their results showed that, although socioconstructivist teaching allowed participants to make some progress, explicit teaching was even more effective in improving multiplicative problem-solving skills. In keeping with these results, our study showed that students made progress with both methods; however, the benefit was greater for the group taught through the explicit instruction method than the group taught by the socioconstructivist method. Other studies in the field of mathematics instruction are consistent with these results (Baxter et al., 2001; Woodward & Baxter, 1997). For instance, Baker et al. (2002) suggested that using explicit instruction principles in problem solving has a positive effect on the success of low-achieving students in mathematics. Other authors argue that students experiencing mathematical difficulties can solve problems if instructions are explicit and tasks are simple (Carnine, 1997; Jones et al., 1997).

In the present study, although the global score increased considerably between the two evaluations for all the students, the students in the explicit teaching condition made more progress on the global subtraction score than the students in the socioconstructivist condition. The global score was calculated by adding up four different exercises, with scores varying in complexity. Though the subtraction with partitioning is more complex than that without partitioning, the ordinality subtraction problems are less familiar to students than the cardinality subtraction problems. Subtractions without partitioning can be solved mentally. In contrast, subtractions with partitioning require the application of a specific technique, and they are more complex. Regarding subtraction problems, experienced teachers report that students perceive cardinality problems as more familiar and accessible than ordinality problems. Indeed, most of the mathematical content to which students are exposed is framed in terms of cardinality. Moreover, in France, the number concept is taught almost exclusively in the cardinality field; therefore, the notion of quantity prevails over that of order. This creates greater familiarity with cardinality compared to ordinality (Zajonc, 1968). Consequently, students prefer and master cardinality problems more than ordinality ones. The analysis shows that, for subtraction with partitioning exercises and for ordinality subtraction problems, explicit teaching leads to greater progress. For the other two exercises, subtraction without partitioning and cardinality subtraction problems, less complex learning through socioconstructivist teaching or explicit instruction generates similar effects. Alternatively, explicit teaching is particularly effective for complex learning contents and skills (Gauthier et al., 2013). This is consistent with results obtained by Kroesbergen et al. (2004), who showed that socioconstructivist and explicit instruction methods are similar in efficiency with regard to automaticity skills on simpler tasks. However, there is little research in the field that directly compares the effectiveness of the two methods and even less that takes into account the complexity of the contents. Our results are to be interpreted with caution until replicated by further research that manipulates in an experimental design the two types of teaching and the complexity of the notions to be taught.

Despite the encouraging results of this study and the suggestions for further research, it has some limitations. First, in our study, the teachers in the control condition were not given training and a precise script to follow during the lessons, in contrast to the teachers in the experimental condition. A study including a standardized socioconstructivist condition and a control condition should be run to clarify the present results. Second, in our study, for institutional reasons and for standardization reasons, the subtraction technique was fixed. We acknowledge that other efficient techniques exist and should be considered by research. Third, more classes should be enrolled in further comparable studies, involving students from advantaged social backgrounds as well. Moreover, a larger scale study, in which the level of the class is controlled, would increase the security of suggesting that the observed effects were due to intervention and not to a possible non-randomized sample. Fourth, our conclusions concern the subtraction learning through the partitioning technique only. Further research is needed to compare the effectiveness of the two methods for other techniques, mathematics areas, different grades, and other training fields.

The subtraction through the partitioning principle is a source of learning difficulties in low-achieving students. Our study suggests that explicit teaching is more effective in handling it. Explicit teaching multiplies the learning and training opportunities during modelling and guided practice. Indeed, the teacher verbalizes the procedures during the former and students verbalize and explain their reasoning during the latter. Additionally, errors are handled differently in the two types of teaching. Socioconstructivist teaching exposes students to both the right and wrong solutions to the exercises. We believe that this can be a source of confusion and insufficient, incomplete learning, as the wrong solution might be encoded in each student's memory. Explicit instruction gives a crucial role to feedback, in that every error must be corrected immediately before continuing the learning process. This explains the relevance of this type of teaching for complex and new tasks with regard to students with learning difficulties.

Taken together, the results of this study provide additional empirical evidence supporting the effectiveness of teaching mathematics using the explicit method. These are in line with the idea that certain teaching methods have beneficial effects on the results of students from disadvantaged social backgrounds. Furthermore, they are of interest to the schoolteacher's community working in priority education networks in France. Indeed, the PISA survey (Schleicher, 2019) depicts France as a very unequal country, widening gaps between achieving and under-achieving students. The results of this study are important, as they show that schools can be a source of academic achievement if the teaching methods chosen by the teachers are adapted to their students' specificities. This corroborates Hattie's (2012) meta-meta-analysis findings, arguing that the teacher and the pedagogical choices made by the teacher are a crucial factor in students' academic achievement. However, we do not want to be ideologically opposed to pedagogical orientations but to make the most appropriate choices, based on research and adapted to the students' learning needs, complexity, and stage of learning.

In conclusion, the choice of teaching methods for students enrolled in priority education networks should be at the heart of the school reform in France today. Among the existing methods, explicit teaching addresses the challenges that impact on the performance of students with learning difficulties in mathematics. The results of this research show the effectiveness of this type of teaching in this field and opens up the possibility of applying it to other disciplines, including complex concepts.

Disclosure statement

No potential conflict of interest was reported by the authors.

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