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Differentiated instruction in primary mathematics: Effects of teacher professional development on student achievement

Emilie J. Prast*, Eva Van de Weijer-Bergsma, Evelyn H. Kroesbergen, Johannes E.H. Van Luit

Utrecht University, Department of Pedagogical and Educational Sciences, P.O. Box 80140, 3508 TC Utrecht, The Netherlands

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ABSTRACT

This large-scale study examined the effects of a teacher professional development (PD) programme about differentiated instruction on students' mathematics achievement. Thirty primary schools (N = 5658 students of grade 1–6) divided over three cohorts participated: Cohort 1 received the PD programme in Year 1, Cohort 2 in Year 2, and Cohort 3 was control. During the PD, teachers learned how to adapt mathematics education to diverse educational needs using within-class ability groups. In Year 1, the PD had a significant small positive effect on student achievement growth. The effect size was similar for low-achieving, average-achieving and high-achieving students. In Year 2, no significant effects were demonstrated. In sum, teacher PD about differentiation has the potential to promote the achievement of all students. However, implementing differentiation is not straightforward and future research is necessary to unravel which factors make PD about differentiation succeed.

1. Introduction

Primary school classrooms are traditionally diverse in terms of the academic ability and achievement level of the students. With the current movement towards inclusion of children with special educational needs in general education classrooms, the range of ability and achievement levels is continuously increasing, as are the specific educational needs associated with these. Differentiation, i.e. the adaptation of instruction to students' different educational needs, is often promoted as a solution for responding to this diversity. In this study, we investigate whether teacher professional development (PD) about differentiation has a positive effect on student achievement in primary school mathematics.

1.1. Definitions: differentiation, ability grouping, and adaptive teaching competency

Roy, Guay, and Valois (2013, p.1187) define differentiated instruction as 'an approach by which teaching is varied and adapted to match students' abilities using systematic procedures for academic progress monitoring and data-based decision-making.' Thus, the focus is on differentiation based on students' current achievement level, also called cognitive or readiness-based differentiation. According to this definition, teachers should monitor students' academic progress to identify students' educational needs and then adapt instruction to these needs. The way in which progress is monitored and the nature of instructional adaptations can vary substantially, and various organisational formats can be used (e.g. individual or group-based; see Prast, Van de Weijer-Bergsma, Kroesbergen, and Van Luit (2015) for a discussion of this issue).

One frequently used way to organise differentiation is homogeneous within-class ability grouping (hereafter: ability grouping), in which students of similar academic ability or (current) achievement level are placed together in subgroups within the heterogeneous classroom (Tieso, 2003). Ability grouping is not synonymous to differentiation: it is an organisational format that can be used to implement differentiation, provided that instruction and practice are indeed adapted to the educational needs of the different ability groups.

A related term for adapting instruction to students' educational needs is adaptive teaching. A distinction is made between macro-adaptations (planned adaptations, e.g. pre-designed tasks at various levels of difficulty for low-achieving and high-achieving students) and micro-adaptations (spontaneous adaptations in direct response to students' needs; Corno, 2008). The term 'differentiation' seems to be more commonly used for macro-adaptations, whereas 'adaptive teaching' is more commonly used for micro-adaptations. However, the construct of 'adaptive teaching competency' (Vogt & Rogalla, 2009) does include both adaptive planning competency (teachers' capacity to plan adaptations beforehand; macro-adaptivity) and adaptive implementation competency (teachers' capacity for making adaptations on the spot; micro-adaptivity). In this article, we use 'differentiation' to refer to the process of monitoring progress and making instructional adaptations as

* Corresponding author.
E-mail addresses: e.prast@uu.nl (E.J. Prast), e.vandeweijer@uu.nl (E. Van de Weijer-Bergsma), e.h.kroesbergen@uu.nl (E.H. Kroesbergen), j.e.h.vanluit@uu.nl (J.E.H. Van Luit).

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defined by Roy et al. (2013). In line with Vogt and Rogalla (2009), we use 'adaptive teaching competency' to refer to teachers' capacities for making both planned and spontaneous adaptations to students' identified educational needs. We focus on planned adaptations based on students' current achievement level, but acknowledge that teachers should also be able to make adaptations on-the-fly in direct response to students' needs.

1.2. Achievement effects of ability grouping

Reviews about the effects of ability grouping have shown that positive effects can be obtained if instruction is tailored to the needs of the students in the subgroups and if the grouping arrangement is flexible (Kulik & Kulik, 1992; Lou et al., 1996; Slavin, 1987; Tieso, 2003). In contrast, slight negative effects of within-class ability grouping in primary school were found across three studies in which variations in instructional treatment were not explicitly described (Deunk, Doolaard, Smale-Jacobse, & Bosker, 2015).

An unresolved issue is the potential existence of differential effects depending upon achievement level. While Slavin (1987) reported a higher median effect size for low-achieving students than for average-achieving and high-achieving students, other reviews have found different patterns with smaller (Kulik & Kulik, 1992; Lou, Abrami, & Spence, 2000) or even negative effects (Deunk et al., 2015) for low-achieving students. Previously reported negative effects of ability grouping for low-achieving students have been ascribed to stigmatization and lower educational quality in low-ability groups (Gamoran, 1992). However, it has also been argued that these negative conditions can be prevented: negative stigma may be overcome by ensuring that the subgroups are within-class and flexible (Tieso, 2003) and by promoting a growth mindset rather than a fixed mindset of ability level (Dweck, 2000; i.e. participation in additional instruction should be communicated as an opportunity to learn, rather than as a sign of fixed low ability). Moreover, when ability grouping is used as a means to adapt education to the specific needs of the students in the groups, this may enhance (rather than reduce) educational quality for low-achieving students because the instruction can be better attuned to their needs (Gamoran, 1992). In an experimental study in which different types of ability grouping were compared and coupled with systematically prescribed instructional differentiation, Tieso (2005) found positive effects of flexible within-class grouping for all subgroups (low-achieving, average-achieving, and high-achieving).

1.3. Achievement effects of differentiation

A recent comprehensive literature review about the effects of differentiation on student achievement demonstrated that high-quality research about this topic is scarce (Deunk et al., 2015). For primary schools, only sixteen studies met the inclusion criteria, and most of these were still either too narrow (ability grouping only, without information about whether instructional adaptations were made; e.g. Leonard, 2001) or too broad (interventions in which differentiation was one of many components; e.g. Success for All; Borman et al., 2007) to specifically evaluate the effects of differentiation. However, promising findings were obtained with the five remaining studies, which demonstrated significant positive effects of two technological applications for differentiation. Individualizing Student Instruction (McDonald Connor, Morrison, Fishman, Schatschneider, & Underwood, 2007; McDonald Connor et al., 2011a; McDonald Connor et al., 2011b) provides the teacher with recommendations about the amount and type of literacy instruction needed by individual students based on their scores on a computerised test. Accelerated Math (Ysseldyke & Bolt, 2007; Ysseldyke et al., 2003) continuously monitors students' progress and adapts practice tasks to students' individual skill level. While the review thus yielded evidence for the effectivity of technological applications for individual differentiation, studies in which (group-based) differentiation is mainly implemented by the teacher are scarce and often suffer from methodological limitations - most importantly small sample size and lack of a control group. Nevertheless, case studies of individual teachers and their classes (Brimijoin, 2002; Brown & Morris, 2005; Grimes & Stevens, 2009) do suggest that teachers may enhance the achievement of their students by implementing differentiation, although the generalisability of these findings may be limited due to the small sample size. In sum, there is some evidence to suggest that differentiation may promote student achievement in primary schools, especially when technological applications are used. However, there is still a need for large-scale studies in which differentiation is primarily in the hands of the teacher. While technological applications can be valuable for quantitative differentiation, teachers are still necessary for refined, qualitative diagnosis and adaptations.

1.4. Adaptive teaching competency

Teachers have an important role in enhancing student achievement: students of effective teachers achieve more (Nye, Konstantopoulos, & Hedges, 2004). According to the dynamic model of teacher effectiveness (Kyriakides, Creemers, & Antoniou, 2009), the most effective teachers distinguish themselves by the application of differentiation. Such teachers are skilled at adapting education to the needs of their students: they possess 'adaptive teaching competency' (Vogt & Rogalla, 2009). This requires extensive subject matter knowledge as well as advanced diagnostic, didactical, pedagogical, and classroom management skills (Smeets, Ledoux, Regtvoort, Felix, & Mol Lous, 2015; Vogt & Rogalla, 2009). For teachers with less-developed knowledge and skills, implementing differentiation can be difficult. Many teachers feel that initial teacher education did not sufficiently prepare them for implementing differentiation (Inspectorate of Education, 2015). Therefore, a need for PD about differentiation has been identified (Royal Dutch Academy of the Sciences, 2009; Schram, Van der Meer, & Van Os, 2013).

1.5. Differentiation in mathematics using the cycle of differentiation

Against this background, project GROW (in Dutch, this is an acronym for differentiated mathematics education) was launched with the goal of developing and evaluating an effective PD programme for differentiation in primary school mathematics. We focused exclusively on mathematics, since domain-specific guidelines may provide teachers with more concrete advice for practical application than general guidelines. To ensure strong links between theory and practice, we collaborated intensively with a consortium of educational consultants and teacher trainers with expertise in mathematics. In the first stage of the project, we sought consensus among these experts about what teachers should do in daily practice to implement differentiation successfully. This resulted in the cycle of differentiation displayed in Fig. 1 (see also Prast et al., 2015).

The cycle of differentiation starts with the identification of educational needs. First, the teacher should analyse the students' current skill level and divide the students over homogeneous achievement groups (typically low-achieving, average-achieving, and high-achieving). These achievement groups are used part of the time, besides whole-class instruction and individual practice and feedback, to cater specifically for the educational needs of the different subgroups. Students should be able to switch between groups based on changes in their educational needs (Tieso, 2003). In addition to achievement tests, ongoing and refined diagnostic measures such as the analysis of daily work and diagnostic interviews should be used to signal changes in educational needs and to determine qualitative educational needs (i.e. why a student struggles with a particular type of sums and what the student needs to overcome this problem). In the second step, the teacher sets differentiated goals which should be challenging but realistic for the students in the different subgroups (Csikszentmihalyi, 1990).