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COUNTING ON – LONG TERM EFFECTS OF AN EARLY INTERVENTION PROGRAMME

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This paper reports the long-term results of an intervention study with 134 six-year-old students from seven preschool-classes in northern Sweden to evaluate whether the Think, Reason and Count in Preschool-class programme (TRC) could prevent at-risk students from becoming low-performing students in mathematics. Whereas the pre-test score revealed that the intervention and the control group preformed equally, scores on the delayed follow-up-test in Grade 3 showed that the intervention group performed better than the control group and that at-risk students had closed the performance gap between themselves and their not-at-risk peers.

INTRODUCTION

Because mathematics performance prior to starting primary school has correlation to later mathematics performance (Duncan et al., 2007), low-performers in early mathematics education tend to remain low-performers if they do not receive appropriate support (Geary, 2013; Morgan, Farkas & Wu, 2009; 2011). Sayers, Andrews & Björklund Boistrup (2016) highlights evidence of that correlation and underscore that certain basic mathematics skills can predict later arithmetical competence and that these factors indicates a cross-culturally common phenomenon. In response, efforts to prevent future low performance in mathematics among low-performing students should be made before the students begin their formal education (Morgan et al, 2011). On a broader scale, to improve students’ overall performance in mathematics in educational systems, the most effective way is to reduce the number of low-performing students in general (OECD, 2016).

In Sweden, the continued increase of low-performing students in mathematics demands for methods preventing at-risk students from developing into low-preforming students (OECD, 2016). In general, the Swedish school-system is obliged to support students at risk of not achieving the national education goals. As researchers have suggested, if key components in mathematics could be addressed early in education, then low-performing students might remedy or at least not fall further behind (Gersten, Jordan & Flojo, 2005). The most successful method of preventing further low-performance has been early interventions before students begin their formal education (McIntosh, 2008; Duncan et al., 2007; Nunes, Bryant, Sylva & Barros, 2011). Furthermore, a critical point in mathematical development is the transition from informal (i.e. preschool) to formal mathematical education (McIntosh, 2008). In the
Swedish school-system this transition occurs in preschool-class (age 6). Studies have shown that using the *Think, Reason and Count in preschool-class* (TRC) programme, developed by Sterner, Helenius and Wallby (2014), can improve students’ performance in mathematics (Sterner, 2015). As an added benefit, teachers who use the TRC programme become more aware of their students’ mathematical development which helps them to identify at-risk students (Vennberg, 2015). In response to those findings, the purpose of our study was to examine whether the TRC programme affects students’ long-term performance in mathematics?

**BACKGROUND**

**Low-performing student and at-risk students**

Swedish students’ mathematics performance in the Programme for International Student Assessment (PISA) has gradually declined and Sweden’s proportion of low-performing students has the highest increase in comparison to all other countries that participated in PISA 2003-2012 (OECD, 2016). PISA scores show that 28% of Swedish students score below Level 2—the baseline level of proficiency in mathematics—and are thus considered to be at great risk of being or becoming low-performers. Van Luit & Van de Rijt’s (2005) standardised Early Numeracy Test, ENT is often used to identify students at risk of becoming low-performing students. ENT scores are grouped at five levels (i.e. Levels A-E), of which Levels D and E represent the first quartile of the lowest-performing students. Fuchs & Fuchs (2005) have suggested that students that perform in that quartile on standardised tests are at risk of experiencing difficulties with mathematics. In Sweden, attempts have been made to understand the declining scores in international evaluations (e.g., PISA and Trends in International Mathematics and Science Study) and why nearly 10% of students fail the Swedish national tests in mathematics administrated in Grade 3, 6, 9 or earn failing grades in mathematics, if not both (Swedish National Agency for Education, 2016). Because students can encounter obstacles in their mathematics development during the transition from informal to formal mathematical learning (McIntosh, 2008), it is imperative to focus on Swedish preschool-class, at the threshold of that transition.

**The Swedish context**

All children in the Sweden are required to begin attending compulsory school from the year they turn 7 and continue attending for 9 years. Preschool-class was introduced as a separate, optional form of schooling in the Swedish school system in 1998 (Swedish National Agency for Education, 2001) to bridge informal learning in preschool and the formal learning in compulsory school and to link these school forms differences in pedagogic, tradition and culture. Beginning in the Fall 2018, preschool-class, in its unique form, will be compulsory in Sweden and added as a separate form of schooling within the school-system (Prop. 2017/18:9). At the time of the study reported here, the preschool-class did not yet have a syllabus for mathematics. Nonetheless, the core content of the TRC programme aligns with the mathematics content of the syllabus in
the Swedish National Curriculum that currently regulate and control the pre-
school-class assignment (Swedish National Agency for Education, 2016a).

Early interventions
Research in international settings has shown that early intervention in students’
mathematics education can benefit their development in mathematics (McIntosh,
(Mononen, Aunio, Koponen & Aro, 2014) has shown that many interventions can aid
at-risk students, although clear evidence of capacity to close the performance gap to
their not-at-risk peers remains lacking. Nevertheless, it is suggested that the longer the
effect of the intervention, the greater the odds that it can prevent students’ difficulties
in mathematics. In this study reported here, we used the TRC programme (Sterner et
al., 2014) as an intervention. The TRC programme aims at bringing forth the math-
ematical abilities that are necessary to learn and perform mathematics (e.g. Kilpatrick,
Swafford & Findell, 2001; NCTM, 2001). The TRC programme is evidence based and
builds upon structured activities in mathematics in which students, both individually
and in groups, meet, use, develop and reason about different representations of num-
bbers. The activities are to be implemented with a specific teaching model. The TRC
programme draws upon research that has been proven to be effective for stu-
dents-at-risk but is designed for regular teaching in all preschool-classes. Three design
principles were combined to support teaching: structured activities with specific c
ontent, a modified circular teaching–learning structure based on the model of con-
crete–representational–abstract sequence of instruction and reasoning about the stu-
dents’ own documented work (Sterner & Helenius, 2015).

AIM
Studies from various countries have concluded that early interventions are crucial to
prevent at-risk students from developing into low-performing students. However, re-
sults on whether such interventions have any positive long-term effects remain in-
conclusive. Therefore, we aim to investigate eventual longitudinal effects on students’
mathematical performance in Grade 3 (i.e. at 9 years old) after an extensive
whole-class intervention in preschool-class (i.e. at 6 years old). We sought to answer
three questions. RQ1: Does implementing the TRC programme have any effect de-
tectable in difference between pre- and post-test score? RQ2: To what extent does the
TRC programme affect students’ long-term performance as measured by the Swedish
national tests in mathematics in Grade 3? RQ3: How does pre-test performance levels
(A-E) in mathematics prior to formal schooling influence the mathematics scores on
such national test in Grade 3?

METHOD
Participants and Procedures
The research design comprised a pre-test, an intervention, a post-test and a delayed
follow up-test. The sample comprised 149 students from seven preschool-classes in
four schools in a midsize town in northern Sweden. Fifteen students who did not participate in all three tests were excluded from the analyses. Hence, the data analyses included 134 students. The schools were chosen with the help of the municipality administration in order to achieve an equivalent selection based on socio-economic backgrounds factors. The classes were divided into an intervention group of four classes \((n=79)\) and a control group of three classes \((n=55)\). The mathematics teaching and content in the intervention group shifted into that of the TRC programme only, and the teachers attended a teaching development programme focused on the underlying mathematical theories and ideas of the TRC programme.

**Measures**

We assessed the students’ mathematical performance at three time points: prior to the intervention in November in preschool-class (pre-test, T1), immediately after the intervention in June in preschool-class, (post-test, T2) and 3 years after the intervention in March, when the students were in Grade 3 (delayed follow-up-test, T3). The students’ performance was assessed T1 and T2 by using the ENT (Van Luit et al., 2005) which is used in many countries to identify at-risk students and in studies comparing different countries (Aunio & Niemivirta, 2010). The ENT consists of two comparable parts, called A and B; ENT A was used as a pre-test (T1) and ENT B as a post-test (T2). The criterion to identify students at risk of becoming low-performers was a score in the 25th percentile (i.e. Levels D and E) at T1. To determine whether the intervention helped to increase the students’ performance in mathematics in the long-term, we compared scores at T1 and T2 to scores on the Swedish national tests in mathematics in Grade 3 (T3). The Swedish national test in mathematics is compulsory for students in Grade 3, and its purposes are several. It is not only to support an equal assessment of students’ knowledge but also to provide a basis for analysing the extent to which knowledge requirements are met among schools across the nation. Although the test does not give a complete picture of students’ knowledge in mathematics, because not all areas in the syllabus are tested, the design is based on the curriculum, the syllabus in mathematics and the related knowledge requirements that describe the lowest acceptable level (PRIM-gruppen, 2016; Swedish National Agency for Education, 2016b).

**Method of analysis**

An initial control analysis revealed that the exclusion of students that did not complete all three tests did not affect the comparability of the two groups. To determine whether the intervention had any detectable effect, a difference score was calculated as the progression between the pre- and post-test (T1 and T2). An independent \(t\)-test was conducted to measure whether any significant difference emerged in the progress of the two groups. An additional \(t\)-test was conducted to control for any difference in national test scores (T3) between the groups. Next, the groups were divided into four sub-groups according to the levels of their performance in mathematics at T1; sub-group *Low* comprised all at-risk students (i.e. Levels D and E). A graph showing the average progress across the tests for each subgroup was constructed, which allowed
us to investigate the group of at-risk students in greater depth. Because the number of at-risk students were small ($n=10$ and $n=18$) the difference was analysed by a non-parametric test, the Wilcoxon signed-rank test, which is considered to be robust with small sample sizes and eventual differences in variance. All statistical analyses were performed with the Statistical Package for the Social Sciences version 24.0.

RESULTS

Result of the initial $t$-test revealed a significant difference in progression between T1 and T2 in favour of the intervention group ($t = -2.098$, $df = 132$, $p = .038$, $g = .368$). Results of the subsequent $t$-test indicate a significant difference between the two groups on the national test score as well ($t = -2.113$, $df = 88.141$, $p = .037$, $g = .397$), as shown in Figure 1a.

![Figure 1. (a) Mean scores for the national tests, T3. (b) Progress in scores on the three tests for each sub-group. Note. ILow=Intervention group, low-performers; CLow=Control group, low-performers; etc.](image)

We more closely investigated the difference in T3 by dividing the two groups into sub-groups based on the performance levels used to classify at-risk students in T1. A closer look at these sub-groups shows that the main difference between the groups in T3 is related to the at-risk students (Figure 1b). Results of a non-parametric test showed that the only significant difference in T3 scores occurred between the sub-groups with at-risk students—that is, ILow and CLow ($Z = -2.376$, $p = .016$). Another compelling result is that the at-risk students in the intervention group caught up to their not-at-risk peers and partly closed the performance gap, whereas the distance between the lowest quartile and the second-lowest quartile was constant over time in the control group. Those results indicate that the TRC programme works as intended and seems to have a lasting effect on the students’ performance in mathematics, as measured by scores on the national test in Grade 3. Clearly, such improvement among at-risk students does not negatively affect students who perform at higher levels. In
fact, some indications (Figure 1b) suggest that even students at the higher performance levels might benefit from the intervention as well as their at-risk peers.

DISCUSSION

We examined whether the early and extensive TRC programme, *Think, Reason, and Count in preschool-class*, exerted any detectable long-term effect on Swedish students’ performance in mathematics as measured by the Swedish national test 3 years after the intervention. As in a previous study (Sterner, 2015), the intervention affected students’ performance and short-term progress, and the progress indicated by the difference in pre- and post-test scores was greater in the intervention group. That result could have stemmed from the fact that at-risk students were identified earlier (Vennberg, 2015) and that additional support was provided at a critical transitional point in the development of their mathematical thinking (McIntosh, 2008). Attention given to mathematical reasoning, which is a part of the TRC programme, could also have exerted an effect. Indeed, the ability to reason mathematically is one of the core competences of mathematics (Kilpatrick et al., 2001; NCTM, 2001), and practicing that ability can be the key component essential for mathematical progression (Gersten et al., 2005; Norqvist, 2016). This could be a key component in mathematics that could be addressed early so that low-performing students might remedy or at least not fall further behind their not-at-risk peers. The intervention group also performed better than the control group from the long-term perspective, as measured by scores on the national test in Grade 3. That result could derive from a factor other than the intervention; however, a close look at the data did not indicate any distinct decline or increase in individual class performance, which could signify an extraordinary poor or excellent learning environment. The preschool-classes were also chosen to ensure a similar representation of socio-economic background factors in the two groups, factors which did not change during the 3 years between T2 and T3. Although countless other factors could have influenced the students, but there is an indication that the TRC programme seems to have had a long-term effect on the participating students’ national test scores. Furthermore, the data suggest that the TRC programme affected at-risk students in the long-term. In the intervention group, such students had caught up with their not-at-risk peers, while such progress had not occurred in the control group. At-risk students in the control group remained low-performers in Grade 3, which confirms Duncan’s (2007) and Sayers’s (2016) conclusion that the mathematics-related knowledge students bring to school determines their later performance and grades in mathematics. Regarding practice, our findings imply that teachers and principals need to dedicate time to implement the TRC programme in whole-class mathematics work in preschool-class. Such action could be the successful prevention before formal education to prevent future low-performing students as suggested by the results of several earlier studies (e.g., Duncan et al., 2007; McIntosh, 2008; Morgan et al, 2011; Nunes, et al., 2011). Additionally, since the longer the effect of the intervention lasts the greater the odds that it prevents students from facing difficulties in mathematics, the TRC programme could improve the overall performance in mathe-
matics in educational systems, because the most effective way to do that is to reduce the number of low-performing students (OECD, 2016).

CONCLUSION

Our findings indicate that consciously, systematically application of the TRC programme in preschool-class can improve students’ long-term performance in mathematics. In particular, participation in the TRC programme improved the possibilities for at-risk students to perform at the same level as their not-at-risk peers and such progress seems to have lasted. More detailed analyses of the scores of at-risk students on Sweden’s national test in mathematics can elaborate the differences in performance between and within the groups of at-risk and not-at-risk students, as well as identify factors that help at-risk students to avoid becoming low-performers later in their mathematics development.

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