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Readiness-based differentiation in primary school mathematics: Expert recommendations and teacher self-assessment

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Abstract

The diversity of students' achievement levels within classrooms has made it essential for teachers to adapt their lessons to the varying educational needs of their students ('differentiation'). However, the term differentiation has been interpreted in diverse ways and there is a need to specify what effective differentiation entails. Previous reports of low to moderate application of differentiation underscore the importance of practical guidelines for implementing differentiation. In two studies, we investigated how teachers should differentiate according to experts, as well as the degree to which teachers already apply the recommended strategies. Study 1 employed the Delphi technique and focus group discussions to achieve consensus among eleven mathematics experts regarding a feasible model for differentiation in primary mathematics. The experts agreed on a five-step cycle of differentiation: (1) identification of educational needs, (2) differentiated goals, (3) differentiated instruction, (4) differentiated practice, and (5) evaluation of progress and process. For each step, strategies were specified. In Study 2, the Differentiation Self-Assessment Questionnaire (DSAQ) was developed to investigate how teachers self-assess their use of the strategies recommended by the experts. While teachers (N = 268) were moderately positive about their application of the strategies overall, we also identified areas of relatively low usage (including differentiation for high-achieving students) which require attention in teacher professional development. Together, these two studies provide a model and strategies for differentiation in primary mathematics based on expert consensus, the DSAQ which can be employed in future studies, and insights into teachers' self-assessed application of specific aspects of differentiation.

Keywords: differentiation; mathematics; primary school; teacher self-assessment; Delphi method

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1. Introduction

Every day, primary school teachers are faced with the task of teaching students of diverse academic ability and achievement levels. Therefore, teachers should adapt their lessons to the diverse educational needs of their students (Corno, 2008). Such adaptations are often promoted using the term *differentiation* or *differentiated instruction*, defined by Tomlinson et al. (2003, p.120) as "an approach to teaching in which teachers proactively modify curricula, teaching methods, resources, learning activities, and student products to address the diverse needs of individual students and small groups of students to maximise the learning opportunity for each student in a classroom".

The international trend towards inclusive education makes the need for differentiation especially urgent. Within response to intervention models, general education teachers are required to provide both universal support - i.e., a good general education for all students (Tier 1) - and targeted support (Tier 2) such as small-group instruction for struggling students (Fuchs & Fuchs, 2007; McLeskey & Waldron, 2011). Small-group or individual interventions carried out by an educational specialist (Tier 3) are only available for a limited number of students whose problems persist despite the supports provided by the general education teacher. Thus, general education teachers have the primary responsibility for providing a good education to all students, regardless of their achievement level.

Attending to the educational needs of students with a broad range of ability and achievement levels is a challenge for teachers. Successful differentiation requires advanced subject matter knowledge, pedagogical skills and classroom management skills (VanTassel-Baska & Stambaugh, 2005). Consequently, a need for professional development in the area of differentiation has been identified repeatedly (Johnsen, Haensly, Ryser, & Ford, 2002; Van den Broek-d'Obrenan et al., 2012; VanTassel-Baska et al., 2008).

To design effective professional development programmes, it is important to know what teachers should do in their day-to-day teaching to differentiate their lessons for students of diverse achievement levels. What constitutes best practice? In two studies, we investigated how teachers should differentiate according to experts as well as the degree to which teachers already apply the recommended strategies. The focus was exclusively on mathematics since strategies for differentiation may vary across subject areas. Moreover, domain-specific guidelines or strategies tend to be more concrete and may therefore provide stronger guidance to teachers.

Differentiation is an umbrella term that may be used to refer to one or several of a variety of instructional modifications. It may involve modifications of the content (what students learn), the process (how they learn it), or the product of learning (how students demonstrate their learning) (Tomlinson, 2005). Various student characteristics may serve as a ground for differentiation. For example, Tomlinson et al. (2003) distinguish between differentiation by student readiness (representing the current level of knowledge and skills in the subject area), learning profile (a student's preferred ways of learning, such as a preference for visual input) and interest (topics about which the student wants to learn more).

In the current study, the focus is on differentiation by student readiness. Readiness is influenced by a child's natural ability as well as learning experiences and is reflected in the child's current knowledge and skill level. The importance of differentiation by student readiness is supported by the theoretical constructs of the zone of proximal development (Vygotsky, 1978), challenge-skill balance (Csikszentmihalyi, 1990), aptitude-treatment interaction (Cronbach & Snow, 1977), and adaptive teaching (Corno, 2008). Vygotsky (1978) stated that learning occurs when a child engages in activities that fall within its zone of proximal development (ZPD), i.e. that are slightly more difficult than what the child already masters independently. When children within one classroom have widely varying readiness levels, their zones of proximal development also differ. A task that is just within reach for average-achieving students (i.e. in their ZPD) may be too difficult for children with lower readiness levels when the gap between existing knowledge and skills and the task is too big. Conversely, children with higher readiness levels may already master the task and in this case they are not challenged to reach beyond what they can already do. This implies that children within the same classroom may need different instructional treatments to work in their ZPD. To work in the

ZPD, the skill level of the students should be in balance with the difficulty level of the tasks. Such a challenge-skill balance may result in effective and engaged learning, while tasks that are much too difficult or too easy may lead to frustration, boredom, and withdrawal from learning (Csikszentmihalyi, 1990). Additionally, certain characteristics of the learning environment may be useful for some learners but not for others, depending on the aptitude of the student (Cronbach & Snow, 1977). Because of the variation in student aptitudes and the resulting diversity of educational needs, teachers should adapt education to the needs of their students (Corno, 2008). What these theories have in common is the idea that students with different readiness levels have different educational needs and that instruction should be matched to these needs, which is exactly what differentiation aims to do.

Roy, Guay, and Valois (2013) took a step towards clarification of the term differentiation by identifying two main components of readiness-based differentiation: academic progress monitoring and instructional adaptations. Ideally, the developments in students' achievement or understanding are closely followed, for example using frequent formal or informal tests, and adaptations are then made to ensure a good fit between the readiness of the student and the instruction.

Most approaches to differentiation include these two components in some way. Nevertheless, the way in which progress is monitored and the nature of instructional adaptations strongly vary across intervention studies (e.g. Brown & Morris, 2005; McDonald Connor et al., 2009; Reis, McCoach, Little, Muller, & Kaniskan, 2011; Tieso, 2005; Ysseldyke & Tardrew, 2007). Students' achievement may be measured with standardised, curriculum-based, or informal assessments. In some cases, the results of these assessments are used to determine the instructional treatment for an extended period of time (weeks or months) whereas other interventions continuously monitor progress and adapt the instructional treatment accordingly. Adaptations may be at the level of individual students or subgroups of students. When grouping is used, such groups may be between-class or within-class, fixed or flexible (Tieso, 2003). Adaptations may entail modification of the amount of instruction, the content or type of instruction, the content or type of independent practice tasks, or combinations of these elements. Given the diverse interpretations of the term differentiation, there is a need to specify what effective differentiation entails.

One line of research has examined the effects of various types of ability grouping. The best results are obtained when students can switch between groups based on changes in their educational needs (the progress monitoring component of differentiation) and when instruction is tailored to the needs of the students in the groups (the instructional adaptations component) (Kulik & Kulik, 1992; Lou et al., 1996; Slavin, 1987; Tieso, 2003). When these conditions are met, homogeneous within-class ability grouping has demonstrated positive effects on student achievement across multiple studies (Kulik & Kulik, 1992; Lou et al., 1996; Slavin, 1987; Tieso, 2005). 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). So, it seems to be important to use the grouping arrangement as a means to provide the different subgroups with the instruction that they specifically need, i.e. to differentiate instruction. Another issue in the literature on ability grouping is the potential existence of differential effects, i.e. different effects for students of different ability levels. While Slavin (1987) reported a higher median effect size for low-ability students than for average-ability and high-ability students, other reviews have found different patterns with smaller or even negative effects for low-achieving students (Deunk et al., 2015; Kulik & Kulik, 1992; Lou et al., 1996). More research is necessary to determine in which situations such differential effects may arise.

A recent review (Deunk et al., 2015) examined the effects of various readiness-based differentiation practices on student achievement. Although the authors aimed to include all high-quality studies published about this topic since 1995, only sixteen studies about differentiation in primary school could be included. Most of these sixteen studies were either too narrow (ability grouping without explicit instructional differentiation) or too broad (interventions in which differentiation was one of several components of a comprehensive school reform initiative) to be informative about the effects of differentiation on student achievement. However, promising results were obtained with two computerised interventions for differentiation: Individualizing Student Instruction (McDonald Connor, Morrison, Fishman, Schatschneider, & Underwood, 2007; McDonald Connor et al., 2011a; McDonald Connor et al., 2011b) and Accelerated Math (Ysseldyke et al., 2003; Ysseldyke & Bolt, 2007). The Individualizing Student Instruction programme 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 is a technological application which continuously monitors students' progress, adapts practice tasks to students' individual skill level, and informs the teacher when students struggle with certain types of problems. Both of these interventions, which clearly contain both components of differentiation (progress monitoring and instructional adaptations), have demonstrated significant positive effects across multiple studies.

Prior research has shown that there is room for improvement in teachers' implementation of differentiation. The Dutch Inspectorate of Education recently found that adequate adaptations to diverse educational needs are only made at about half of the schools (Van den Broek-d'Obrenan et al., 2012). In US middle schools, both teachers and students reported low usage of differentiation strategies (Moon, Callahan, Tomlinson, & Miller, 2002). In a recent study on Canadian elementary schools, teachers self-reported moderate use of differentiation strategies, but strategies requiring more time to implement were used relatively infrequently (Roy et al., 2013). Similarly, studies about adaptations for students with learning disabilities found that teachers tend to implement *typical* adaptations which can be easily implemented for all students rather than *specialised* adaptations, i.e. adaptations targeted at the unique educational needs of individual students (McLeskey & Waldron, 2002, 2011; Scott, Vitale, & Masten, 1998). However, a recent study carried out in Finland found that teachers do provide more individual support to struggling students (Nurmi et al., 2013). For high-achieving or gifted students, low levels of differentiation have generally been found (Reis et al., 2004; Westberg, Archambault, Dobyns, & Salvin, 1993; Westberg & Daoust, 2003). In sum, prior studies have generally found low to moderate use of differentiation strategies, although the degree of implementation of differentiation seems to vary depending on the specific strategies for differentiation examined, the targeted population of students, and perhaps also the country in which data are collected. Specialised adaptations as well as adaptations targeted specifically at high-achieving students seem to be used relatively infrequently.

In conclusion, there is a clear need to apply differentiation based on differences in students' readiness and teachers could use some help in doing this. The literature shows that differentiation should include progress monitoring and instructional adaptations. However, the ways in which this can be done effectively are less clear. Promising results have been obtained with two computerised interventions. However, high-quality research about the achievement effects of interventions in which differentiation is mainly implemented by the teacher himself is scarce. There is a need for general guidelines for differentiation that can be applied in a wide array of schools, independently from curricular methods or technological applications. Therefore, Study 1 sought to achieve consensus among a consortium of mathematics experts about a feasible model and associated strategies for differentiation. Study 2 linked the results of Study 1 to teachers' daily practice by examining how teachers self-assess their use of the strategies for differentiation recommended by the experts.

2. Study 1

2.1 Aims Study 1

The aim of Study 1 was to operationalise the concept of differentiation by achieving consensus among a consortium of mathematics experts about a coherent set of strategies for differentiating primary school mathematics education. The result of the consensus procedure needed to be feasible for use by general education teachers in daily mathematics teaching. Additionally, it needed to be applicable in diverse schools, independent from curricular method.

Expert consensus procedures can be valuable when scientific literature provides insufficient information to make complex decisions (Landeta, 2006) and have been applied before to achieve consensus about effective teaching (Teddlie, Creemers, Kyriakides, Muijs, & Yu, 2006). While several individual experts have made recommendations for differentiation in primary mathematics in books and journals for practitioners, consensus among various experts could provide a more solid foundation. For differentiation in mathematics, teacher educators with expertise in the didactics of primary mathematics are the relevant group of experts. Teacher educators may have gained practical knowledge regarding the effectivity and feasibility of diverse strategies for differentiation. Making use of this experiential knowledge has the potential to complement the scientific literature and strengthen the link between theory and practice.

2.2 Method Study 1

2.2.1 Participants

The consortium of experts was designed to include distinguished Dutch pre-service and in-service teacher educators with a professional focus on mathematics education. To be eligible for participation, potential members had to be experts in their field, as demonstrated by their (1) experience in providing pre-service or in-service teacher training about teaching mathematics (2) regular presence as invited speaker at educational conferences and (3) role as a consultant to the Ministry of Education, Culture and Science to discuss new educational policy. The senior authors approached potential candidates with these criteria in mind. All experts who were invited to participate agreed to join the consortium.

This resulted in a consortium of eleven experts (seven men, four women) representing eight large national and regional institutes for pre- and in-service teacher training spread across the Netherlands. The members had experience in at least two of the following areas: in-service teacher training for mathematics (M = 8.6 years, SD = 8.5 years), pre-service teacher training for mathematics (M = 5.4 years, SD = 6.3 years), carrying out educational evaluation studies (M = 25.0 years, SD = 21.2 years) and teaching (M = 5.7 years, SD = 5.4 years). The current daily work of the consortium members included educating pre-service teachers, providing professional development for in-service teachers, and guiding schools in the implementation of new educational approaches including differentiation.

2.2.2 Consensus procedure

Focus group discussions (Liamputtong, 2011) and the Delphi method (Hasson, Keeney, & McKenna, 2000) were used to investigate the experiential knowledge of the experts on differentiated mathematics education systematically. Focus group discussions are structured discussions with a group of persons involved in the topic in which certain roles (e.g. a discussion leader, a timekeeper and a secretary) and rules (e.g. only on-topic contributions) are specified and adhered to. The Delphi technique entails the repeated administration of a questionnaire in order to achieve consensus among experts. After the first round of administration, the initial responses are presented anonymously to the participants, who are then asked to fill out the questionnaire again. This procedure is repeated until consensus (specified with a consensus criterion) is reached. The order of focus group discussions and Delphi rounds in the current study is presented in Figure 1. The whole procedure took place between November 2011 and January 2012.

In the first three-hour focus group discussion, the experts were invited to share their knowledge, prompted by eight core questions about differentiation (see Figure 1). These questions were deliberately left open to elicit broad input. No particular theoretical perspective was chosen a priori apart from the assumption that student readiness would be an important ground for differentiation (see questions 6 and 7). Rather, the questions were asked from a practical point of view (what does and does not work in practice and how can this be improved). In principle, the questions were discussed one by one in the listed order, but in practice, the discussion sometimes moved back and forth between the various questions because of their high interrelatedness. After the first focus group discussion, the first author restructured the meeting minutes in terms of (initial) answers to the eight core questions.

Second, based on this input, the researchers constructed an online Delphi questionnaire (Round 1). During the first focus group discussion, one of the experts had listed five general themes that are central to differentiation: organisation, goals, instruction, practice, and learning styles. These themes were used to structure the Delphi questionnaire. The theme 'differentiation in kindergarten' was added to account for aspects of differentiation specific to kindergarten (kindergarten is integrated in the Dutch primary school system). For each theme, the first author summarised the main ideas of the focus group discussion and proposed this to the other authors. Apart from some minor changes, the other authors agreed that these summaries accurately reflected what had been said in the discussion. These summaries were included in the Delphi questionnaire as one-paragraph concepts for differentiation (see Appendix 1). For each theme, statements about specific elements of the concept were also included (for example: 'the low-achieving subgroup profits from extended instruction'). The experts rated their agreement with the concepts and with the specific statements on a Likert scale ranging from 1 (*do not agree at all*) to 5 (*fully agree*). Additionally, open questions prompted participants to provide any comments they had.

Third, a Round 2 Delphi questionnaire was developed which included only those questions on which no overwhelming consensus had been reached in Round 1. The consensus criterion for Round 1 was that all responses should be at one end of the scale (i.e. either 4 and 5 or 1 and 2), with a maximum of one neutral response (3). The questions on which consensus had not yet been reached were presented to the participants again accompanied by a bar chart of the responses in Round 1. Additionally, comments provided by the participants in Round 1 were included as new questions in Round 2. Using a more lenient consensus criterion of maximally three neutral responses and the rest at one end of the scale, the researchers determined for which items consensus was achieved in Round 2.

Fourth, the researchers presented the results of the Delphi questionnaire to the experts during the second focus group discussion which lasted two hours. The items on which consensus had not been achieved were discussed to clarify misunderstandings (especially about the open comments provided by the participants in Round 1) and resolve conflicting opinions.

Fifth, the first author reviewed the meeting minutes of the focus group discussions and the responses to the Delphi questionnaire to synthesise the input, resulting in a proposed model for implementing differentiation. The other authors agreed with this model.

Sixth, the proposed model for differentiation was sent to all consortium members and discussed during a third one-hour meeting of the focus group.

2.2.3 Attendance rates of consortium members

Of the eleven consultants, six (54.5%) attended the first two focus group discussions and completed the two Delphi questionnaires and four (36.4%) completed three out of four components (i.e. either both discussions and one questionnaire or both questionnaires and one discussion). One participant only completed the Delphi questionnaire, after being informed about the content of the first focus group discussion in a separate meeting with the researchers. All members received the proposed model for differentiation by email and were given the opportunity to send any comments or questions, and six participants (54.5%) attended the third meeting in which the cycle was discussed.

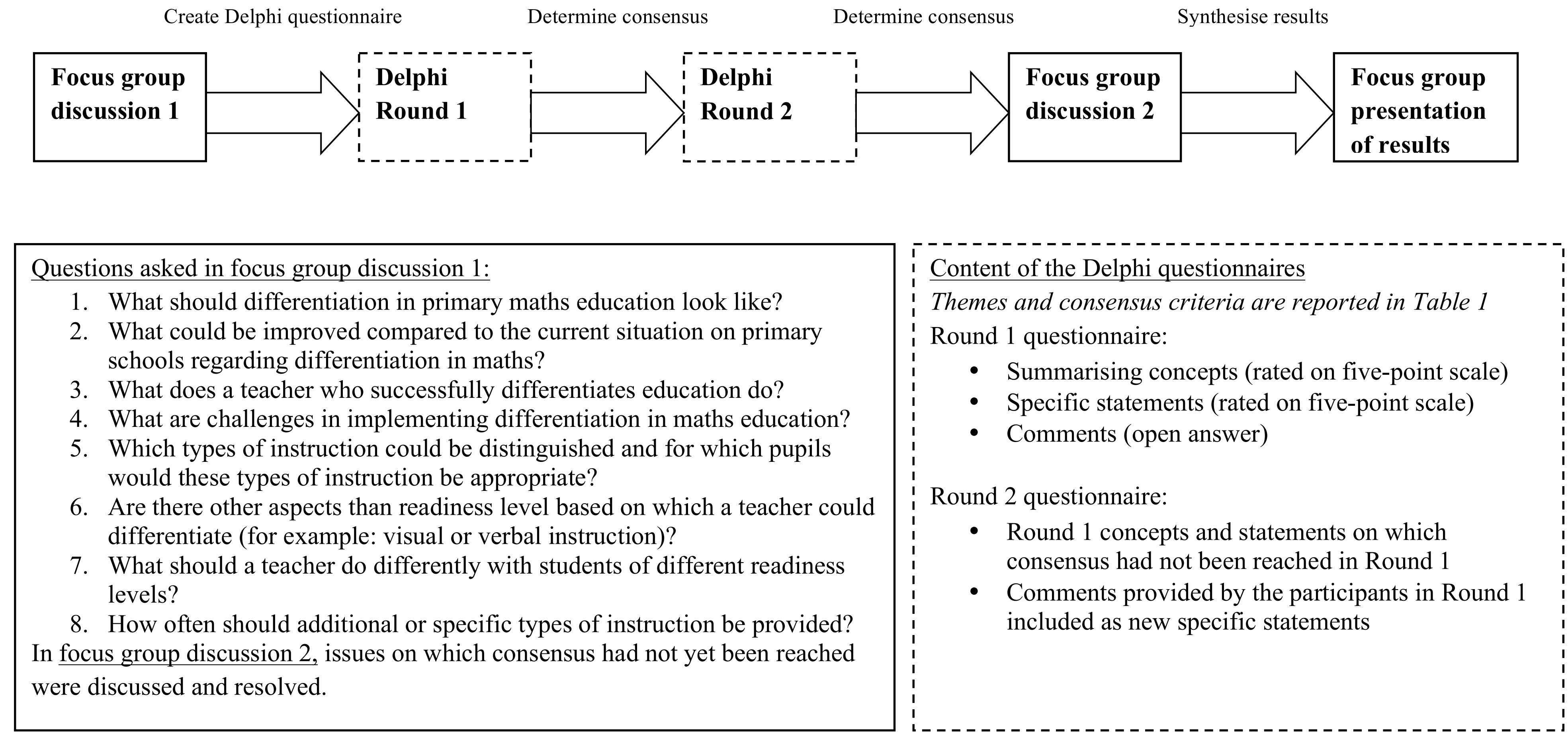

Figure 1. Consensus procedure.

2.3 Results Study 1

In Round 1 of the Delphi questionnaire, the experts agreed with the concepts for differentiation in instruction, differentiated goals, differentiated practice, differentiation based on learning styles, and differentiation in kindergarten which had been formulated based on the first focus group discussion. Positive consensus on the remaining concept (organisation of differentiation) was reached in Round 2. Table 1 provides an overview of the degree of consensus achieved on the specific statements in the two rounds of the Delphi questionnaire. Consensus was reached on 35 items in the first round and on an additional 25 original items in the second round, amounting to consensus on 74.1% of original items after two rounds. Regarding the new statements that were derived from the open comments in Round 1, consensus was reached on 46.0% of these statements in Round 2. The items on which consensus had not been reached after the second Delphi questionnaire were discussed in the second focus group discussion. Differences in interpretation of certain items were resolved and consensus was reached about the main issues. Items on which no consensus had been reached in the Delphi questionnaires often concerned issues about which the experts were unsure or had no pronounced opinion, including the importance of specific elements (e.g. videotaped instruction, mind maps, games, student choice) and preference for certain grouping formats (e.g. pairs or small groups). In the second focus group discussion, the overall conclusion about these elements and formats was that they all have their merits and that the choice is dependent on the situation, but that they are not crucial for differentiation.

Table 1

Overview of consensus on statements in the Delphi questionnaire

		Original statements			New statements in Round 2	
Theme	Subtheme	No. of statements	Consensus after Round 1	Consensus after Round 2[a]	No. of statements	Consensus after Round 2
Organisation of differentiation		11	4	7	14	2
Differentiation in instruction						
	General	5	3	4	14	4
	Whole-class instruction	9	2	6	10	6
	Subgroup instruction for low-achieving students	10	3	8	7	3
	Subgroup instruction for high-achieving students	12	6	8	4	3
Differentiated goals		10	4	8	23	10
Differentiated practice		14	5	9	6	3
Differentiation based on learning styles		3	1	3	25	15
Differentiation in kindergarten		7	7	7	10	6
Total		81	35	60	113	52

[a] total amount of items on which consensus was reached, including items on which consensus had already been reached in Round 1

The experts approved the model for differentiation which was created based on their input. The model, dubbed the *cycle of differentiation*, consists of the following five steps: identification of educational needs, differentiated goals, differentiated instruction, differentiated practice, and evaluation of progress and process (see Figure 2). A distinction is made between instruction and practice. Instruction refers to moments during which the teacher provides instruction to the whole class, subgroups of students, or individual students, whereas practice refers to moments during which students work on tasks, individually or in groups.

These two can happen simultaneously, for example when the teacher provides instruction to a subgroup while other students are working on practice tasks. In the following paragraphs, we describe the key recommendations for each step in the cycle of differentiation provided by the experts in the consensus procedure.

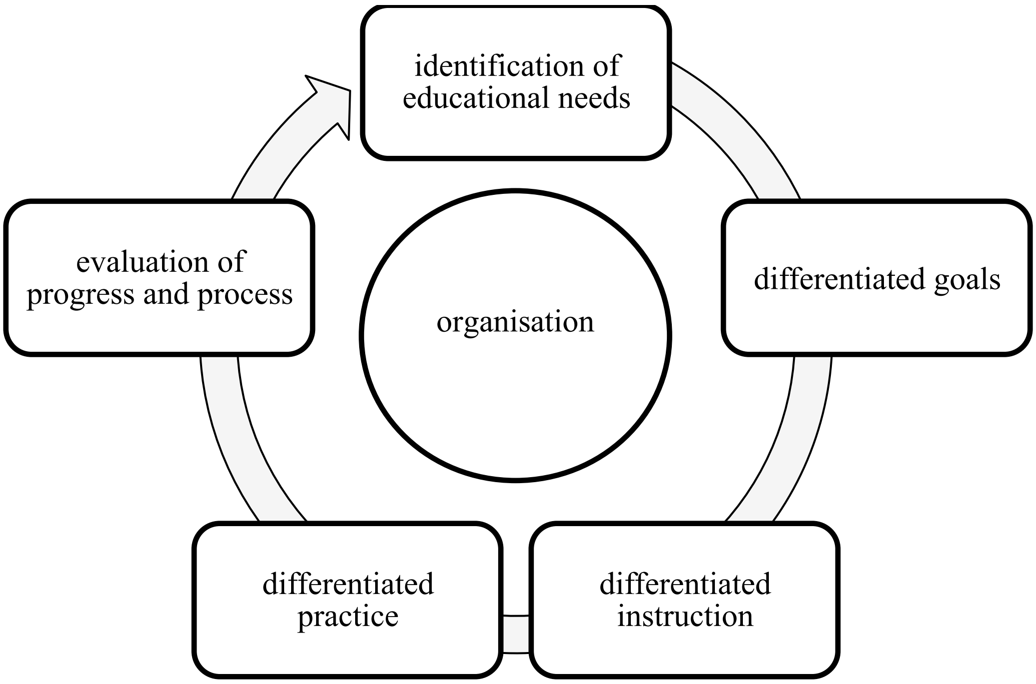

Figure 2. Cycle of differentiation.

Organisation is placed centrally in the cycle, because successful implementation of differentiation depends on a facilitative organisational structure and good classroom management. A key organisational characteristic of the model for differentiation agreed upon by the experts is the assignment of students to subgroups based on achievement level, allowing teachers to make instructional adaptations for subgroups of students with similar educational needs. Only the remaining individual educational needs that are not met within the subgroup call for individual accommodations.

The first step in the cycle of differentiation is the identification of educational needs. Initially, the teacher should assign students to subgroups (typically a low-achieving, an average-achieving and a high-achieving subgroup) based on their results on standardised tests and curriculum-based tests. In the course of the schoolyear, teachers continuously gather new and more detailed information about students' educational needs, for example with the analysis of daily work, informal observations and diagnostic conversations. The subgroups should be flexible, i.e. students should be able to switch groups based on changes in their educational needs.

Based on the educational needs of the students, differentiated goals should be set. Overarching objectives (the material that students should master at the end of primary school) and lesson goals (goals for a specific lesson) are distinguished. Overarching objectives should not only be formulated for average-achieving students but also specifically for low-achieving and high-achieving students (see also Appendix 1, differentiation in goals). The overarching objectives should be translated into concrete lesson goals, which are provided mostly by the curriculum. However, only some of the mathematics curricula available in the Netherlands differentiate lesson goals for three achievement levels. When the curriculum does not differentiate goals sufficiently, the teacher should formulate challenging but realistic lesson goals for all subgroups.

Based on the educational needs and the goals that have been set, the teacher differentiates instruction through broad whole-class instruction, subgroup instruction tailored to the needs of that subgroup, and individual adaptations. During whole-class instruction, the teacher should serve a broad range of educational needs by varying the difficulty level of questions, stimulating all children to think about the answer to a question by giving thinking time, teaching at various levels of abstraction, and using several input modalities (e.g. visual, verbal, tactile). In subgroup instruction, the teacher should adapt instruction to the educational needs of low-achieving and high-achieving students. It is assumed that, in general, low-achieving students need more guidance (e.g. explicit instruction) and instruction at lower levels of abstraction (e.g. using blocks to represent and calculate a sum) while high-achieving students need more exploratory instruction about advanced content with a focus on conceptual understanding (e.g. the relation between multiplication and division). To the extent possible, the teacher should also take into account individual differences during subgroup instruction and while giving individual feedback.

In the practice phase of the lesson, the subgroups need quantitatively and qualitatively different tasks. For the low-achieving subgroup, completing all regular tasks is often not realistic, so the tasks that are crucial for mastery of the objectives for low-achieving students should be selected (the remaining tasks can still be completed when students have time left). For the high-achieving subgroup, the regular material should be compacted. For the most popular Dutch mathematics curricula, guidelines exist to inform the teacher which tasks can be skipped by high-achieving students. In other cases, the teacher should remove most of the repetitive tasks and select the tasks that are crucial steps towards mastery of the objectives. The time freed up by compacting should be spent on enrichment. Some curricula provide enrichment tasks and these tasks can be used in some cases, but they are often not sufficiently challenging for very high-achieving students. Therefore, supplemental enrichment curricula should also be used. Technological applications such as mathematics websites and instructional computer programmes can also be valuable tools for individual differentiation, provided that they are used deliberately for additional practice in areas the student does not master yet or for enrichment at an appropriate challenge level.

The final step in the cycle of differentiation is the evaluation of progress and learning process. Based on daily work and achievement tests, the teacher should evaluate whether the students have met the lesson goals. Regarding process, the teacher should evaluate whether the applied adaptations of instruction and practice had the desired effect. For example, when a teacher has intentionally taught the low-achieving subgroup at a lower level of abstraction, the teacher should evaluate whether this was helpful for these students. To gauge the effectiveness of the accommodations made, the teacher may supplement achievement results with informal measures such as observations or diagnostic conversations. The evaluation phase informs the teacher about students' current achievement level and about instructional approaches that work for these students, completing the cycle and serving as new input for the identification of educational needs.

2.4 Concluding summary Study 1

The aim of Study 1 was to operationalise the concept of differentiation by achieving consensus among a consortium of mathematics experts about a coherent set of strategies for differentiating primary school mathematics education. A combination of focus group discussions and the Delphi technique was used to investigate the experiential knowledge of eleven experts in mathematics education systematically. Consensus was reached on all summarising concepts and on the majority of specific statements from the Delphi questionnaire. The input from the experts was synthesised into a cycle of differentiation consisting of the following five steps: identification of educational needs, differentiated goals, differentiated instruction, differentiated practice, and evaluation of learning progress and process. For each step, strategies were specified, providing teachers with concrete guidelines for implementing differentiation in primary school mathematics.

3. Study 2

3.1 Aims Study 2

Study 2 linked the results of Study 1 to teachers' daily practice by investigating teachers' self-assessed use of the strategies for differentiation recommended by the experts. Therefore, we developed the Differentiation Self-Assessment Questionnaire (DSAQ) which covers the recommended strategies in five subscales corresponding with the five steps of the cycle of differentiation (see also section 3.2.2). Since the DSAQ was newly developed, we also aimed to investigate its statistical properties, including its factor structure and relation with other scales.

The development of a new instrument was necessary to ensure coverage of the broad set of strategies recommended by the experts in Study 1. Another recently developed instrument to measure teachers' self-reported use of differentiation is the Differentiated Instruction Scale (DIS; Roy et al., 2013). This instrument was based on a similar theoretical framework and there is overlap between the content of the items of the DIS and the DSAQ. However, the DIS has only twelve items and is not sufficiently specific to measure all strategies recommended by the experts. Regarding progress monitoring, for example, the DIS includes the rather general item 'analyse data about students' academic progress' while the DSAQ distinguishes between the different types of progress monitoring recommended by the experts, ranging from standardised tests to diagnostic interviews. Thus, the added value of the DSAQ is that it is a detailed measure of the specific strategies recommended by the experts in Study 1.

The first aim of the current study was to examine the factor structure of the DSAQ. The literature reviewed in the introduction indicates that effective differentiation entails two components: progress monitoring and instructional adaptations. The steps in the cycle of differentiation reflect these components: identification of educational needs and evaluation of progress and process involve progress monitoring, while differentiated goals, instruction, and practice involve instructional adaptations. For the DIS, Roy et al. (2013) found that a model with these two factors provided a better fit to the data than a model in which all items loaded on one general differentiation factor. Therefore, we investigated whether the DSAQ has a similar factor structure by comparing the fit of a two-factor model with one factor for progress monitoring and one factor for instructional adaptations to the fit of a one-factor model.

The second aim was to examine the convergent and divergent validity of the DSAQ by investigating its relationship with other teacher self-report scales. Teacher self-efficacy is a multidimensional construct which comprises teachers' perceived ability to perform various aspects of teaching (Skaalvik & Skaalvik, 2007; Tschannen-Moran & Woolfolk Hoy, 2001). Theoretically, self-assessed usage of differentiation as measured by the DSAQ should be more closely related to aspects of self-efficacy related to differentiation than to other aspects of teacher self-efficacy. Specifically, we expected stronger correlations with scales that measure teachers' self-efficacy for instruction to students of diverse achievement levels, for adapting education to individual students' needs, and for self-assessed prerequisite knowledge for differentiation (which would support convergent validity) than with scales that measure teachers' self-efficacy for motivating students, for coping with changes and challenges, and for classroom management (which would support divergent validity).

The third and main aim was to investigate teachers' self-assessed use of the strategies for differentiation recommended by the experts. Besides examining teachers' overall usage, we also aimed to identify strategies which were relatively infrequently used. Such information may provide starting points for teacher professional development by indicating in which areas teachers perceive most room for improvement. Based on the literature reviewed in the theoretical background as well as on the input from the experts in Study 1, we hypothesised that average scores would be low to moderate and that specialised strategies aimed at individual students' unique educational needs as well as strategies targeted specifically at high-achieving students would be used relatively infrequently.

3.2 Method Study 2

3.2.1 Participants and procedure

The sample consisted of 268 primary school teachers working at 31 schools participating in a large-scale project about differentiation. Schools were informed about the project through flyers and advertisements and could register themselves for participation on a project website. The schools were located in rural and urban areas spread across the Netherlands and were diverse in terms of school size, student population, religious background, and mathematics curriculum used. All 325 teachers of Grade 1 through 6 of the participating schools were invited by email to fill out an online questionnaire containing the DSAQ and related scales. The questionnaire was administered at the beginning of the 2012 - 2013 school year. A total of 268 teachers (83%) completed the questionnaire and gave informed consent. The remaining teachers did not give informed consent (n = 3), completed the questionnaire only partly (n = 7) or did not respond at all (n = 47). On average, participants had 15.6 years of teaching experience (range 0 – 40 years). Seventy-one teachers (26%) taught a multigrade class. Fifty-four teachers (20%) worked full-time, whereas most teachers worked two, three or four days a week (61, 81 and 55 teachers respectively).

3.2.2 Instruments

The DSAQ was developed to examine how teachers assess their use of the strategies recommended by the experts in Study 1. Each subscale represents one step of the cycle of differentiation and covers core strategies for differentiation belonging to that step. Subscales and sample items are provided in Table 2. Organisational aspects of the model for differentiation were not captured in a separate scale but were partly covered in the subscales corresponding to each step of the cycle. In an earlier pilot study, a pilot version of the DSAQ had been completed by 27 teachers recruited at four schools. Based on the analysis of the internal consistency of the pilot version, which was acceptable to good, some adaptations were made in the final version of the DSAQ. The internal consistency of the final version, obtained in the current sample (N = 268), is reported in section 3.3.1.

To assess the convergent and divergent validity of the DSAQ, subscales from two well-established multidimensional teacher self-efficacy scales were selected. The Norwegian Teacher Self-Efficacy Scale (Skaalvik & Skaalvik, 2007) was developed with special attention for adapting education to individual educational needs. It consists of six subscales with acceptable to good internal consistency which load on six primary factors, which in turn load on a second-order factor for general teacher self-efficacy (Skaalvik & Skaalvik, 2007). For the current study, the subscales for Instruction - which emphasises instruction to students of diverse achievement levels - and Adapting Education to Individual Students' Needs[1] were selected to assess the convergent validity of the DSAQ while the subscales for Motivating Students and for Coping with Changes and Challenges were selected to assess the divergent validity. The subscales were translated into Dutch and the wording was adapted to make the items domain-specific for mathematics instruction.

To further examine the divergent validity, the subscale for classroom management from the well-established Ohio State Teaching Efficacy Scale (OSTES; Tschannen-Moran & Woolfolk Hoy, 2001) was administered in Dutch translation (Goei, Bekebrede, & Bosma, 2011). The OSTES consists of three subscales which load on a first-order factor and on a general teaching efficacy factor. The subscales have demonstrated high internal consistency and can be used independently with in-service teachers (Tschannen-Moran & Woolfolk Hoy, 2001).

As a third potential support for convergent validity, a self-assessment scale about Prerequisite Knowledge for Differentiation was adapted from an informal scale that had already been used to assess the

[1] Compared to the four-item NTSES subscale for Adapting Instruction to Individual Students' Needs, the added value of the DSAQ is that it provides a more detailed measure of self-assessed use of a range of differentiation strategies.

level of prior knowledge in professional development programmes (Nationaal Expertisecentrum Leerplanontwikkeling, 2010). Teachers self-assess the extent to which they already possess the knowledge necessary for implementing differentiated instruction.

3.2.3 Analyses

Because we wanted to compare the fit of two specific models based on theory and previous findings, we used confirmatory factor analysis (CFA) to investigate the factor structure of the DSAQ. We first tested a one-factor model in which all DSAQ subscales loaded on one general differentiation factor. Second, we tested a two-factor model with one factor for progress monitoring (subscales Identification of Educational Needs and Evaluation of Progress and Process) and one factor for instructional adaptations (subscales Differentiated Goals, Differentiated Instruction and Differentiated Practice). Version 7.3 of the Mplus statistical package (Muthén & Muthén, 1998-2012) was used. Model fit was evaluated with the chi-square statistic, the comparative fit index (CFI), the Tucker-Lewis Index (TLI), the root mean squared error of approximation (RMSEA), and the standardised root mean square residual (SRMR). Values above .95 for the CFI and TLI and values below .06 and .08 for the RMSEA and SRMR, respectively, indicate good model fit (Hu & Bentler, 1999). The maximum likelihood estimator was used. In the standardised solution, the variance of the factors was fixed to 1 so all factor loadings could be estimated freely.

Correlational analyses were performed to assess the convergent and divergent validity of the DSAQ. We expected moderate to strong positive correlations with Prerequisite Knowledge for Differentiation, Adapting Education to Individual Students' Needs, and Instruction (for students of all achievement levels). For the latter two scales, we expected that correlations would be lower for the factor Progress Monitoring than for the factor Instructional Adaptations, because Progress Monitoring does not focus on the instructional phase. Regarding divergent validity, we hypothesised that DSAQ scores would be less strongly related to self-efficacy for Motivating Students, Coping with Changes and Challenges, and Classroom Management, although we still expected positive correlations because these dimensions of teacher self-efficacy can be helpful when implementing differentiation.

To identify areas of relatively low use, we compared the means of all single items to the mean of their factor. If a mean was more than one standard deviation below the mean of the factor, it was classified as relatively low.

Table 2

Sample items and descriptive statistics (N = 268) of the administered scales

Scale	Sample item	Response options	No. of items	α	*M*	*SD*
DSAQ						
Identification of educational needs[a]	I analyse the answers on curriculum-based tests to assess a student's educational needs	1 = does not apply to me at all, 5 = fully applies to me	5	.69	3.64	.55
Differentiated goals[a]	I set extra challenging goals for high-achieving students	1 – 5 as above	6	.79	3.78	.55
Differentiated instruction[a]	I adapt the level of abstraction of my instruction to the educational needs of the students	1 – 5 as above	7	.72	3.81	.42
Differentiated practice[a]	I select the most important elaboration activities for very low-achieving students	1 – 5 as above	8	.72	3.46	.55
Evaluation of progress and process[a]	I use diagnostic conversations to evaluate whether specific students have met the lesson goals	1 – 5 as above	7	.86	3.56	.57
Additional scales						
Instruction[b]	How certain are you that you can explain central themes in mathematics so that even the low-achieving students understand?	1 = not certain at all, 4 = absolutely certain	4	.74	3.13	.37
Adapting education to individual students' needs[b]	How certain are you that you can adapt instruction to the needs of low-achieving students while you also attend to the needs of other students in class?	1 - 4 as above	4	.78	2.91	.44
Coping with changes and challenges[b]	How certain are you that you can manage instruction regardless of how it is organised (working with subgroups, multigrade classes with 3 grades, etc.)?	1 - 4 as above	4	.76	2.99	.43
Motivating students[b]	How certain are you that you can get students to do their best even when working with difficult problems?	1 - 4 as above	4	.76	2.95	.42
Classroom management[c]	How much can you do to control disruptive behavior in the classroom?	1 = nothing, 9 = very much	7	.92	7.17	.77
Prerequisite knowledge for differentiation[d]	I know the different solution strategies that are used by children	1 = does not apply to me at all, 5 = fully applies to me	10	.84	3.79	.41

[a] Newly deloped DSAQ-scales [b] Adapted from Skaalvik and Skaalvik (2007) [c] Taken from Goei, Bekebrede, and Bosma (2011) [d] Adapted from Nationaal Expertisecentrum Leerplanontwikkeling (2010)

3.3 Results Study 2

3.3.1 Properties of the DSAQ: internal consistency and factor structure

As reported in Table 2, the internal consistencies of the DSAQ subscales were acceptable to good (Streiner, 2003).

The results of the confirmatory factor analysis indicate that the one-factor model in which all five subscales loaded on a general differentiation factor did not fit the data well: $\chi^2(5) = 55.126$, $p < .001$; RMSEA = .193 (90% CI .149 - .241); CFI = .912; TLI = .824; SRMR = .050. The two-factor model had a good fit: $\chi^2(4) = 5.637$, $p = .228$; RMSEA = .039 (90% CI .000 - .107); CFI = .997; TLI = .993; SRMR = .017. For the factor Progress Monitoring, standardised factor loadings were .84 (SE = 0.03, R^2 = .71) for Identification of Educational Needs and .85 (SE = 0.03, R^2 = .73) for Evaluation of Progress and Process. For the factor Instructional Adaptations, standardised factor loadings were .77 (SE = .04, R^2 = .59) for Differentiated Goals, .75 (SE = .04, R^2 = .56) for Differentiated Instruction, and .74 (SE = .04, R^2 = .54) for Differentiated Practice ($p < .001$ for all factor loadings). The correlation between the factors was .78 ($p < .001$). Since the two-factor model provided a better fit, the two factor scores (average of the subscale scores comprising that factor) were used in subsequent analyses.

3.3.2 Convergent and divergent validity: correlations with other scales

The correlations between the two DSAQ factors and related scales are reported in Table 3. In support of convergent validity, the correlation with Prerequisite Knowledge for Differentiation was strong for both factors. As hypothesised, correlations with self-efficacy for Instruction and self-efficacy for Adapting Education to Individual Students' Needs were moderate to strong for the factor Instructional Adaptations and somewhat lower for Progress Monitoring. Regarding divergent validity, the correlations with Motivating Students and Classroom Management were less strong, although still in the moderate range. Contrary to expectations, Coping with Changes and Challenges correlated strongly with the factor Instructional Adaptations.

Table 3

Correlations (p < .001) between DSAQ factor scores and related scales

Scale	Progress Monitoring		Instructional Adaptations	
	r	95% CI	*r*	95% CI
Selected for convergent validity				
Prerequisite knowledge for differentiation	.62	.54 - .68	.70	.64 - .76
Instruction (to students of all achievement levels)	.40	.30 - .49	.47	.37 - .56
Adapting education to individual students' needs	.38	.28 - .48	.56	.48 - .64
Selected for divergent validity				
Motivating students	.30	.19 - .40	.37	.27 - .47
Classroom management	.34	.23 - .44	.40	.30 - .50
Coping with changes and challenges	.42	.31 - .52	.58	.49 - .65

3.3.3 Distribution of DSAQ scores: mean scores and infrequently reported strategies

The mean factor scores were 3.60 (SD = 0.52) for Progress Monitoring and 3.68 (SD = 0.43) for Instructional Adaptations. With a range from 1.83 to 4.86 for Progress Monitoring and from 2.45 to 4.94 for Instructional Adaptations, the factor scores were normally distributed at the high end of the scale. Table 2 provides the means and standard deviations of all subscales. Taken together, the mean factor and subscale scores reflect moderate to high self-assessed use of differentiation strategies.

Table 4 provides the means and standard deviations for each item of the DSAQ. Five items - numbers 3.7, 4.2, 4.4, 4.8, and 5.5 - had a mean score at least one standard deviation below the mean of their factor. Two of these - the use of diagnostic conversations to evaluate whether the learning goals have been met and the adaptation of type of practice to students' needs - reflect specialised strategies because they involve the refined diagnosis of and adaptation to individual students' needs. Other specialised strategies (items 1.5 and 5.7) also had somewhat lower means, although these means were within one standard deviation of the factor mean. The three remaining infrequently reported items concerned adaptations for high-achieving students, namely additional on-level instruction or guidance, curriculum compacting, and the use of computer programmes for additional challenge. Nevertheless, two other strategies targeted at high-achieving students (items 2.5 and 4.5) were frequently reported.

Table 4

Means and standard deviations of DSAQ items (scale range 1 - 5)

DSAQ item	*M*	*SD*
Subscale 1: Identification of educational needs		
1.1 I analyse the answers on curriculum-based tests to assess a student's educational needs	4.02	0.77
1.2 I analyse the answers on standardised tests to assess a student's educational needs	3.49	0.91
1.3 I assess specific students' educational needs based on daily maths work	3.75	0.72
1.4 I assess specific students' educational needs based on (informal) observations during the maths lesson	3.76	0.77
1.5 If necessary, I conduct diagnostic conversations to analyse the educational needs of specific students	3.20	0.90
Subscale 2: Differentiated goals		
2.1 I set different goals for the children, dependent on their achievement level	3.62	0.79
2.2 I set extra challenging goals for high-achieving students	3.57	0.83
2.3 I set well-considered minimum goals for very low-achieving students	3.75	0.76
2.4 I know the opportunities for differentiation offered by the curriculum	4.03	0.68
2.5 I use the opportunities the curriculum offers for differentiation for high-achieving students	3.88	0.84
2.6 I use the opportunities the curriculum offers for differentiation for low-achieving students	3.83	0.82
Subscale 3: Differentiated instruction		
3.1 I adapt the level of abstraction of instruction to the needs of the students	3.95	0.55
3.2 I adapt the modality of instruction (visual, verbal, manipulative) to the needs of the students	3.82	0.62
3.3 I adapt the pace of instruction to the needs of the students	3.95	0.56
3.4 I deliberately ask open-ended questions during whole-class instruction	3.82	0.67
3.5 I deliberately ask questions at various difficulty levels during whole-class instruction	3.69	0.73
3.6 I regularly provide low-achieving children with additional instruction (extended instruction, pre-teaching)	4.25	0.64
3.7 I regularly provide high-achieving students with additional instruction or guidance at their level, in a group or individually	3.20	0.92

Table 4 (continued)

DSAQ item	*M*	*SD*
Subscale 4: Differentiated practice		
4.1 I vary different types of practice during the maths lesson (e.g. individual or group work, solution spoken, written or drawn)	3.53	0.78
4.2 I adjust different types of practice to the needs of the students in the classroom (e.g. having a specific child complete exercises on the computer because this child learns more in this way)	3.04	0.83
4.3 I select the most important tasks for very low-achieving students	3.73	0.73
4.4 I use curriculum compacting for high-achieving students	3.20	1.25
4.5 I provide high-achieving students with enrichment tasks	4.00	0.87
4.6 I also use computer programmes or maths websites in my maths lessons	3.68	0.97
4.7 I use computer programmes and/or maths websites to offer children focused practice in a skill that they do not sufficiently master	3.32	0.96
4.8 I use computer programmes and/or maths websites to offer specific children additional challenge in the maths lesson	3.15	1.05
Subscale 5: Evaluation of progress and process		
5.1 I use scores on standardised and curriculum-based tests to evaluate whether the learning goals have been met	4.04	0.73
5.2 I analyse the answers on curriculum-based tests to evaluate whether the learning goals of that unit have been met	4.06	0.72
5.3 I regularly evaluate whether all students have met the learning goals based on their daily maths work	3.75	0.85
5.4 I evaluate whether all students have met the lesson goals based on (informal) observations during the maths lesson	3.45	0.86
5.5 I conduct diagnostic conversations to evaluate whether specific students have met the lesson goals	2.85	0.87
5.6 I evaluate whether the type of instruction and practice chosen by me were effective for the majority of the students in the class	3.44	0.77
5.7 I evaluate whether a specific type of instruction was effective for specific students	3.32	0.80

3.4 Concluding summary Study 2

Study 2 investigated teachers' self-assessed implementation of differentiation using the DSAQ. The first goal was to examine the psychometric properties of the DSAQ. The subscales of the DSAQ were internally consistent and loaded on two correlated but distinct factors: Progress Monitoring and Instructional Adaptations. Confirmatory factor analysis demonstrated that this two-factor structure provided a better fit than a one-factor model, which converges with the findings reported by Roy et al. (2013). The second goal was to examine the convergent and divergent validity of the DSAQ. The pattern of correlations between the DSAQ and other scales supported its convergent and divergent validity. As expected, strong to moderate correlations with Prerequisite Knowledge for Differentiation, Adapting Education to Individual Students' Needs, and Instruction were found. As hypothesised, the correlations with the scales selected for testing the divergent validity were lower, except for the correlation with Coping with Changes and Challenges which was unexpectedly strong.

The third and main goal was to examine teachers' perceived usage of the strategies recommended by the experts. With factor means in the moderate to high range, teachers assessed their use of differentiation strategies more highly than we had expected. Five items with relatively low means were identified. In support of our hypothesis, these items concerned specialised strategies and strategies targeted at high-achieving students.

4. General discussion

Teachers are required to implement differentiation for students of diverse achievement levels. However, the term differentiation had been used in diverse ways and the literature did not provide sufficient information regarding the most effective strategies to provide teachers with general guidelines for implementing differentiation. To fill this gap, Study 1 operationalised the concept of differentiation by achieving consensus among a consortium of experts about a model and strategies for differentiation in primary school mathematics. Study 2 investigated the degree to which Dutch teachers already implement the strategies suggested by the experts.

Study 1 resulted in a model for differentiation consisting of five steps: identification of educational needs, differentiated goals, differentiated instruction, differentiated practice, and evaluation of progress and process. These steps reflect the two core components of differentiated instruction identified by Roy et al. (2013). Progress monitoring is captured by the steps of identification of educational needs and evaluation of progress and process. The component of instructional adaptations is represented by the steps of differentiated goals, instruction, and practice. Study 2 demonstrated that a two-factor model in which the subscales of the DSAQ load on these two factors provides a better fit than a one-factor model. Our findings converge with the findings reported by Roy et al. (2013), supporting the idea that progress monitoring and instructional adaptations are two distinct but related components of differentiation.

New in this study is expert consensus on *how* progress should be monitored and *how* goals, instruction and practice should be adapted to the learning needs of students with diverse achievement levels. Regarding progress monitoring, the experts recommended to use standardised and curriculum-based tests first to divide students over achievement groups. More refined and informal measures such as the analysis of daily work should be used frequently to monitor short-term progress, to diagnose unique educational needs, and to determine whether a (temporary) adjustment of the groups is necessary. Compared to technological applications which tend to make use of one or two types of assessment to monitor progress (e.g. McDonald Connor et al., 2009; Ysseldyke & Tardrew, 2007), the experts recommended a broader range of strategies and indicated how they can be used together. The strategies have complementary purposes: while relatively formal and standardised tests are useful to get an overview of what a student can do, more informal and qualitative measures such as diagostic conversations and the analysis of daily work provide valuable information about why a student struggles with a certain problem and what the student needs.

The use of within-class homogeneous achievement groups provides the opportunity to tailor subgroup instruction to similar educational needs and has demonstrated positive effects (Kulik & Kulik, 1992; Lou et al., 1996; Slavin, 1987; Tieso, 2005). In line with Slavin (1987), the experts stressed the importance of flexibility, i.e. allowing students to switch between groups based on changes in their educational needs. The literature indicates that the effects of within-class ability grouping may depend upon student achievement level, with smaller or even negative effects for low-achieving students (Deunk et al., 2015; Lou et al., 1996). Nevertheless, the experts clearly perceived small-group instruction as a good way to provide low-achieving students with the instruction they specifically need. Also, students are only grouped for part of the lesson and participate in the whole-class instruction for students of all ability levels as well. Future research should establish whether these conditions ensure that low-achieving students also profit from this type of within-class flexible ability grouping.

Regarding instructional adaptations, the experts recommended a coherent set of strategies to differentiate goals, instruction and practice. This comprehensive approach is somewhat broader than technology-based interventions which have tended to focus on differentiation of either instruction (Individualizing Student Instruction) or practice (Accelerated Math). Many of the strategies recommended by the experts are supported by previous research, including the adaptation of practice tasks to the skill level of the student (Ysseldyke & Tardrew, 2007), the use of explicit instruction and visual representations for low-achieving students (Gersten et al., 2009) and the use of compacting, enrichment, and instruction at challenge level for advanced students (Rogers, 2007). To use teachers' time efficiently, the experts recommended to teach the whole class when possible, to use subgroups when the diverse educational needs of subgroups require this, and to serve remaining unique educational needs individually. Thus, the experts recommended both universal supports (supports for all students such as varying the difficulty level of questions in broad whole-class instruction) and targeted supports (supports specifically for low-achieving and high-achieving students including small-group instruction and differentiation in practice tasks). The experts also recommended some adaptations to individual students' educational needs (e.g. the adaptation of type of practice to the preference of specific students), but they realised that such specialised adaptations were advanced and primarily suitable for teachers who already master basic strategies for differentiation.

To link the advice provided by the experts to teachers' daily practice, Study 2 investigated teachers' self-reported usage of the recommended strategies. Overall, DSAQ scores were moderate to high, exceeding the expectations we had based on previous studies. Perhaps, the different context (primary schools in the Netherlands versus middle schools in the United States) can explain the discrepancy with the low use of differentiation strategies reported by Moon et al. (2002). Our findings are more similar to those of a recent study with Canadian primary school teachers in which moderate usage was reported (Roy et al., 2013). Nevertheless, the moderately high self-assessments in the current study seem discrepant with the finding of the Dutch Inspectorate of Education that adequate adaptations to students' diverse educational needs are only made at about half of the schools (Van den Broek-d'Obrenan et al., 2012). Also, the experts in Study 1 clearly perceived a need for professional development about differentiation. Perhaps, the inspectors of education and the experts from our consortium have high standards for the *quality* of implementation which are not captured by the DSAQ. Teachers might also overestimate their implementation. Refined observational studies are necessary to examine whether teachers' high self-assessed usage of differentiation strategies can be confirmed by external observers.

In line with previous studies (McLeskey & Waldron, 2002, 2011; Reis et al., 2004; Scott et al., 1998; Westberg et al., 1993; Westberg & Daoust, 2003), specialised studies and strategies targeted at high-achieving students were used relatively infrequently. Two specialised strategies - the use of diagnostic conversations to evaluate whether the learning goals have been met and adaptation of the type of practice to specific students' needs - were relatively infrequently reported. This corresponds with the view expressed by the experts that individual-level differentiation is advanced and primarily suitable for teachers who already implement group-based strategies for differentiation successfully (Van Groenestijn, Borghouts, & Janssen, 2011).

Three strategies targeted at high-achieving students - curriculum compacting, the use of computer programmes for additional challenge, and targeted instruction for these students - were used infrequently. The difference between the use of instruction targeted at high-achieving students versus low-achieving students is especially striking. Perhaps, teachers are not aware that high-achieving students also need guidance when working on sufficiently challenging enrichment tasks (VanTassel-Baska & Stambaugh, 2005). Many teachers do implement some differentiation in practice tasks. However, there is still a lot of room for improvement, since it seems that only few teachers use a complete approach including challenging goals, curriculum compacting, enrichment tasks and on-level guidance. Low usage of differentiation for high-achieving students has repeatedly been attributed to a lack of the specific attitudes, knowledge, and skills this requires (Latz, Speirs Neumeister, Adams, & Pierce, 2009; Megay-Nespoli, 2001; VanTassel-Baska & Stambaugh, 2005). Many teacher educators feel that initial teacher training does not adequately prepare teachers to differentiate instruction for high-achieving students (Schram, Van der Meer, & Van Os, 2013). Thus, it seems important that this topic receives sufficient attention in teacher training and professional development programmes.

The following limitations should be taken into account. First, the results of consensus procedures are inherently restricted by the participating experts. The risk that other experts might have provided different input cannot be eliminated but was diminished in this study by recruiting experts working for several different institutions for both pre-service and in-service teacher training. Second, some experts missed some components of the procedure (a focus group discussion or a round of the Delphi questionnaire). This limitation was compensated for by the repetitive nature of the procedure: participants who missed one component could still provide comments and additional input in the subsequent component. Third, it is possible that teachers provided socially desirable answers since a self-report questionnaire was used in Study 2. The variability between the items provides an indication that teachers did not simply rate themselves highly on all items to create a favourable impression. Nevertheless, we state again that observational studies are necessary to investigate how self-reported use is related to observed use of differentiation strategies. Fourth, it is unknown whether non-responders differed from teachers who did respond to the questionnaire, although the response rate of 83% is quite good.

A strong combination of methodologies was used. Study 1 employed an innovative methodology which combined the advantages of two methods: focus group discussions are suitable for creating shared understanding and generating ideas, while the Delphi procedure gives all participants an equal and anonymous say in the systematic evaluation of those ideas. This combination was fruitful and efficient and we recommend it for future research. Moreover, the collaboration with experts who were familiar with the daily practice of teaching enhanced the feasibility of the findings. Based on their experience in various settings, the experts perceived these strategies as effective and feasible. In addition to this expert perspective, Study 2 examined the results of Study 1 from a teacher perspective. The fact that the teachers in Study 2 reported to use most of the strategies recommended by the experts in Study 1 shows that teachers acknowledge the need to differentiate and that the recommended strategies are largely compatible with teachers' daily practice. At the same time, the discrepancy between the teachers' and experts' perception of the degree of application of differentiation opens up an interesting avenue for future research. Thus, the inclusion of two complementary sources of information provides a richer perspective on differentiation. Despite these methodological advantages, future research is necessary to test empirically whether the implementation of the strategies recommended by the experts leads to higher student achievement.

The results of the current studies contribute to scientific research as well as to educational practice. Although the experts in Study 1 departed from a practical rather than a theoretical perspective, the elements of the cycle of differentiation overlap with elements of more general didactical models, such as Van Gelder's didactical analysis model (Van Gelder, Oudkerk Pool, Peters, & Sixma, 1973) and De Corte's didaxology (De Corte, Geerligs, Lagerweij, Peters, & Vandenberghe, 1976). Apparently, effective readiness-based differentiation is consistent with the principles of general good teaching, with the addition that each stage of teaching needs to be differentiated. A first theoretical implication is that, rather than studying specific elements (i.e. differentiated practice) in isolation, it seems promising to move towards an integral view of differentiation which involves all stages of teaching. Second, the experts clearly endorsed the view that students of different achievement levels have different educational needs and need different treatments at least part of the time, echoing the aptitude-treatment interaction literature (Cronbach & Snow, 1977). This emphasises the need to consider the potential variation between students in the design and analysis of educational intervention studies: what works for high-achieving students, may not work for low-achieving students and vice versa.

At the practical level, the model and strategies for differentiation recommended by the experts can be used in teacher training and professional development, for which purpose they have also been published in a Dutch journal for practitioners (Van de Weijer-Bergsma & Prast, 2013). Current educational policies require teachers to implement differentiation and our results provide teachers with concrete advice on how to do this. The cycle of differentiation can be used as a framework to structure professional development about differentiation. It shows teachers that differentiation requires attention at all stages of teaching in one coherent approach. The recommended strategies provide teachers with practical suggestions for each step (these can be found in section 2.3, Appendix 1, and also in the DSAQ-items listed in Table 4). The focus on mathematics promoted the concreteness of the results, since domain-specific guidelines can be applied directly without the need to transfer general principles. For example, the general guideline that advanced learners should be adequately challenged was made ready for use by providing achievement criteria for selecting high-performing students, suggestions for increasing task difficulty, guidelines for compacting, and a list of supplemental enrichment curricula. Nonetheless, the principles behind these concrete recommendations, including the cycle of differentiation, seem to be applicable in other domains as well. Future research could examine whether and how our results extend to other domains.

Study 2 provides researchers and practitioners with a new tool, the DSAQ. Researchers can use it, for example, as a pre- and post-assessment in intervention studies or to investigate teachers' self-assessed implementation in other countries. In professional development, the DSAQ can inform trainers about areas in which teachers perceive most room for improvement. Theoretically, Study 2 builds on the existing literature by providing support for the two-dimensional structure of differentiation. Moreover, this study is the first to investigate the self-reported use of a broad range of strategies for differentiation in mathematics in the Netherlands. The identified areas of low usage have practical implications, including the need to pay sufficient attention to differentiation for high-achieving students in teacher training and professional development.

Keypoints

- Effective combination of the Delphi technique and focus group discussions to achieve consensus among experts
- Use of experts' practical knowledge to enhance feasibility of the findings
- A model and strategies for implementing differentiation in primary school mathematics, usable in teacher professional development
- A new questionnaire (the DSAQ) to measure teachers' self-assessed implementation of differentiation strategies, usable in future research
- Teacher self-assessment indicating moderate to high usage and identification of relatively infrequently used strategies

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Appendix 1: Summarising concepts included in the Delphi questionnaire

What follows are the translations of the concepts as they were included in the Delphi questionnaire. Background information that might be relevant for non-Dutch readers is given in the footnotes.

Organisation

The starting point is convergent differentiation[2]. Students are assigned to one of three subgroups based on standardised tests and / or curriculum-based tests. If curriculum-based tests are used to assess what students already master, the test score of the previous unit can be used, but an alternative is to use the end-of-unit test of the upcoming unit as a pretest. The teacher can change the grouping arrangement for a certain unit or lesson based on test scores. During mathematics classes, whole-class instruction, instruction to one of the subgroups (of low-achieving or high-achieving students) and independent practice are alternated. Average achievers take part in the whole-class instruction and receive individual feedback or guidance during the time for independent practice.

Differentiation in instruction

During whole-class instruction, the teacher serves different levels and educational needs to the extent that this is possible. The teacher can do this by teaching at different levels of abstraction and showing the connection between these different levels. The teacher should ask questions at varying difficulty levels, implying that some questions may be too easy or too difficult for some of the students in the class. During instruction to a subgroup, the teacher takes into account the educational needs of the students in that specific subgroup. For example, the teacher spends more time on lower levels of abstraction when teaching the low-achieving subgroup, while instruction to the high-achieving subgroup is mainly at a high level of abstraction. Additionally, it is assumed that the low-achieving subgroup needs more guidance (more direct instruction) than the high-achieving subgroup (more exploratory instruction). To the extent possible, the teacher also takes into account individual differences within a subgroup. For example, the teacher can accommodate to a student's need to verbalise a solution strategy himself, or a student's need for visualisation. An additional strategy for differentiation in instruction is the use of instructional videos.

[2] In the Netherlands, a distinction is often made between convergent and divergent differentiation (Gelderblom, 2007). In convergent differentiation, all student in a classroom work on roughly the same topics at the same time (even if they might engage in the topic at varying levels of complexity). In divergent differentiation, different students work on different learning goals and topics at the same time.

Differentiation in goals

A strong awareness of the learning trajectories and accompanying educational goals is essential for a good lesson. For differentiated education, this means that different goals are set for different students. Goals are differentiated primarily at the subgroup level. Highly competent teachers can also differentiate goals on an individual basis based on their professional insight. For the low-achieving subgroup, the objective is to master the fundamental level (1F)3 at the end of primary school. For the average-achieving subgroup, the objective is to master the target level (1S) at the end of primary school. For the high-achieving subgroup, mastery of the target level is a minimum requirement, but additionally, more advanced goals (for example regarding logical reasoning) are set for these students. The goals for the end of primary school are converted into specific lesson goals for the three subgroups based on the curriculum and the professional insight of the teacher. These lesson goals should be both ambitious and realistic. The teacher keeps in mind the lesson goals while preparing and teaching his lesson. After the lesson, the teacher evaluates whether lesson goals have been met.

Differentiation in the practice phase

The different subgroups need quantitatively and / or qualitatively different practice tasks. From the tasks that the curriculum offers, the tasks at the minimum and fundamental level are most important for low-achieving students. The high-achieving subgroup can skip a large proportion of the tasks at minimum and fundamental level. Existing guidelines for compacting4 can be used to select the tasks that high-achieving students do need to do. High achieving students spend the time that is freed up by compacting the regular material on enrichment. The enrichment tasks provided in the regular curriculum are often not sufficiently challenging, especially for gifted students. Additional enrichment should be provided for these students. Such enrichment may include assignments for which students have to carry out research or use information from different sources. Besides the adaptation (selection and supplementation) of tasks, practice can also be differentiated during instruction to subgroups. For example, the teacher could use the extended instruction for low-achieving students to solve the exercises together step-by-step, while a discussion of the big ideas behind a certain task may be more useful in the high-achieving subgroup.

Differentiation based on learning styles

The educational needs of different students may also vary within subgroups. For example, students may have a preference for certain formats (whole-class instruction, working together, working individually) and certain input modes (visual or verbal, written or spoken). It has been mentioned repeatedly that it is important for some students to express the content themselves or to have the content explained to them by another student. Teachers need to be aware of these differences between students and learn how they can vary their instruction, tasks and formats to accommodate various educational needs. Especially during the instruction to subgroups the teacher can accommodate to individual educational needs, provided that he is able to identify what kind of instruction or type of task a student needs to understand the content.

[3] In the Dutch educational system, overarching objectives (comparable to the common core state standards employed in the US) have been defined at two levels: the fundamental level (1F) that should be reached by all students and the target level (1S) that should be reached by about 65% of the students (Expertgroep doorlopende leerlijnen taal en rekenen, 2008).

[4] An educational advisory company has published guidelines for compacting the most popular Dutch mathematics curricula (Janson & Noteboom, 2004). Children for whom the material should be compacted receive an additional booklet with an overview per lesson of the exercises they should do and the exercises they can skip.

Differentiation in kindergarten

When the files of students with problematically low mathematics achievement in primary school are examined, it often turns out that problems with preparatory mathematics were already detected in kindergarten but that no or insufficient action has been taken to tackle those problems in the meantime. Factors that may play a role in this lack of action are beliefs of the teacher ('the child is not ready for preparatory mathematics' or 'children of this age should be allowed to play'), inadequate communication to the teacher of the next grade, and lack of knowledge of ways to tackle low achievement in (preparatory) mathematics. In order to respond more quickly to early signals of problems with acquiring preparatory mathematics skills, teachers should (a) set more specific and ambitious goals (what should the child be able to do at the beginning of grade 1?), (b) be more knowledgeable about levels of abstraction and be able to demonstrate the connections between various levels of abstraction, (c) realise that learning can take place in the process of playing if the activity is well adapted to the child's educational needs, and (d) that certain children need some additional instruction, also in kindergarten. Additionally, more attention should be given to providing extra challenge to students with highly developed preparatory mathematics skills.

Table 5

Table of footnotes

No.	Footnote
1	Compared to the four-item NTSES subscale for Adapting Instruction to Individual Students' Needs, the added value of the DSAQ is that it provides a more detailed measure of self-assessed use of a range of differentiation strategies.
2	In the Netherlands, a distinction is often made between convergent and divergent differentiation (Gelderblom, 2007). In convergent differentiation, all student in a classroom work on roughly the same topics at the same time (even if they might engage in the topic at varying levels of complexity). In divergent differentiation, different students work on different learning goals and topics at the same time.
3	In the Dutch educational system, overarching objectives (comparable to the common core state standards employed in the US) have been defined at two levels: the fundamental level (1F) that should be reached by all students and the target level (1S) that should be reached by about 65% of the students (Expertgroep doorlopende leerlijnen taal en rekenen, 2008).
4	An educational advisory company has published guidelines for compacting the most popular Dutch mathematics curricula (Janson & Noteboom, 2004). Children for whom the material should be compacted receive an additional booklet with an overview per lesson of the exercises they should do and the exercises they can skip.