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Small group interventions for children aged 5-9 years old with learning difficulties in mathematics

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Abstract

The research related to educational interventions for children with mathematical learning difficulties has been increasing steadily. In this chapter I focus on small group interventions for children aged 5-9 years old with learning difficulties in mathematics. First I describe the important issues: (1) who are the children having problems in mathematics, what do we mean with (special) education intervention, (3) what does Responsiveness to Intervention mean and (4) what intervention features have been found effective for children aged 5-9 years with learning difficulties in mathematics. Then I describe the research and developmental work that has been done in Finland on designing evidence-based Web services for educators related to mathematical learning difficulties, assessment and interventions. The two Web services are LukiMat and ThinkMath. Together, these two evidence-based Web services include the knowledge base, assessment batteries and intervention tools to be used in relation to mathematical learning difficulties in the age group 5-9 years.

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Introduction

The research related to educational interventions for children with mathematical learning difficulties has been increasing steadily. The main aim of this chapter is to describe the research and developmental work that has been done in Finland on designing evidence-based Web services for educators related to mathematical learning difficulties, assessment and interventions. The two Web services (LukiMat and ThinkMath) have been developed by two different, but related, research teams at the Niilo Mäki Institute (University of Jyväskylä) and the University of Helsinki. Together, these two evidence-based Web services include the knowledge base, assessment batteries and intervention tools to be used in relation to mathematical learning difficulties in the age group 5-9 years. The materials encourage educators to provide educational support for children according to the Responsiveness to Intervention model. In this chapter, the focus is in the developmental work on our small group intervention materials, hence ThinkMath webservice. To introduce the topic this chapter begins with description of few important concepts – who are the children having problems in mathematics, what do we mean with the concept of intervention, what does Responsiveness to Intervention mean and what intervention features have been found effective for children aged 5-9 years with learning difficulties in mathematics.

Learning difficulties in mathematics

In the literature, there are several different terms used in relation to learning difficulties in mathematics, such as low performance in mathematics, learning difficulties in mathematics, mathematical learning disability, dyscalculia, mathematics disorder and many more. These various terms refer to different definitions (e.g., in terms of various cut-off scores) and different origins of the problems ranging from neurological dysfunctions to inappropriate opportunities to learn and practice mathematical skills (e.g., low socio-economical status of the child's family) (Ansari, 2015; Mazzocco, 2009). Geary (2013), suggests that children who score at or below the 10^{th} percentile on standardized mathematics achievement tests for at least two consecutive academic years are categorized as having an MLD (Mathematical learning disability). He further suggests that all children scoring between the 11^{th} and 25^{th} percentiles, inclusive, across two consecutive years are classed as LA (Low Achievers). The various terms are quite confusing, but when we talk about young children just starting their school career it seems to be appropriate to use the terms "low performing" or "mathematical learning difficulties" thus avoiding the "stronger terms" like "mathematical learning disability" and "dyscalculia", which clearly indicate to the possible neurological dysfunctions in the background of severe learning problems in basic arithmetic learning which is mostly visible in educational context only after couple of year math learning. For teacher it is also important to understand that mathematics performance is a continuum; there is no strict point where the problem starts.

Intervention

At the moment the concept “intervention” is a popular term and used with various meanings in education. Intervention can refer to the intervention programs which are used with children which have learning difficulties to change the originally bad learning prognosis (i.e. extra educational support). Intervention can also refer to the research design that is used to study children’s development, in that the aim is to investigate what factors affect the learning. This approach is often used by developmental psychologists. In addition, intervention research design can be used to investigate the effects of a particular intervention program, which can then be published and used by educators. This approach is common among special education and educational psychology research.

The most important way to measure the effectiveness of the educational intervention programs is to study the increase in learning (i.e., achievement) of the children as a result of extra practice, hence intervention (Jimerson, Burns & VanDerHeyden, 2007). The recommended and often used intervention research design includes a pretest (i.e., baseline measurement) and immediate and delayed post-test measurements with control groups. The intervention and control group design allows researchers and teachers to compare whether the children receiving intervention develop faster than their peers who are not getting extra attention for instance in mathematics learning. Researchers use a bit different approaches to judge if the intervention program is effective. In general, it is possible to say that an intervention program is effective if the children with low performance or learning difficulties progress better than their performance control peers. Secondly, it would be better results for intervention program if the children with low performances are able to maintain their head start compared with the control group even after the intervention phase has ended. Thirdly, the best results would be, in addition to the aforementioned effects, if the low-performing children closed the gap with their average performing peers. It is the researchers' task to explain these possibilities of effectiveness measuring to educators who need to make decisions related to how to support the children with learning difficulties (Jimerson Burns & Van Der Heyden, 2007).

However, deciding which intervention program is best for the particular children is more complex than only deciding how effects needs to be detected. When we need to make a decision which intervention program to use, we need to compare programs and studies with different features. This task needs to be done carefully as intervention programs and studies can differ in various aspects, which can make comparison difficult (Fischer, Moeller, Cress & Nuerk, 2013; Mononen, Aunio, Koponen & Aro, 2014). The interventions can vary in terms of target children, comparison group, aims, setting, duration, mathematical content, conductor and professional developmental support, instructional design features which all can have impact, individually or together, on the intervention effectiveness (Fischer et al., 2013, Mononen et al. 2014).

The aims of intervention program can be remedial or preventive. Remedial intervention is needed when children have already been identified with severe mathematical learning difficulty (i.e., mathematical learning disability, dyscalculia) (Kuzian et al. 2011). Preventive intervention programs aim to avoid later learning problems. Preventive interventions are often used with younger children in preschool and primary grades and aim to assure that children learn well the very fundamental skills needed in later learning (Toll & Van Luit, 2014). The focus groups can differ in intervention studies, they can be children who have diagnosed severe problems in learning mathematics (Kuzian et al. 2011), or children who have low achievement (i.e., performance) in mathematics (Toll & Van Luit, 2012), or children who are at risk for learning difficulties based on their low socio-economical family background (Dyson, Jordan & Glutting, 2011). Target group can also differ in their age, at the moment there is most research done with younger children (preschool and primary grades) (Bryant et al. 2008; Clarke et al., 2016) but also good progress is emerging with interventions for older students (Moser Opitz et al. 2016; Xin et al. 2017). There can be also differences in intervention setting: interventions can be conducted individually (Fuchs, Fuchs & Compton, 2012; Hunt, Tzur & Westenskow, 2016), in pairs (i.e. dyads) (Barnes et al. 2016), in small groups of children (3-8 children) (Bryant et al. 2008; Mononen & Aunio, 2014; Moran, Swanson, Gerber & Fung, 2014) or with whole classroom (Clarke et al., 2011). Related to intervention setting, the intervention can be core instruction thus taking place during regular mathematics lessons and replacing the math curriculum previously used in that classroom (Clarke et al. 2011). Intervention can be supplementary, during which children follow the average mathematics lessons and on top of that get extra educational support in skills they have individual needs (Powell et al. 2015). Time practiced is also important feature (i.e. exposure time for treatment), intervention programs can be short, with couple of hours or more extensive having more than 60 hours; also the time practiced at one session can differ a lot, for instance from 10 minutes to 60 minutes, and on top of that the number of sessions can differ. For instance Salminen and her colleagues (2015) investigated the differences in time used in computer assisted instruction research in the field of mathematical learning difficulties, and found them to vary between two weeks to whole semester, and sessions lasting from one minute to 60 minutes, there was also big variance in number of sessions; from 7 sessions to 50 sessions. Dennis and his colleagues (2016) reported the intervention length in minutes to vary between 400 minutes to 5400 minutes in mathematics learning small-group interventions for kindergarteners. Mathematical content can also vary. There are intervention programs that practice only some quite narrow skill, like numerical magnitude comparison and number line estimation in study of Sigler and Ramani (2009) and then there is intervention programs that practice several mathematical skills (Aunio, Hautamäki & Van Luit, 2005; Barnes et al. 2011). The skills practiced can be very basic skills by nature (Sigler & Ramani, 2009) or the focus can be on complex mathematical problem solving (Pfannenstiel, Bryant, Bryant, & Porterfield, 2015; Sharp & Dennis, 2017).

Interventions can be lead by researchers (Dyson, Jordan & Glutting, 2011) or educators (Mononen & Aunio 2014, 2016) (i.e. agent of intervention). If the intervention is conducted by the teacher there is a need for good professional development support for them so that she understands the principles and way of conducting the intervention the same way as has been the developers' idea, this way the ecological validity is secured (Cary, Clarke, Doabler, Smolkowski, Fien & Baker, 2017). Interventions can include various instructional features such as explicit and systematic instruction (Toll & Van Luit, 2014), use of visual representations in the introduction of mathematics ideas at concrete-representational-abstract (CRA) levels (Mononen & Aunio, 2014, 2016), or use of computer-assisted-instruction (CAI) (Salminen et al. 2015). When the effectiveness of intervention is studied it is important to measure the impact related to comparative group of children, so that similar performance level children are compared with each other in similar learning environments, ideally the intervention is the only difference between participating children.

In summary, finding the best intervention program to support children is a complex issue. We need more results comparing similar intervention programs applied with similar way, to be able to be sure which are best ways to support children in their learning. Maybe good guideline for educator is to think what kind of mathematical learning problems children have (what skills are the ones the child lacks) and then look at the literature what kind of intervention programs have been developed to meet those learning needs. Then it is good for educator to think if the situation (children, learning needs, learning environment) is similar to that in which the particular intervention program has been found efficient.

The features of effective instruction for children with mathematical learning difficulties

There has been fast progress in the development intervention study methodology. At first there were individual intervention studies with quite small samples with convenience sampling but with quite a many control variables measure. Currently there seem to high demand of randomized control trials (RCT), large scale interventions and replication studies (e.g., Gersten Rolfhus, Clarke, Decker, Wilkins & Dimino, 2015), to have reliable evidence that interventions are effective. An alternative way to understand the effectiveness of interventions in children's learning are the meta-analysis, reviews and systematic reviews which aims to summarize the previous intervention research results. They provide broader picture of the field of interventions than individual studies. Research reviews have produced some results with interventions for students with learning difficulties in mathematics (Chodura, Kuhn & Holling, 2015; Codding, Burns & Lukito, 2011; Gersten et al. 2009; Jitendra & al. 2018; Kroesbergen & van Luit 2003; Maccini, Mulcahy & Wilson, 2007; Zhang

& Xin, 2012) but only few have concentrate on young children (Dennis et al., 2016; Mononen Aunio, Koponen & Aro , 2014).

In the review of Mononen et al. (2014) the interventions show from small to average effect sizes in improvement of the early numeracy skills of children aged 4 to 7. Results indicate that different types of instructional design features, including explicit instruction, computer-assisted instruction (CAI), game playing, or the use of concrete-representational-abstract levels in representations of math concepts, lead to improvements in mathematics performance. Therefore, rather than waiting to provide effective mathematics interventions at school (e.g., Baker et al., 2002; Slavin & Lake, 2008), evidence-based programmes before the onset of school could be used to promote early numeracy skills, especially for low-performing children and to children from low SES environments.

In a recent meta-analysis, that included also younger children, Dennis et al. (2016) found that studies conducted at the kindergarten level yielded significantly weaker effects than studies conducted at the elementary level. Their results also showed that that interventions provided for students who had low math performance (at or below 35th percentile) at the time of identification yielded strong intervention effects compared to those children performing above 35^{th} percentile. In addition interventions were more effective when they were provided by the researchers and researcher-trained graduate assistants, those provided by teachers and paraprofessionals produced weaker effects. Dennis and his colleagues (2016) found effective instructional variables to be: peer-assisted learning, explicit teacher led instruction (i.e. sequencing task from easy to difficult, task analysis), but interventions including the use of technology were least effective in improving the mathematics performance of students with MD. In addition, they found that intervention delivered in form of small-group instruction was a more effective for this group of students.

Dennis et al. (2016) replicates the results, at least partly, in previous meta-analysis concerning group-based interventions for children with mathematical learning difficulties (Baker, Gersten & Lee, 2002; Swanson et al. 1999). These studies show that intervention studies that used explicit and strategic instructional procedures with students with learning difficulties have been found to have larger effect sizes compared to other instructional approaches (Baker et al., 2002; Chodura & al., 2015; Gersten et al., 2009; Kroesbergen & Van Luit, 2003; Mononen et al., 2014; Miller et al., 1998; Swanson et al., 1999). Explicit interventions included for instance sequencing of instruction in to logical sequences, providing clear presentation of subject matter, guided practice, independent practice and evaluating student learning on a regular basis. Explicit instruction often includes using Concrete-representational-abstract (CRA) sequence which have been found be effective instructional feature (Mononen et al., 2014; Miller et al., 1998; Xin & Jitendra, 1998). Peer-assisted instruction has been found to be effective instructional feature with younger students (Baker et al., 2002; Kunsch et al., 2007). The effects of CAI in interventions for children with learning difficulties in mathematics are controversial, some found support (Miller et al., 1998; Kroesbergen and Van Luit, 2003, Mononen et al. 2014) and other ones are more critical (Dennis et al., 2011; Räsänen et al., 2010).

Previous meta-analysis (Chodura et al. 2015; Dennis et al., 2016; Jitendra et al. 2018; Mononen et al., 2012) have pointed some weaknesses in intervention studies in the field of mathematical learning difficulties. These are for instance, longitudinal effects of intervention is hard to study as there is no delayed measurement used, there is also not enough information to know how children with mathematical learning difficulties are identified (challenges with selection and outcome measurements, and cut-off criteria).

To know if the intervention studies published after latest meta-analysis (Dennis et al. 2012) have faced the pointed weaknesses. I made a small review with intervention studies published after 2014 in peer reviewed English journals, conducted in small group of children, applied at least quasi-experimental design with control group, focused on early numeracy (grade K-2) and children with learning difficulties in mathematics (Table 1). I found seven intervention studies published in peer reviewed English journals, all of the had been made in United States, in half of the studies they were all using some way to randomize students in the intervention and control group, they were used as supplementary and not replacing the core mathematics instruction. The children had low performance in early numeracy in six studies and possibly also in Clarke et al. (2016) in which teacher identified those children most likely benefit from small group instruction. In three studies children also had low income family background (Barnes et al. 2016; Dyson et al. 2015; Hassinger-Das, Jordan & Dyson, 2015). Three (Clarke, Doabler, Smolkowski, Baker, Fien & Cary 2016; Clarke, Doabler, Smolkowski, Kurtz-Nelson, Fien, Baker & Kosty, 2016; Doabler, Clarke, Kosty, Kurtz-Nelson, Fien, Smolkowski & Baker, 2016) out of seven studies used ROOTS intervention program developed by Clarke's research group in University of Oregon. All of the intervention studies focus on several mathematical skills. Cut-off criteria for low early performance varied between below 10 and below 35 percentile in standardized mathematics measurement, resulting quite big variation in skills in target group of children. In all of the studies a variety of standardized measurements were used (such as the Number Sense Brief Screener; SAT; TEMA-3:WJ-III) but also measurements designed by research group were used (EN-CBM, ASPENS) as outcome measurements. All seven studies reported significant intervention effects on children's early mathematics performance. But only three studies reported the delayed measurements results, confirming the lasting effects of interventions (Clarke, Doabler, Smolkowski, Kurtz-Nelson, Fien, Baker & Kosty, 2016; Dyson, Jordan, Beliakoff & Hassinger-Das, 2015; Hassinger-Das, Jordan & Dyson, 2015). This small review confirms the pervious findings that explicit and systematic small group interventions have effects on early numeracy learning of low performing students. From European point of view it would be good to validate the findings also with samples outside United States. One challenge what science face here is that we have to develop ways how to describe our measurements, criteria and outcome, so that it is possible to relate them with measurements designed in other countries as well. In some countries we still lack good quality standardized measurements to identify mathematical learning difficulties and to follow the development in core skills. We still need more intervention studies to report the results from delayed measurement.

Responsiveness to Intervention practice in supporting children with learning difficulties

At the beginning of the 21st century in the United States and Europe, the way to approach individuals with learning difficulties started to change. The focus shifted from diagnosing the individual in clinical settings to viewing individuals' learning as part of his or her learning context and emphasizing the early identification of learning difficulties to provide early interventions (i.e., Responsiveness to Intervention, RtI)

(Hallahan, Pullen & Ward, 2013). Responsiveness to Intervention can be seen as a pedagogical problem solving model, whose most important goal is to provide all children the most efficient instruction and intervention according to their needs (Jimerson et al., 2007). The instruction and support are divided most often into three levels of support: Tier 1, Tier 2 and Tier 3 (Riley-Tillman & Burns, 2009), but other tier systems also exist (Fuchs, Fuchs & Schumacher, 2011). Increasing levels means that the focus becomes more individualized, the support becomes more intensified and the support is provided over a longer period of time (Riccomini & Smith, 2011). Bryant, Bryant, Gersten, Scammacca & Chavez (2008) describes the relations between tiers so that Tier 1 consists of evidence-based core instruction for all children, Tier 2 includes supplemental intervention and ongoing progress monitoring for children who struggle with learning and Tier 3 is reserved for children who are struggling so much that they require intensive intervention. Previous research shows that research-based intervention programs that are provided with care and whose effectiveness has been investigated produce better learning results in the classroom than non-research based interventions (e.g. Jacob & Parkinson, 2015; Slavin & Lake, 2008).

In general, intervention programs can be used in classroom-level, small group and individual level. The most important difference between them is in focus. The classroom interventions mostly try to rise the level of whole group of learners, these can be called Tier 1 interventions if RtI is applied. The need for such interventions comes from the information about for instance the differences between schools or school districts. Small group interventions are designed to meet the specific learning needs of children who have learning difficulties. Individual interventions focus on learning difficulties of an individual student. Individual and small group interventions are often used in Tier 2 and 3 if RtI is applied. Small group interventions offer good possibilities for children to work together and practice skills that they have problems with tasks designed to their level of knowledge and needs. When there is only 4-8 children in a group it is easier for teacher to focus on children's learning, she is able to guide and coach their learning. In small group there is also possibilitie teacher to teach the target skill or topic, and then let children to practice together and individually. The main challenge with individual interventions is the demand of resources, at the moment schools do not have enough resources to offer individual interventions for children who needs support.

Finnish evidence-based Web services for educators

In Finland there has been a positive tendency over the last 10 years to boost teachers' levels of knowledge concerning individual learning differences in early reading and mathematical skills. The emphasis has been mainly on the early identification of learning difficulties and early intervention, with the aim of moving towards the Responsiveness to Intervention model and general (Tier 1), intensified (Tier 2) and special educational support (Tier 3) in the national education system (National core curriculum for basic education (2014/2016). The nationwide attempts in the field of early mathematics funded by the National Ministry of Education and Culture have been focused on producing evidence-based knowledge for educators and providing them with assessment tools and intervention programs to be used with children struggling with learning. I have been part of two teams that have designed two Web services for educators, namely LukiMat (www.lukimat.fi) and ThinkMath (http://blogs.helsinki.fi/thinkmath/in-english/). From these web services ThinkMath focuses on small group intervention programs, thus it is in focus of this chapter, LukiMat has been described in another paper (Aunio, 2016)

ThinkMath Web service development started at the University of Helsinki in 2011. It provides educators with hands-on intervention materials to be used with children, aged 5-8 years, who have problems with learning early mathematical skills. The main idea behind ThinkMath was that educators needed evidence-based materials for offline use, as there was a significant lack of computer devices for young children to use in early childhood settings or in early primary school grades. ThinkMath delivers intervention materials and knowledge to educators. There is a knowledgebase with evidence-based information concerning (1) mathematical skills development and learning difficulties, (2) thinking skills development, (3) motivational issues related to learning, (4) executive functions relevance for learning, and (5) (special) educational interventions. In the knowledge base we have provided short videos to explain the main ideas to educators as clear and fast as possible. The Material section offers group-based intervention materials for practicing for instance mathematical skills with children in small groups.

The base for the development of mathematics knowledge base and materials was the core factor model of the mathematical skills in children aged 5-8 years (Aunio & Räsänen, 2015), which we originally developed for LukiMat. The model aimed to be a working model for the educators by presenting them with an overview of the most important skills that develop in early childhood, and secondly, aimed to make educators aware of the individual differences in early mathematical skills development. This model was based on a systematic literature review of longitudinal studies investigating mathematical development in this age group. We also analyzed the assessment batteries designed for identifying the children with potential learning difficulties in mathematics. We were able to categorise skills into four main groups of numerical factors that are most crucial to the development of mathematical skills: symbolic and non-symbolic number sense, understanding mathematical relations, counting skills, and basic skills in arithmetic (Aunio & Räsänen 2015). In the ThinkMath materials we focused to practice these skills with children performing low.

The design related to pedagogical characteristics followed the findings in the research literature (Mononen et al., 2014). In the ThinkMath mathematical skills intervention programs, explicit teaching was one of the main guidelines along with several ways to practice the skills in focus (e.g., Gersten et al., 2008; 2009). In line with these recommendations, each lesson consists of a teacher-guided activity to model a new mathematical learning concept or strategy as well as guided and peer activities (e.g., hands-on activities with manipulatives, or card and board games based on the current topic) At the end of the lesson, there is a short, paper-and-pencil individual activity. Another general feature is that mathematical ideas are represented following the concrete, representational and abstract levels, thus giving meaning to abstract concepts by using visual representations (e.g. cubes, bundles of sticks, dot cards structured in tens and hundreds) (e.g., Mononen, 2014). The teacher manual includes 12-15 lesson plans of 35–45 minutes each. The lesson plans include specific instructions for teachers to follow in each activity. The manipulatives are made of low cost, everyday materials found in every classroom, combined with printable materials (e.g., dot and place value cards) included in the manual. During the development of the intervention materials, we worked closely with educators and investigated the effects of these intervention programs on low-performing children through quasi-experimental, pre-post measurement with intervention and control groups in different age groups (Mononen, Aunio & Leijo, in revision; Mononen & Aunio, 2014; Mononen & Aunio, 2016).

Studies with ThinkMath intervention programs

The second grade intervention study (Mononen & Aunio, 2014) was done with 88 children (M age 8 y. 2 m.) from four classes in schools located in two southern Finnish cities. The intervention program used in this study was Improving Mathematics Skills in the Second Grade (Mononen and Aunio, 2012a). It aims to practice number word sequence skills, counting and conceptual place value knowledge in the 1-1000 range and following the guidelines of explicit instructions. Children's mathematical skills were measured with the Assessment of Mathematics Skill in the Second Grade (AMS-2) (Aunio & Mononen 2012a). It is a paper-and-pencil test and measures (1) the number of forward and backwards word sequence skills, (2) numerical relational skills associated with base 10 and place value knowledge, (3) addition and subtraction word problems, 4) multi-digit addition and subtraction calculations with number symbols, all within a 1-1000 range and (5) addition and subtraction facts in the 1-20 range (40 items, 2 minutes' time). Children's thinking skills were assessed using the Assessment of Thinking Skills in the Second Grade (Hotulainen, Mononen & Aunio, 2012a). Reading comprehension and fluency skills were measured using a standardized reading test for primary grades (Lindeman, 2005). Mathematical skills were measured three times: shortly before the intervention, immediately following the intervention and three months after the intervention. The thinking and reading skills were assessed at the first of the three time points. Children were divided in the low-performing intervention group (n= 11), the low performing control group (n=13) and the typically performing control group (n= 64 children). The intervention program lasted 6 weeks, and there were two 45-minute intervention sessions per week. The results demonstrated that the low performing intervention group made significant improvements in mathematics whole scale, and addition and subtraction facts but did not show significantly better scores compared to the low-performing control group. In addition, neither the intervention children nor the control children were able to perform at the same level of their peers following the intervention. There was no difference between low performance children in the control and intervention groups in terms of their thinking and reading skills. Although there were not many scientifically significant results, there was a trend to be seen that when children with low mathematical skills received extra support, their skills developed, but when the intensified instruction ended so did the development of their skills. This was especially true of arithmetical fluency skills.

Mononen and Aunio (2016) investigated the impact of ThinkMath intervention for Finnish first graders (N=151, M age = 7 y. 2 m.) with low numerical performance. The children were from nine classrooms located in three cities of Southern Finland. This program focused on increasing the counting skills knowledge, including the number sequence and enumeration skills in number range 1-20 (Mononen & Aunio 2012b). The study applied a quasi-experimental design using control groups. The effects of intervention was examined using the Assessment of Mathematics Skills in the First Grade (Aunio & Mononen 2012b). This group-based paper-and-pencil test includes mathematical tasks in the range from 1 to 100: (1) mathematical relational skills (i.e. number comparison); (2) counting skills (i.e. verbal and object counting) and (3) word problems (i.e. verbal addition and subtraction problems). Single-digit addition and subtraction facts in the range from 1 to 20 are also assessed (within a 2-

minute time limit). A sum score for the subscales 1–3 (i.e. a combined scale) was used to identify the low-performing children. In addition, the relations between inductive reasoning (Assessment of Thinking Skills in the First Grade by Hotulainen, Mononen & Aunio 2012b), language (reading fluency Allu by Lindeman 1998; listening comprehension Ytte test by Kajamies et al. 2003) and mathematical skills were examined. The intervention program was provided in small groups 12 times during 8 weeks, one session lasted about 45 minutes. The development of intervention children (n = 11) was compared to the development of low performing (n = 26) and typically performing (n = 114) children. The results showed significant effects of intervention, as the children in the intervention group made significantly greater gains in their mathematical performance from Time 1 to Time 2, compared with the low performing control and typically performing children. One important finding was that the children with low performance in mathematical skills showed lower performance also in their inductive reasoning and reading fluency skills than did children with typical performance. This means that supporting these children we need to also think how to support children's thinking skills early on. The main conclusion is that a relatively short counting skills intervention that applied explicit teaching showed promising effects in improving low-performing children's mathematical performance as a supplemental instruction.

In our kindergarten intervention study (Mononen, Aunio & Leijo, in revision) the children in the low performing group were studied in more detail. The children in this group were children whose mathematics performances were below the 10^{th} percentile (i.e., very low performing, n=20), and children whose mathematical performances lay between the 11^{th} and 25^{th} percentiles (i.e., low performing, n=18). The results were collected with a scale (Aunio & Mononen, 2012c) measuring mathematical relational skills, number-word-sequence skills and counting skills which showed that the number children who reached an average level of performance at the post-test stage was higher among the group of children with low performance (67%) versus those with very low performance (35%) (Mononen, Tapola & Aunio, 2015).

Westerholm and Aunio (submitted) investigated the effects of ThinkMath-intervention for Finnish as a second language kindergarteners. There were nine children (M age 6 y. 8 m.) participating the study from one metropolitan area school.

In this study we used ThinkMath: Mathematical relational and counting skills 1-20 intervention program (Mononen & Aunio 2012b) as was used in study of Mononen and Aunio (2016). Children practiced making comparisons on quantities and numbers using related concepts such as more and less and counting number sequences orally. In addition, counting objects and matching them with number words and number symbols were practiced. Based on the research literature concerning the learning challenges of children with instruction language as a second language (Arnold ym., 2002; Clements & Sarama, 2008; Codding ym., 2009; Fuchs, Compton ym., 2008; Fuchs, Fuchs ym., 2008; Klein ym., 2008; Mercer & Sams, 2006; Starkey, Klein & Wakeley, 2004) we added motivation (i.e., prize) and explaining mathematical talk into the intervention program. Children's mathematics skills were measured with Early Numeracy Test (Van Luit, Van de Rijt & Aunio, 2006) before, immediately after and five weeks after the intervention ended. The intervention program lasted 8 weeks having 35-75 min sessions twice a week. The results showed that ThinkMath intervention program with added motivating features and explicit mathematical talk was useful way to support the early mathematics learning of children that had Finnish as a second language and low mathematical performance in kindergarten.

ThinkMath service has risen interest outside Finland also. We have now two international research projects, one in South Africa (e.g., Aunio, Mononen, Ragpot & Törmänen, 2016) and one in Norway (https://thinkmathglobal.com). The most important scientific question still is, if it is possible to enhance the early mathematics learning of children with low performance with ThinkMath small groups interventions. In South Africa the learning context is quite different than in Finland, it will be interesting to see what kind of challenges the differences in teacher education, classroom organization and children's background offers us. Our project in Norway will increase our knowledge about how well our originally Finnish programs work in system where school starting age is different and teacher education is less research based than in Finland.

Conclusion

The existing intervention studies, meta-analysis and reviews have shown that it is beneficial to use small group mathematics interventions applying explicit and structurated with low performing young children.The work on Finnish ThinkMath project have not only shown that it is possible to develop evidence-based materials and that educators appreciate them, but also that Web services are a very efficient way to deliver such information and materials. Even though it is challenging to obtain significant and lasting learning effects with intervention studies in natural educational settings, these studies are essential in providing educators with evidence-based materials. In future we will need more research reviews and large-scale intervention studies to be able to understand how to support children with various age and needs in mathematical learning.

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Table 1			Sample				Intervention			
Authors	Title	Age	At-risk status	Number of participants	Duration	Leader	Instructional design feature	Math Measure	Pre-post Effect size	Follow-up (Yes/ No)
Barnes, Klein, Swank, Starkey, McCandliss, Flynn, Zucker, Huang, Fall & Roberst (2016)	Effects of tutorial interventions in mathematics and attention for low-perfoming preschool children.	4.50 years	low performance (below 25th percentile in TEMA-3) and low-income family	N=541 (M+Att n=181; M only n=180; Business-as-usual (BaU) n=180)	24 weeks (1920 min)	Researcher	explicit + systematic instruction, cumulative review; teaching to mastery, scaffolding, progress monitoring. Pre-K-Mathematical Tutorial (PKMT)	Child Math Assessment (CMA) (Starkey & Klein 2012); Test of Early Mathematics Ability, 3rd ed. (TEMA-3) Ginsburg & Baroody 2003)	In independent contrats with BaU group, both the M+ATT group (ES=.43) and the M only group (ES=.60) had greater math knowledge at posttest CMA.	No
Clarke, Doabler, Smolkowski, Baker, Fien & Cary (2016)	Examining the efficacy of a tier 2 kindergarten mathematics intervention.	5.54 years	teacher identified five lowest performing children who would benefit from small group math instruction. Of the 122 children 91% scored at or below 10th percentile in TEMA	N=140 (intervention n=67, control n=73)	20 weeks (1200 minutes)	Researcher	ROOTS (whole number understanding), explicit & systematic instruction: modeling and demonstrating, quided practice, visual represenatations, feedback. Math verbalization. Systematic instruction: prioritizing instruction around critical content, connecting new content with students' bakground knowledge, selecting and sequencing instructional examples and scaffolding instruction.	Test of Early Mathematics Ability (TEMA (Pro-Ed, 2007), Early Numeracy Curriculum-Based Measurement (EN-CBM, Clarke & Shinn, 2004)	Found statistically significant gains among the intervention students over those in control classrooms on TEMA standard scores (t= 2.19, df 27, p=.0371) but not in the EN-CBM total score (t=1.35, df 27, p=.1870). The correspondend to Hedge's g effect sizes of .38 for the TEMA standard score and .30 for the EN-CBM.	No
Clarke, Doabler, Smolkowski, Kurtz-Nelson, Fien, Baker & Kosty (2016)	Testing the immediate and long-term efficacy of tier 2 kindergarten mathematics intervention.	5.2 years	Low performance. Children qualified for the intervention if they scored of 20 or less on the NSB (Jordan et al 2008) and had composite score on ASPENS that placed in the srtatigic or intensive range (Clarke, Gersten et al. 2011)	N=290 (two-student ROOTS condition (n=58); five-student ROOTS condition (n=145), no-tratment control condition (n=87)	10 weeks (1000 min)	Researcher	ROOTS (whole number understanding), Explicit & systematic. Explicit instruction: (a) teacher modeling, (b) deliberate practice (incl scaffolding) (c) visual representations of mathematics (d) academic feedback.	ROOTS Assessment of of EARLY Numeracy Skills (RAENS) (Doabler, et al. 2012); Assessing Student Proficiency in Early Number Sense (ASPENS) (Clarke, Gersten et al. 2011); Number Sense Brief (NSB) Screener (Jordan et al. 2008); Test of Early Mathematics Ability-Third Edition (Ginsburg & Baroody 2003); The Standford Achievement Test- Tenth Edition (SAT).	Statistically significant differences by condition in gains from fall to sprong for four dependent variables. Students in the ROOTS condition made greater gains than control students on the ASPENS (t=5.20, df=136, p<.0001, oral counting (t02.14, df=132, p=.0333), TEMA standard scores (t=3.35, df=142, p=.0010, and RAENS (t=6.84, df=162, p<.0001. The time X condition model estimated differences in gains between conditions of 0.75 for the NSB (Hedges's g= .16), 19.7 for ASPENS (g=.58), 6.5 for oral counting (g=.28), 2.45 for the TEMA standard score (g=.32) and 4.7 for the RAENS (g=.75)	yes

Doabler, Clarke, Kosty, Kurtz-Nelson, Fien, Smolkowski & Baker (2016)	Testing the efficacy of a tier 2 mathematics intervention: A conceptual replication study.		Low performance. Children with both an NSB score of 20 or less and an ASPENS composite score in the "stratetic" or "intensive" ranges were concidered at risk for MD and eligible for intervention.	N=319 (ROOTS-small condition (n=67), the ROOTS-Large (n=162) and control condition (n=90)	10 weeks (1000 min)	Researcher	ROOTS (whole number understanding), Explicit & systematic. Explicit instruction: (a) teacher modeling, (b) deliberate practice (incl scaffolding)© visual representations of mathematics (d) academic feedback.	ROOTS Assessment of of EARLY Numeracy Skills (RAENS) (Doabler, et al. 2012); Assessing Student Proficiency in Early Number Sense (ASPENS) (Clarke, Gersten et al. 2011); Number Sense Brief (NSB) Screener (Jordan et al. 2008); Test of Early Mathematics Ability-Third Edition (Ginsburg & Baroody 2003); The Standford Achievement Test- Tenth Edition (SAT).	Students in the ROOTS condition made greater gains than control students on the NSB ((t=3.15, df=94, p=.0022), ASPENS (t=5.60, df=118, p<.0001. The Time x Condition model estimated differences in gains between conditions of 1.94 for the NSB (g=0.40), 21.78 for the ASPENS (g=0.64), 2.43 for the TEMA-3 standard score (g=0.31) and 6.50 for the RAENS (g=1.08).	no
Dyson, Jordan, Beliakoff & Hassinger-Das (2015)	A kindergarten number-sense intervention with contrasting conditions for low-achieving children	5.2 years 5.5 years	Low income and low performance. Below 25th percentile (number sense screener, Jordan et al. 2010)	N=126 (Number list practice (n=40), Number-fact practice (n=44), Control (n=42))	8 weeks (720 min)	Researcher	Researchers designed intervention material practicing Number, Number relations, Number Fact practice and Number list practice. Practice conditions. Children in both conditions received the same 25-minute number-sense intervention. Lessons differed for the two intervention groups only in the last 5 minutes of the 30-minute lesson. Number-list practice, each child played a vesion of the GreatRace Game (Ramani & Siegler 2008). Number-fact practice: children participated in an activity that engaged quick answers to addition and subtraction combinations that had been thaught in the lesson that day or in previous lesson.	Number competencies - Number Sense Screener (Jordan, Glutting, Ramineni & Watkins, 2010; Arithmetic Fluency (Jordan & Montani, 1997), mathematics calculation achievement (Woodcock-Johnson III tests of Achievement (WJ-III) Standard Test Book Form A: Calculation Subtest (Woodcock, McGrew & Mathe 2007). Background variables : Nonverbal reasoning (WPPSI, Wechsler 2002), Spatial ability (The Children's mental transformation task (CMTT) (Levine, Huttenlocher, Taylor & Langrock (1999), Inattentive behavior (SWAN rating scale, Swanson et al. 2006); Reading achievement (WJ-III Standard test book Form A:Letter-word identification subtest (Woodcock et al. 2007)	There was a significant main effect for group at each time point and for each measure. For number sense, the number-list condition outperformed the control group (although not always significantly) at both postest and delayed posttest with effect sizes greater than .25 (ES=.32 and ES= .26, respectively). The effect sizes for the number-fact practice versus control were more than twice those of the number-list practice at the both time points (ES=.82 and ES=.56, respectively) The effect of the number-fact condition over the number-list condition produced an effect size even greater than the effect of the number list over the control (ES=.42)	yes

Gersten, Rolfhus, Clarke, Decker, Wilkins & Dimino (2015)	Intervention for first graders with limited number knowledge: Large-scale replication of a Randomized Controlled trial.	first graders	lowest 35th of students screened in six math subtests (Timed computation, Fuchs, Hamlett & Fuchs 1990; Concepts/applications Fuchs et al. 1990; Story problems Jordan, Kaplan Locuniak &Ramineni 2007; The number knowledge test (Okamoto & Case 1996) Quantity discrimination (Clarke, Baker, Cahrd & Otterstedt 2006)	N= 994 (intervention n=615, control n=379)	17 weeks (1920 min)	Teacher	Number Rockets program applied the concrete–representational–abstract model, which relies on concrete objects to promote conceptual learning. The sequence of topics was identifying and writing numbers to 99; identifying more, less, and equal with objects; sequencing numbers; skip counting by 10s, 5s, and 2s; writing number sentences; place value, addition and subtraction.	Screening measures: Timed coputation (Fuchs, Hamlett & Fuchs, 1990); Concepts/Applications (Fuchs et al. 1990); Story problems (Jordan, Kaplan, Locuniak & Ramineni 2007), the number knowledge test (Okamoto & Case 1996) Quamtity discrimination (Clarke, Baker, Chard & Otterstedt 2006); Digit-span backward (Geary 1993). Outcome measures: Test of Early Mathematics Ability - Third Edition (TEMA-3) & Assessment to explore any unintended negative consequences - The Woodcock-Johnson III Letter/Word subtest.	Significant effect size of .34 sstandard deviation (SD) units is relatively large for large-scale research study. The effect size is virtually indentical to the mean effect size found in the original efficacy study of .337 SD units. Thus, one can clearly infer that the original findings were replicated in the large-scale study.	no
Hassinger-Das, Jordan & Dyson (2015)	Reading stories to learn math. Mathematics vocabulary instruction for children with early numeracy difficulties.	kindergarten	low-income; low scores (<=22 out of 44 = below 25th percentile)) Number Sense Brief (NSB, Jordan wt al. 2010)	N=124 (a storybook number competencies (SNC) intervention, a number sense intervention, business-as-usual control)	8 weeks (720 minutes)	Researcher	Storybook Number Competencies (SNC) Intervention targeting mathematics vocabularly knowledge (e.g. equal, more, less) and number concepts.	Measures : Mathematics vocabularly (The Bracken Basic Concept Scale - Third edition. Receptive: Quanity subtest (BBCS-3R; Bracken 2006a); Number sensse (Jordan et al 2010) Mathematics achievement (Woodcock-Johnson III Test of Achievement Normative Update brief Battery/Form C (WJ-III) Applied Problmes and Calculation subtest (Woodcock, McGrew & Mather, 2007)	Findings demonstrated that the SNC intervention group outperformed the other groups on measures of mathematics vocabularly, both in terms of words that were closely aligned to the intervention and those that were not.	yes