Learning Disabilities: A Contemporary Journal 11(2), 17-26, 2013

Mathematics Instruction: Do Classrooms Matter?

Annemie Desoete*
Pieter Stock
Ghent University, Belgium

Counting abilities have been described as determinative precursors for a good development of later mathematical abilities. However, an important part of variance in mathematical achievement has also been associated with differences between instruction methods given in schools. In this study counting and instruction as predictors for mathematical skills were studied in 423 children. Our data revealed that the mastery of the counting principles in kindergarten was predictive for the risk of mathematical (dis)abilities in grade 1. Moreover, children sharing a common instructional background tended to have more similar scores on mathematical tests, yet, the importance of mastery of the counting principles in the prediction of later mathematical achievement was the same for all classrooms.

Keywords: Mathematical abilities, risk for math disability, counting, procedural calculation, fact retrieval, kindergarten predictors, classroom, and instruction.

Introduction

Mathematics is inherently present in everyday life. Although mathematical problems have serious educational consequences, this area has received little attention in research until recently (Engle, Grantham-McGregor, Black, Walker, & Wachs, 2007; Landerl, Bevan, & Butterworth, 2004). However, Dowker (2005) indicated that the impact of poor mathematical skills is greater than the influence of poor reading skills. Differences in mathematical abilities between and within individuals are normal. Teachers are expected to cope with learning differences and to adjust their teaching style to the needs of all students. But in some cases, these differences appear to be so severe or resistant that they can be considered as characteristics of 'problems' or even 'disabilities' (Grégoire & Desoete, 2009). Most practitioners and researchers currently report a prevalence of mathematical learning disabilities (MLD) between 2 and 14% of children (Barbaresi, Katuskic, Colligan, Weaver, & Jacobsen, 2005; Desoete, Roeyers, & De Clercq, 2004; Shalev, Manor, & Gross-Tsur, 2005). The prevalence of MLD in siblings even ranges from 40 to 64% (Desoete, Praet, & Ceulemans, 2013; Shalev et al., 2001).

The term MLD refers to a significant degree of impairment in the mathematical skills (with substantially below mathematical performances). In addition, children with MLD do not profit enough from (good) help. This is also referred to as a lack of responsiveness to intervention. Finally, the problems in MLD cannot be totally explained by impairments in general intelligence or external factors that could provide sufficient evidence for scholastic failure. The challenges that people with MLD face (see e.g. Desoete, Van Hees, Tops, & Brysbaert, 2012; Vanmeirhaeghe

*Please send correspondence to: Annemie Desoete, annemie.desoete@ugent.be.

& VanHees, 2012) become evident through a statement made by Kristel, a Master in education: "Why was elementary school like hell? Because I felt a huge pressure on me. Open your manual on page 68. There we go again! Where is page 68? Other pupils already had taken down the title, while I was still looking for page 68. It was a constant feeling of needing to exert myself. I had to concentrate very hard in order to follow what was going on. That is what made it so difficult for me. Everyone was faster than I was."

A child with MLD needs extra support to enable him or her to follow a lesson according to his or her own intellectual level. MLD goes namely far beyond (mental) arithmetic. Even remembering definitions takes more efforts, as becomes evident through a statement by Sara, a Bachelor in journalism: "I need three times more time than an average student to learn the same subjects."

While early literacy is stimulated by almost all parents, early numeracy and counting gets less universal attention, although also the development of mathematical (dis)abilities begins before formal schooling starts (Ceulemans, Loeys, Warreyn, Hoppenbrouwers, & Desoete, 2012; Sophian, Wood, & Vong, 1995). It is therefore not surprising that children start with a quite heterogeneous baggage of counting skills at the school-desk. In addition, Opdenakker and Van Damme (2006) found that an important part of the variance in mathematical abilities in first grade were associated with differences between schools.

This study focused on counting abilities (Aunola et al., 2004; Gersten, Jordan, & Flojo, 2005; Le Fevre et al., 2006) in combination with mathematical instruction (Opdenakker & Van Damme, 2006) as a predictor of mathematical (dis)abilities in a large sample of children with a wide range of mathematical competencies.

Counting can be considered as a key ability for the development of age adequate mathematical skills. By means of counting, number facts are stored in long-term memory (Geary, 2011). In addition, counting activities lead to better strategies for addition and subtraction (Le Fevre et al., 2006) and multiplication (Blöte, Lieffering, & Ouwehand, 2006).

The mastery of the essential counting principles has been described as an essential feature for the development of counting (Geary, 2004; Gelman & Meck, 1983; Wynn, 1992). Children have to master the stable order, the one-to-one correspondence and the cardinality principle in kindergarten. The stable order principle implies that the order of number words must be invariant across counted sets. The one-to-one correspondence principle holds that every number word can only be attributed to one counted object. Once the cardinality principle is acquired, children know that the value of the last number word represents the quantity of the counted objects. Knowledge of the stable-order principle is reliable first of all, followed by the one-to-one correspondence principle, while mastery of the cardinality principle was found to develop the slowest (Butterworth, 2004; Fuson, 1988).

Mathematical instruction might differ in the adopted instructional paradigm (Case, 1998; Daniels & Shumow, 2003; De Corte, 2004; Ellis & Berry, 2005). The adoption of a traditional approach (e.g., emphasis on rules, memorizing, and rehearsing), a structuralist approach (e.g., stressing abstract conceptualizations of mathematical content) or a constructivistic view towards learning (e.g., teaching mathematics presenting problems within a familiar context in order to give meaning), will affect the design of learning materials and the instructional strategies suggested in textbooks (Carnine, Dixon, & Silbert, 1998; Van de Walle, 2007). This has been researched in an extensive way in relation to mathematics (Cooper, 1993; Nathan, Long, & Alibali, 2002). Moreover, differences between the instructional interventions and curricula are found in the timing and the stage at which the conceptions are presented to children as well as in the kinds of learning opportunities provided and in its organizing and sequencing (Schmidt, McKnight, Valverde, & Houang, 1997). As such, a large variation of teaching practices is adopted to teach mathematics in primary education. Depending on the curriculum, the textbooks used in the classroom, and the preferences and beliefs of each individual teacher, instruction can strongly differ across classrooms (Remillard, 1999). However, Slavin and Lake (2008) revealed that there is a lack of evidence supporting a differential effect of mathematics curricula on students' mathematicals performance results.

Although some authors stressed the importance of instruction and curricula (e.g., Chval, Chávez, Reys, & Tarr, 2009; Van Steenbrugge, Valcke, & Desoete, 2010; Zhao, Valcke, Desoete, Verhaeghe, & Xu, 2011) there is inconclusive evidence (Slavin & Lake, 2008) on the influence of instruction on children's mathematical skills in grade 1.

In this study the relationship between mastery of the counting principles in kindergarten (child factors) on the one hand and instruction (classroom factors) on the other hand on (dis) mathematical abilities will be analyzed.

Method

Participants

This study was carried out with 423 children (223 girls) in kindergarten. Of this sample, 369 children were tested in grade 1. All participants were Caucasian native Dutch-speaking boys and girls living in the Flemish part of Belgium. The children in this study had a mean age of 70.02 months (SD = 4.01 months) and attended on average 7.42 months (SD = 1.03 months) of school in the last kindergarten class when tested the first time.

Subjects were retrospectively classified as at-risk for a math learning disability (MLD) if they had scored < -1.5 on the z-score of one of the mathematical ability tests in grade 1 (n = 48). Children who scored z-scores above -1.5 on both mathematical tests in grade 1 were classified as typical achievers (n = 321), not at-risk for a math disability.

Materials

All counting abilities were tested in kindergarten with the TEDI-MATH (Grégoire, Noel, & Van Nieuwenhoven, 2004). The TEDI-MATH has proven to be a well validated and reliable instrument. Children had to judge the counting of linear and random patterns of drawings and counters. To assess the abstraction principle, children had to count different kinds of objects that were presented in a heap. Furthermore, a child who counted a set of objects was asked 'how many objects are there in total?', or 'how many objects are there if you start counting with the leftmost object in the array?'. When children had to count again to answer, they did not gain any points, as this was considered to represent good procedural knowledge but a lack of understanding of the counting principles. One point was given for a correct answer with a correct motivation. A sum score was constructed (maximum: 13 points). Cronbach's alpha was .85.

In order to obtain a complete overview of the mathematical abilities of children and to test for procedural calculation and semantic memory abilities (Pieters et al., 2013), the following mathematical tests were used: the Arithmetic Number Fact Test (Tempo Test Rekenen [TTR]; De Vos, 1992) and the Kortrijk Arithmetic Test Revision (Kortrijkse Rekentest-Revisie [KRT-R]; Baudonck et al., 2006).

The Arithmetic Number Fact Test (Tempo Test Rekenen [TTR]; De Vos, 1992) is a test consisting of number fact problems (e.g., 2 + 5 = ... ; 9 - 2 = ...). Children have to solve as many additions and subtractions as possible within 2 minutes. The psychometric value of the test has been demonstrated on a sample of 10,059 children.

The Kortrijk Arithmetic Test Revision (Kortrijkse Rekentest-Revisie [KRT-R]; Baudonck et al., 2006) is an untimed standardized test on procedural calculation from grade 1 until 6. The KRT-R requires that children solve calculations in a number-problem format (e.g., 16 - 12 = …) or in a word-problem format (e.g., 1 more than 3 is …). The psychometric value of the test has been demonstrated on a sample of 3,246 children and is frequently used in Flemish education and diagnostic assessment.

Procedure

The children were recruited in 25 randomly selected schools, 9 schools were located in a city while 16 of them were located rurally. All parents received a letter with the explanation of the research and could submit informed consent in order to participate.

Children were tested during school time in a separate and quiet room. Toddlers were tested individually. The test leaders all received training in the assessment and interpretation of the tests. After completion of the test procedure, all the parents of the children received individual feedback on the results of their children.

Results

In this sample, only 44.2% of the children mastered the three counting principles by the end of kindergarten (see also Stock, Desoete, & Roeyers, 2009). In addition, a MANOVA with procedural and conceptual counting skills as a dependent variable and group (children at-risk for MLD, children not at-risk for MLD) as a group was significant on the multivariate level ($F(2, 366) = 37.241$; $p < .001$, = partial $\eta^2 = .169$). There were significant differences on the univariate level for procedural ($F(1, 367) = 49.288$; $p < .001$, = partial $\eta^2 = .118$) and for conceptual counting ($F(1, 367) = 48.832$; $p < .001$, = partial $\eta^2 = .117$) with children at-risk for a math disability having lower developed procedural ($M = 41.31$; $SD = 22.89$) and conceptual ($M = 34.27$; $SD = 28.29$) counting abilities compared to their peers not at-risk for math disabilities (procedural counting $M = 69.25$; $SD = 26.10$; conceptual counting $M = 64.35$; $SD = 27.74$).

Since the children in this study were clustered in classrooms and thus not sampled randomly and independently, intra-class correlations were computed for both dependent mathematical ability variables (the procedural calculation and fact retrieval skills of children in grade 1). The intra-class correlation was calculated as the proportion of the between-group variance relative to the sum of the between- and within-group variance.

Table 1. ***Mixed Model Analysis: Null Model of mathematical abilities***

Parameter	Procedural calculation		Numerical Facility	
	Estimate	*SE*	Estimate	*SE*
Level 1 Intercept	.56*	.04	.63*	.05
Level 2 Intercept	.57*	.18	.42*	.14
Intra-class correlation	.50		.40	

Note. * $p < .001$

The intra-class indices (see Table 1) indicated that between 40 and 50% of the variance in the mathematical abilities of children could be explained by getting the same instruction. The individual level intercept variance was .56 for procedural calculation and .63 for numerical facility. The classroom level intercept variance was .57 for procedural calculation and .42 for numerical facility.

In order to take into account this data structure, multilevel analyses were performed with counting skills as the independent predictor, the scores on the mathematical tests as Level 1 and classrooms (or instruction) as Level 2. The results of the analyses are shown in Table 2.

Table 2. ***Mixed Model Analyses: Model including counting and mathematical instruction as factors***

Parameter	Procedural calculation		Numerical Facility	
	Estimate	*SE*	Estimate	*SE*
Fixed				
Intercept	-.13	.13	-.05	.13
Counting skills	.33*	.06	.21*	.05
Random				
Level 2 Intercept	.41*	.13	.36*	.12
Level 2 Instruction	.03	.02	.00	.02

Note. * $p < .001$

The fixed part of the model revealed that counting skills play a significant role in the prediction of both procedural calculation and numerical facility. Children with better counting skills in kindergarten tended to perform better on arithmetic tests in first grade. The random part of the model revealed that there was significant intercept variance between the classrooms for both arithmetic tests, indicating that classrooms differ in their mean performances. Yet, no significant slope variance was found for the scores on the arithmetic tests between the different classrooms.

Discussion

The goal of the current research was to gain more insight into the importance of mastering the counting principles in kindergarten versus the variance between classrooms or the role of instruction on mathematical abilities and the risk for math disability in Grade 1.

In this study, more than half of the children did not master the three counting principles by the end of kindergarten. Large differences in the mastery of the essential counting principles in toddlers existed, so teachers may need to pay a lot of attention to the different baggage children bring with them when entering first grade.

In addition, counting abilities in toddlers and their procedural calculation and fact retrieval abilities one year later in first grade were assessed in a large sample that included children with a wide range of mathematical abilities. Our findings revealed that it was possible to differentiate between children at-risk and not at-risk for mathematical disabilities in elementary schools based on the procedural and conceptual knowledge of counting in kindergarten.

Furthermore, it was supposed that children who performed better on the items of the counting principles as a whole in kindergarten, had better scores on mathematical tests in first grade one year later than children who had lower scores on the counting items. Since high values were found for the intra-class correlations, it was necessary to take into account the clustered structure of the data and to use multilevel analyses. The expected hypothesis could be confirmed. The better children performed on the counting items in the last kindergarten class, the better they performed on the two mathematical tests in first grade. These results confirm the role of counting abilities in the development of proficient arithmetic strategies (Stock et al., 2009, Stock, Desoete, & Roeyers, 2007; Van De Rijt & Van Luit, 1999).

The results pointed out that a large part of the variance in mathematical achievement in first grade can be associated with differences between schools. By using multilevel analyses it was possible to allow for similarities in the performances of children in the same classroom, but no explanatory factors could be found. We found significant random variation for the mean class achievement indicating that the level of performances was quite different between schools and those children sharing a common educational background tended to have more similar scores on mathematical tests when compared with children in other schools. Yet there was no random slope variation, meaning that the importance of mastery of the counting principles in the prediction of later arithmetic achievement was the same for all classrooms. There was no differential influence of the school context on the children's basic counting knowledge.

Yet, the study had a few limitations. In this study the TEDI-MATH items (Grégoire et al., 2004) were used. We thus still` have to be careful with our conclusions since MLD might not be a homogeneous disability (Pieters et al., 2013) and the choice of the used task can have an important impact on the results. Furthermore, the conclusions of this study have to be interpreted carefully since a large proportion of the variance remained unexplained. A lot of other possible powerful predictors besides the counting abilities such as language (Praet, Titeca, Ceulemans, & Desoete, 2013; Vukovic & Lesaux, 2013) and magnitude estimation skills (Stock, Desoete, & Roeyers, 2010) were not taken into account in this research. For example, contextual variables such as home environment and parental involvement (e.g., Reusser, 2000) should be included in future studies. These limitations indicate that only a part of the picture is investigated so the results of the study have to be interpreted with care. Yet the large group of children that was assessed in this study strengthens the generalizability of the results.

In conclusion, our results revealed a relationship between mastery of the counting principles in kindergarten (child factors) on the one hand and instruction (classroom factors) on the other hand, on mathematical abilities and the risk for a math disability. It was possible to explain significant proportions of scores on mathematical tests in first grade based on the counting scores in kindergarten. In addition, there were important differences between schools. Taking into account the large differences in baggage in terms of counting skills children took with them when starting basic schooling and the fact that scores on counting tasks were good predictors for later arithmetic abilities, it is important that teachers in first grade pay enough attention to the instruction of counting skills.

References

Aunola, K., Leskinen, E., Lerkkanen, M. K., & Nurmi, J. E. (2004). Developmental dynamics of math performance from preschool to grade 2. *Journal of Educational Psychology, 96*, 699-713.

Barbaresi, W. J., Katusic, S. K., Colligan, R. C., Weaver, A. L., & Jacobsen, S. J. (2005). Learning disorder: Incidence in a population-based birth cohort, 1976-82, Rochester, Minn. *Ambulatory Pediatrics, 5*, 281-289.

Baudonck, M., Debusschere, A., Dewulf, B., Samyn, F., Vercaemst, V., & Desoete, A. (2006). *De Kortrijkse Rekentest Revision KRT-R. [The Kortrijk Arithmetic Test Revision KRT-R].* Kortrijk, the Netherlands: CAR Overleie.

Blöte, A. W., Lieffering, L. M., & Ouwehand, K. (2006). The development of many-to-one-counting in 4-year-old children.*Cognitive Development, 21,* 332-348.

Butterworth, B. (2004)The development of arithmetical abilities. *Journal of Child Psychology and Psychiatry, 46,* 3-18.

Carnine, D., Dixon, R., & Silbert, J. (1998). Effective strategies for teaching mathematics. In E. Kameenui & D. Carnine (Eds.), *Effective teaching strategies that accommodate diverse learners.* Columbus, OH: Merrill.

Case, R. (1998). Changing views of knowledge and their impact on educational research and practice. In D. Olson & N. Torrance (Eds.), *Handbook of education and human development.* Malden, MA: Blackwell.

Ceulemans, A., Loeys, T., Warreyn, P., Hoppenbrouwers, K., & Desoete, A. (2012). Small number discrimination in early human development: The case of one versus three. *Education Research International, Volume 2012*, 5 pages.

Chval, K. B., Chávez, Ó., Reys, B. J., & Tarr, J. (2009). Considerations and limitations related to conceptualizing and measuring textbook integrity. In J. T. Remillard, B. A. Herbel-Eisenman, & G. M. Lloyd (Eds.), *Mathematics teachers at work: connecting curriculum materials and classroom instruction* (pp. 70-84). New York, NY: Routledge.

Cooper, P. A. (1993). Paradigm shifts in designed instruction: From behaviorism to cognitivism to constructivism. *Educational Technology, 33*, 12-19.

Daniels, D. H., & Shumow, L. (2003). Child development and classroom teaching: a review of the literature and implications for educating teachers. *Journal of Applied Developmental Psychology, 23*, 495-526.

De Corte, E. (2004). Mainstreams and perspectives in research on learning (mathematics) from instruction. *Applied Psychology: An International Review, 53*, 279-310.

Desoete, A., Praet, M., Titeca, D., & Ceulemans, A. (2013).Cognitive phenotype of mathematical learning disabilities: What can we learn from siblings? *Research in Developmental Disabilities, 34*, 404-412.

Desoete, A., Roeyers, H., & De Clercq, A. (2004). Children with mathematics learning disabilities in Belgium. *Journal of Learning Disabilities, 37*, 50-61.

Desoete, A., Van Hees, V., Tops, W., & Brysbaert, M. (2012). Proef op de som. [Divided by numbers]. Gent, Belgium: Academia Press.

De Vos, T (1992). *TTR. Tempotest rekenen [Arithmetic number fact test]*. Lisse, The Netherlands: Swets & Zeitlinger.

Dowker, A. (2005). *Individual differences in arithmetic: Implications for psychology, neuroscience and education.* New York, NY: Psychology Press.

Ellis, M. W., & Berry, R. Q. (2005). The Paradigm Shift in Mathematics Education: Explanations and Implications of Reforming Conceptions of Teaching and Learning. *The Mathematics Educator, 15*, 7-17.

Engle, P., Grantham-McGregor, S., Black, M., Walker, S., & Wachs, T. (2007)How to avoid the loss of potential in over 200 million young children in the developing world. *Child Health and Education, 1*, 67-87.

Fuson, K. C. (1988). *Children's counting and concepts of number.* New York, NY: Springer Verlag.

Geary, D. C. (2004). Mathematics and learning disabilities. *Journal of Learning Disabilities, 37*, 4-15.

Geary, D. C. (2011). Consequences, characteristics, and causes of mathematical learning disabilities and persistent low achievement in mathematics. *Journal of Developmental and Behavioral Pediatrics, 32*, 250-263.

Gelman, R., & Meck, E.(1983). Preschooler's counting: Principles before skill. *Cognition, 13*, 343-359.

Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and Intervention for Students with Mathematics Difficulties. *Journal of Learning Disabilities, 38,* 293-304.

Grégoire, J., & Desoete, A. (2009). Mathematical disabilities-an underestimated topic? *Journal of Psychoeducational Assessment, 27*, 171-174.

Grégoire, J., Noel, M., & Van Nieuwenhoven (2004). *TEDI-MATH.* Bruxelles: TEMA.

Landerl, K., Bevan, A., & Butterworth, B. (2004). Developmental dyscalculia and basic numerical capacities: a study of 8-9-year-old students. *Cognition, 93*, 99-125.

Le Fevre, J.-A., Smith-Chant, B. L., Fast, L., Skwarchuk, S.-L., Sargla, E., Arnup, J. S., Penner-Wilger, M., Bisanz, J., & Kamawar, D. (2006). What counts as knowing? The development of conceptual and procedural knowledge of counting from kindergarten through grade 2. *Journal of Experimental Child Psychology, 93,* 285-303.

Nathan, M. J., Long, S. D., & Alibali, M. W. (2002). The symbol precedence view of mathematical development: A corpus analysis of the rhetorical structure of textbooks. *Discourse Processes, 33*, 1-21.

Opdenakker, M.-C., & Van Damme, J. (2006). Differences between secondary schools: A study about school context, group composition, school practice, and school effects with special attention to public and Catholic schools and types of schools. *School Effectiveness and School Improvement, 17,* 87-117.

Opdenakker, M.-C., Van Damme, J., De Fraine, B., Van Landeghem, G., & Onghena, P.(2002). The effects of schools and classes on mathematics achievement. *School Effectiveness and School Improvement, 13,* 399-427.

Pieters, S., Roeyers, H;, Rosseel, Y., Van Waelvelde, H,, & Desoete, A. (2013). Identifying subtypes among children with developmental coordination disorder and mathematical learning disabilities, using model-based clustering. *Journal of Learning Disabilities, 27*, 90-96.

Praet, M., Titeca, D., Ceulemans, A., & Desoete, A. (2013). Language in the prediction of arithmetics in kindergarten and grade 1. *Learning and Individual Differences, 27*, 90-96.

Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematiccurricula. *Review of Educational Research, 75*, 211-246.

Reusser, K. (2000). Success and failure in school mathematics: Effects of instruction and school environment. *European Child & Adolescent Psychiatry, 9,* 17-26.

Schmidt, W. H., C. C. Mcknight, G. A. Valverde, R. T. Houang, & D. E. Wiley (1997). *Many visions, many aims: A cross-national investigation of curricular intentions in school mathematics (volume 1)*. London, UK: Kluwer.

Shalev, R. S., Manor, O., & Gross-Tsur, V. (2005). Developmental dyscalculia: A prospective six-year follow-up. *Developmental Medicine & Child Neurology, 47*, 121-125.

Shalev, R. S., Manor, O., Kerem, B., Ayali, M., Badichi, N., Friedlander, Y., & Gross-Tsur, V. (2001). Developmental dyscalculia is a familial learning disability. *Journal of Learning Disabilities, 34,* 59-65.

Slavin, R. E., & Lake, C. (2008). Effective programs in elementary mathematics: A best-evidence syntheses. *Review of Educational Research, 78*, 427-515.

Sophian, C., Wood, A. M., & Vong, K. I. (1995). Making numbers count: the early development of numerical inferences. *Developmental Psychology, 31*, 263-273.

Stock, P.,Desoete, A., & Roeyers, H. (2007).Early markers for arithmetic difficulties.*Educational and Child Psychology, 24*, 28-39..

Stock, P., Desoete, A., & Roeyers, H. (2009). Mastery of the Counting Principles in Toddlers: A Crucial Step in the Development of Budding Arithmetic Abilities? *Learning and Individual Differences, 19,* 419-422.

Stock, P., Desoete, A.,& Roeyers, H. (2010). Detecting children with arithmetic disabilities from kindergarten:Evidence from a three year longitudinal study on the role of preparatory arithmetabilities. *Journal of Learning Disabilities, 43*, 250-268.

Van de Rijt, B. A. M., & Van Luit, J. E. H. (1999).Milestones in the development of infantnumeracy. *Scandinavian Journal of Psychology, 40,* 65-71.

Van de Walle, J. A. (2007). *Elementary and middle school mathematics teaching developmentally*. Boston, MA: Pearson education.

Van Steenbrugge, H.,Valcke, M., Desoete, A. (2010). Mathematics learning difficulties in primary education: teachers' professional knowledge and the use of commercially available learning packages. *Educational studies, 36*, 59-71.

Vanmeirhaeghe, B., & Van Hees, V. (2012). *Divided numbers.* Retrieved from http:/ www.studerenmetdyscalculie.be.

Vukovic, R. S., & Lesaux N. K. (2013). The relationship between linguistic skills and arithmetic knowledge. *Learning and Individual Differences, 23,* 87-91.

Wynn, K. (1992). Children's acquisition of the number words and the counting system. *Cognitive Psychology, 24,* 220-251.

Zhao, N. N., Valcke, M., Desoete, A., Verhaeghe J., & Xu, K. (2011). Multilevel analysis on predicting mathematics performance in Chinese primary schools: implications for practice. *Asia-Pacific Education Researcher, 20*, 503-520.