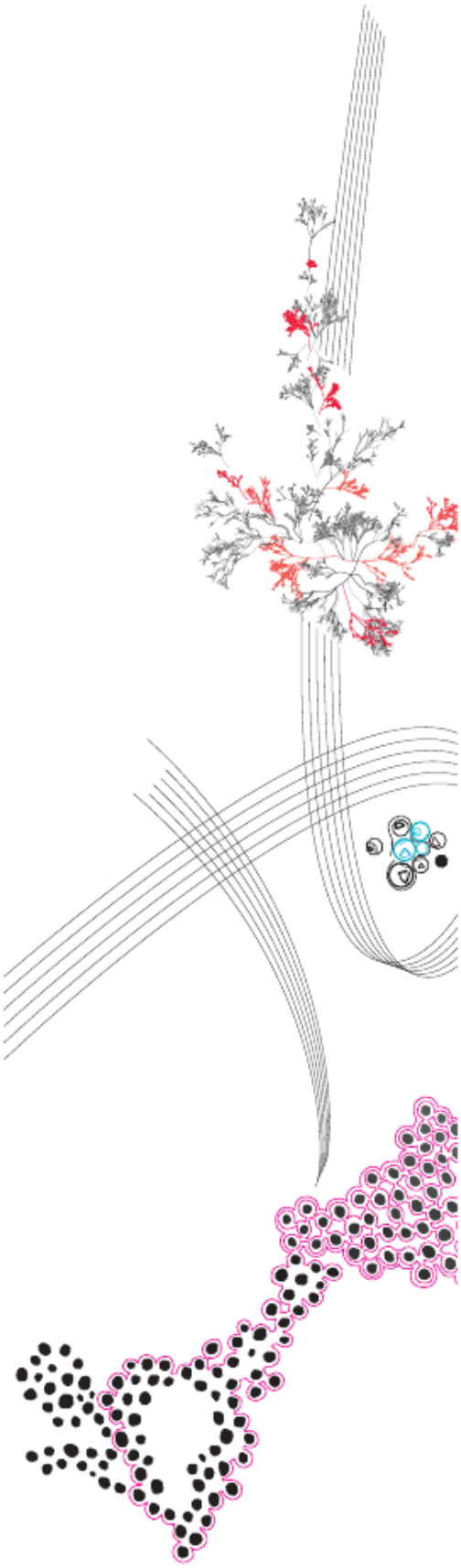

Master Thesis

Teachers' Interpretation of Observed (Non)verbal Student Cues to Monitor Student Progress and Enhance Differentiated Mathematics Instructions

Primary school teachers' reasoning for on the spot instructional decision-making

Sophie Kamphuis

Supervisors: dr. Ilona Friso - van den Bos
dr. Marieke van Geel

BMS Faculty

Educational Science & Technology

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UNIVERSITY OF TWENTE.

Foreword/acknowledgement

Thank you for taking the time to read this thesis. My master thesis was written as a completion of the master's degree in Educational Science and Technology at the University of Twente. In this thesis I have used the knowledge and skills that I gained during the educational period at the university. In addition, during the process of conducting this thesis, I learned about doing research and the complexity of it. Moreover, it has given me insights into bringing together the educational theory at the university with the practice in which I work as a teacher next to my studies. Before starting to write this thesis, I expected the writing process would be challenging. However, during the writing process I discovered that connecting educational practice with theory was very interesting. I got pleasure out of it, although it took a lot of perseverance. I would therefore like to thank everyone who supported me in any way during this process.

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I wish you a pleasant read throughout this thesis.

Sophie Kamphuis

Summary

Teachers have to effectively educate many different types of students in their daily practice. For all these differences, teachers have to use differentiated instructions considering appropriate instructional decisions matching the students' needs. In recent years, research has been conducted into the decisions teachers make throughout the process of differentiation. Although this research focuses mainly on differential choices teachers make prior to their lesson, teachers also appear to extract information from cues that they observe within students while performing their instruction and consequently make instructional decisions on the fly. Little is known about how teachers consciously, subconsciously and deliberately direct their viewing behaviour during instructions to observe these cues with the aim to make instructional decisions considering students' needs. Additionally, no research has been found on which cues teachers consider to be important. Therefore, this study attempts to investigate the following research question: 'How do teachers at a primary school use (non)verbal cues from students to select an appropriate teaching strategy with the aim to differentiate mathematical instructions?'.

In a mixed methods explanatory sequential design, teachers were asked to wear eye tracking glasses during a differentiated mathematical instruction to determine their viewing behaviour and focus. In addition, the Tobii Pro Glasses 3 filmed the instruction as well and with the accompanying eye tracking software the videos were analysed. In the analysis, certain Areas of Interest (AOIs) were determined. The AOIs were either assigned to nonverbal or verbal cues and presented to the participants during a stimulated recall interview with the purpose of examining to what extent these cues seemed to be important for certain instructional decisions. In the interviews, teachers viewed these video fragments of their own instruction at a later time and were asked to reflect on it with guidance of several interview questions: (1) what did you observe within the student?, (2) what is your interpretation of this observation?, and (3) what instructional decisions did you subsequently make?. Eventually, only five recordings were successful due to technical difficulties, of which one recording was used to familiarise the researcher with the eye tracking software. Ultimately, four interviews were conducted.

The assigned AOIs and the interviews provided an answer on the research question. The study results showed teachers appeared to be focused on consciously observing cues of mainly students experiencing difficulty regarding the subject matter and students with known difficulties in their characteristics (e.g. working pace or focus) to decide on their progress and to determine the most suitable instructional decision. Within observing these cues, analyses of the eye tracking video material indicated that most of the teachers seemed to fixate on nonverbal student cues. Within this type of cues, teachers obtained most information from the observations on student work, students' facial expressions and students' body language. While focusing on the work of students, teachers

observed mathematical strategies used by their students. The interpretation of students' facial expressions and body language gave teachers information on how students experienced the difficulty level of the subject matter. The teachers mentioned they combined all gathered information to ad-hoc decide on student progress and instructional decisions matching the needs of students. Considering instructional strategies, teachers most often mentioned the following strategies in order of importance: adjusting instructional time, giving hints, scaffolding, and modelling. In contrast to most of the teachers, one of the teachers seemed to be focused mainly on observing verbal cues, specifically on student responses. Since this teacher possibly required less student knowledge due to a later appointment in the school year, it suggests the degree of knowledge about students could influence the type of cue on which teachers fixate during instructions.

In conclusion, this study provides more insight into the way teachers direct their viewing behaviour during mathematics instructions to consciously observe and interpret student cues and decide on their progress and appropriate instructional decisions. Additionally, this research confirms once again how important the development of skills is for (beginning) teachers to collect knowledge about students and to continue focusing on it. Based on these findings, it is recommended that future research could focus on confirming the results on teachers' viewing behaviour in a broader and larger population to generalize findings. Furthermore, more research is needed into the influence of pedagogical knowledge and noticing different types of cues in order to compose a deeper understanding of how teachers effectively interpret and develop the required student knowledge during instructions.

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Introduction

Primary school teachers have to deal with increasing differences between students on a daily basis (Ledoux et al., 2020). Primary schools are obligated to take in diverse students and as a consequence differences between students increase substantially and continuously (Dixon et al., 2014; Smale-Jacobse et al., 2019). These differences consist of motivation, learning style, interest (Suprayogi et al., 2017), cultural background, socioemotional aspects, developmental level, cognitive ability (Corno, 2008), and socio-economic background; all important features to predict learning (Dijkstra et al., 2016). Therefore, teaching 'to the middle' cannot meet the needs of today's diverse student populations (Haager & Klingner, 2005; Parsons et al., 2017), and for this reason teachers need to actively make adjustments in their instructions to match students' needs as much as possible and reach the maximum potential of students as well (Santangelo & Tomlinson, 2012). Hence teachers attempt to differentiate their instructions to match these needs and stimulate students to perform as optimally as possible corresponding students' qualities and possibilities (Frerejean et al., 2021). However, differentiated instruction is a complex skill for both novice and experienced teachers (Gheyssens et al., 2020), and many teachers struggle with adapting their instruction to the differences between students (Baltussen et al., 2018). Moreover, the majority of novice teachers do not feel prepared to apply differentiated instruction (Inspectie van het Onderwijs, 2015).

The complexity of differentiated instruction has been studied often. Researchers conclude there is no basic procedure or roadmap to ensure proper differentiated instruction. In fact, teachers need to make well-considered choices during differentiated instruction, based on a thorough analysis while instruction takes place in order to respond directly to students' needs (Van Geel et al., 2019). To analyse students' behaviour and needs, teachers have to respond directly to the signals they receive from students during instructions to make appropriate instructional decisions (Corno, 2008). Consequently, noticing relevant cues from students is necessary (Kosel et al., 2021) to monitor and interpret students' understanding and progress (Van Geel et al., 2019), and adapting instructions on these variables (Keller et al., 2022). However, there is still little known about the way teachers consciously or subconsciously direct their viewing behaviour during differentiated instruction to notice these relevant cues (Chaudhuri et al., 2022) and adjust instructions accordingly (Doyle, 2006) responsive to the needs of students.

Therefore, this study's goal is to get insight into the process of teachers noticing and using cues of students in instructional decisions by exploring the following research question: 'How do primary school teachers observe and interpret (non)verbal cues of students to inform them on student progress and consequently decide on an appropriate teaching strategy to enhance a differentiated mathematics instruction?'. The aim is to determine (1) how teachers notice both nonverbal and verbal cues of students during mathematics instructions through in-class eye tracking (Jarodzka et al., 2021)

and (2) use (alternative) teaching strategies based on the observed cues by analysing stimulated recall interviews (McIntyre et al., 2022). By analysing the attentional process in the eye tracking videos, an attempt is made to gain insight into the type of cue that seems most interesting for teachers to inform them on student progress. In the interviews, teachers are asked to explain their interpretation of the observations and to reason their instructional decisions with the needs of students in mind. The intended purpose is to remotely make teachers' thought processes explicit and provide insight into the reason teachers are able to quickly interpret and respond to student cues during a differentiated mathematics instruction.

1. Theoretical Framework

1.1 Differentiated Instruction

Differentiated instruction (DI) is often promoted as a solution to accommodate with students' different educational needs. Available research shows DI resulted in higher academic scores, more motivated students, and higher student engagement and interest (Gambrell, 2011; Johnsen, 2003; McAdamis, 2001; Tulbure, 2011; Valiandes, 2015). While DI is not a new concept, theories about DI differ. Roy et al. (2013) describe DI as an approach in which teachers make use of systematic monitoring of students' academic progress to inform them on appropriate instructional decisions to correspond with the varied abilities of students. Tomlinson (2017) stated that DI is a teaching philosophy and teachers should differentiate learning environments and processes according to student differences to understand, process and internalize information in multiple ways. Although researchers define DI differently, they agree the main focus of DI is to ensure all students will reach an academic goal, though due to student diversity the process of achieving this goal differs between students (Levy, 2008; Suprayogi et al., 2017). Hence, there are several ways for implementing DI. For instance, teachers can use different sets of exercises matching student capability including providing enrichment materials for higher performing students, adjusting processing time, combining student groups considering their level or interest, providing varying ways and degrees of feedback and support, and require different demands regarding the learning objectives (Heacox, 2012). Thus students with various competences will be approached and assessed regarding their capabilities. Therefore, on the one hand, differentiation can be used to overcome students' diverse needs, on the other hand it is an opportunity for enrichment (Corno, 2008).

1.2 The Role of Teachers in Differentiated Instruction

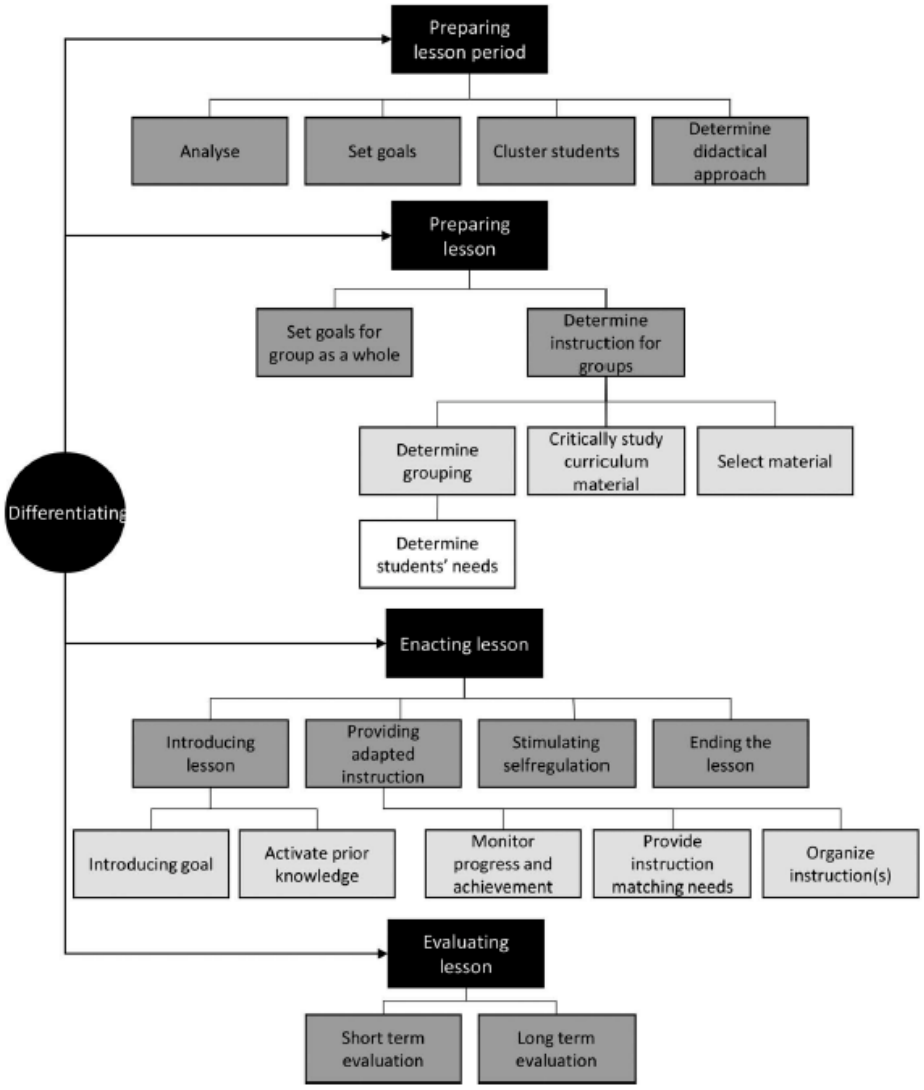
The use of DI requires teachers to be flexible in instructions to suit different needs of students, thence teachers' adaptation ability is an important factor for increasing student achievement (Morrow et al., 2011). Differentiation is a complex teaching skill, and at the same time, the complexity of differentiation differs across situations (Van Geel et al., 2019). It requires teachers to have advanced professional skills to assess which instructional decision to make in certain combinations of circumstances.

Van Geel et al. (2019) investigated the kind of skills and abilities teachers need while using DI and concluded that four chronological differentiation stages can be distinguished. Figure 1 shows the

interrelating stages of differentiation in a differentiation skill hierarchy (Van Geel et al., 2019, p. 60). The figure shows differentiation takes place before, during and after the lesson to be taught.

Figure 1

Differentiation Skill Hierarchy



Note. Reprinted from ‘’Capturing the complexity of differentiated instruction,’’ by M. van Geel, T. Keuning, J. Frèrejean, D. Dolmans, J. van Merriënboer and A.J. Visscher, 2019, *School Effectiveness and School Improvement, (30)*1, p. 60. Copyright 2019 by School Effectiveness and School Improvement.

Horizontally contiguous skills can be conducted subsequently, simultaneously or randomized. Skills lower in the hierarchy are supplementary and conditional to overarching skills. The skill hierarchy is

not a ready-made manual teachers can follow to ensure they secure good quality of DI. In fact, the success of DI highly depends on the well-considered and adequate choices teachers make regarding instructional approaches and materials by analyzing achievement and progress of students through constantly monitoring student progress before, during and after lessons. For example, when teachers provide instructions matching students' needs, they use insights about students acquired in other stages of the differentiation skill hierarchy. Teachers provide adapted instructions based on earlier analysis of student work in the evaluation of lessons, using insights about students' prior knowledge and information acquired during continuously monitoring student progress while enacting the lesson. As a consequence, teachers will continuously utilise and combine information concerning the subject matter with knowledge about their students to make these decisions (Van Geel et al., 2019). Both types of knowledge seem to be affecting instructional practice as well as student learning outcomes (Baumert et al., 2010; Hill et al., 2005).

The success of DI is consequently dependent on the instructional decisions teachers make. An important predictor of this success seems to be the teacher's knowledge of the subject-matter and student knowledge. The degree of knowledge mostly determines the way teachers interpret differences between students and the overall result of DI (Civitillo et al., 2016). For this reason, the teacher's role in DI is crucial, although DI is considered to be a very complex teaching skill (Van Geel et al., 2019). Both novice and experienced teachers seem to experience difficulty with tailoring instructions to fit with students' needs and potential (Baltussen et al.; Inspectie van het Onderwijs, 2015). In addition, while starting their career, novice teachers indicate they are unprepared for using DI (Inspectie van het Onderwijs, 2015). Due to the effectiveness and impact of DI, it is very important there is a greater understanding of the process in order to provide targeted advice for both novice teachers and teachers who have been involved in their profession for a longer period of time.

1.3 Teachers' Knowledge of the Subject-matter

Logically, teachers in primary education need knowledge about all the subjects to be taught and it seems to be important in all phases of differentiation: for analyzing and evaluating subject-matter student results, setting suitable goals, to connect with prior knowledge, and adapt instructions to students' zones of proximal development (van Geel et al., 2019). The emphasis is on a deep understanding, since teachers do not solely have to understand the teaching material, yet also have to explain and instruct new information (Kleickmann et al., 2013). A foundation regarding to knowledge of the subject-matter is laid in teacher training programs and will be expanded through experience (van Geel et al., 2019).

Especially in mathematics, teachers have difficulty to achieve effective and efficient mathematical instructions since students experience abstract mathematical concepts as challenging (Smith & Morgan, 2016). While constructing new knowledge on these mathematical concepts, teachers build upon earlier laid foundations and procedures (Hickendorff et al., 2019). For example, students solely learn multiplications at the time they master basic procedures for addition and subtraction. Previously learned procedures are therefore used as a framework for further mathematical development. As a consequence, difficulties in earlier stages of mathematical development can lead to delays in new concepts to be learned and this can cause extensive differences between students' prior knowledge. In order to overcome these differences, teachers need to recognise students' mathematical thinking during problem solving to understand in which degree students understand mathematical concepts (Fernández et al., 2013). Identifying used strategies of students in problem solving helps teachers to interpret why mathematical problems could be difficult for students and consequently to make appropriate instructional decisions, for example, the selection and design of mathematical tasks in problem solving activities (Fernández et al., 2013). Therefore, observing and interpreting work of students to determine students' mathematical thinking is a key element of effective instruction (Stockero et al., 2017).

1.4 Teachers' Knowledge of Students

One of the most important aspects of teaching is getting to know the students. On the one hand, this exists of the level of achievement: considering the starting point of students regarding the lesson objective and in addition determine an achievable and realistic goal for this specific student. As indicated in Figure 1, a large part of differentiation lies in analyzing the work of students, by checking either exams or lesson work (Van Geel et al., 2019).

On the other hand, getting to know students is about realising the pedagogical needs of the students, such as interest, learning preferences, motivation and problem-solving skills (Van Geel et al., 2019). According to Hattie's (2013) meta-analytical review of more than 800 research studies, effective teachers possess more flexible and innovative pedagogical content knowledge and are more able to adjust instructions responsive to classroom situations. It is therefore highly important teachers possess knowledge on student characteristics and develop awareness of how to address these characteristics with the aim of adjusting instructions suiting students' needs. Teachers collect this information partially through what has been provided by teachers of students in previous years and additionally by receiving signals from students during instructions (Corno, 2008). For example monitoring student progress, observing student behaviour in class and interactions with students will provide crucial information. Hence it is very important teachers continuously monitor the progress and achievement of students by observing student progress, student behaviour and interactions with

students while instruction takes place and adjust instructions to what is noticed (Van Geel et al., 2019).

1.5 Teachers' Viewing Behaviour in Differentiated Instruction

The main goal of observing students is to monitor student progress on the subject by attending, interpreting and deciding how to respond on students aiming to adapt instructions on the fly (Jacobs et al., 2010; Stecker et al., 2008; Van Geel et al., 2019). In other words it is making sense of what students think, say or do to make interpretations about what students already know with the goal of supporting students in their needs for maintaining present knowledge and constructing new knowledge. While observing students, teachers need the ability to attend and make sense of important events gained from students and then decide how to respond to these cues to make appropriate instructional decisions. This noticing is a specialized teacher skill and cannot be compared with general observability in real life (Ball, 2011); thus this skill has to be learned. As a consequence, the attention for evolving this skill gains increasingly awareness in teacher development programs.

During noticing, teachers will focus on attending to strategies used by students, estimate and interpret students' understanding, and as a consequence deciding to respond to these understandings (Jacobs et al., 2010). Research from Jacobs et al. (2010) shows the key component of proper noticing lies in learning to think from the thinking of individual students. By focusing on attending to strategies of students in mathematics for example, expert teachers are better able to recall the detail of students' strategies, because they are better able to distinguish meaningful patterns and discriminate crucial information in complex situations. The ability to notice and interpret students' mathematical thinking is not innate. Teachers develop this skill through experience and relate observations to pedagogical student knowledge (Wolff, 2016). However noticing seems to be a crucial skill in effective instructions, there is little information on the way teachers (sub)consciously and deliberately direct their viewing behaviour in order to observe important cues of students and use these cues to inform them about students' understanding with the aim to adapt instructions to what is noticed.

1.6 Noticing Cues

Students indicate through (non)verbal cues whether or not they experience difficulties with the subject matter. By interpreting both nonverbal and verbal cues, teachers can estimate the extent to which students understand the subject matter. Broadly, these cues are divided into five categories: (1) the affective state of an individual, showing feelings and emotions (e.g. surprise, frustration, joy), (2) reflect the cognitive state (e.g. indicate that a student is thinking), (3) have a conversational function (e.g. indicate a question) (van Amelsvoort et al., 2013), (4) student work (e.g. students performing a

calculation), and (5) behaviour (e.g. students who show task-redundancy) . Table 1 provides an overview on the different (non)verbal cues of students during mathematics instructions.

Table 1

(Non)verbal Cues of Students in Mathematics Instruction

Cues of students in mathematics instruction		
Nonverbal cues	Affective state	Frustration Pride Anxiety Yawning Sighing Nodding
	Cognitive state	Pause Rolling eyes
	Student work	Writing an answer Performing a calculation Tempo
	Behaviour	Disruptive behaviour Focus Involvement
Verbal cues	Conversational function	Asking a question Answering a question Conversation with other students Conversation with the teacher

Note. Partially adapted from ‘’Using nonverbal cues to (automatically) assess children’s performance difficulties with arithmetic problems,’’ by M. van Amelsvoort, B. Joosten, E. Krahmer and E. O. Postma (2013). *Computers in Human Behaviour, 29*(3), p. 654-664. Copyright 2013 by Computers in Human Behavior.

Research of Wolff (2016) shows that teachers need to develop the ability to notice student cues and anticipate on problems based on these cues. This requires ongoing awareness about student pedagogical knowledge, lesson content and curriculum goals to decide on the spot how to attain the learning of students. The quality of noticing and interpreting visual cues of students however, differs across the extent of teaching experience. Experienced teachers are more selective in choosing where to focus their attention and are better able to recognize and interpret meaningful patterns. They utilise certain problems that occur within their classrooms for defining and understanding student thinking and deep analytical reasoning about student behaviour. Novice teachers in contrary, seem to be more concerned about inappropriate student behaviour and tend to focus on short-term solutions to overcome problems. Thus, developing effective noticing skills seems to be a time-consuming job that

evolves through the years of teaching experience.

1.6.1 Differences in Noticing Between Novice and Experienced Teachers

For novice teachers, noticing in general is very difficult. Experienced teachers are better able to notice and recognize subtle events and meaningful patterns, which is crucial in complex classroom situations. In addition, experts develop certain automations in their behaviour to enable the processing of complicated information consciously (Berliner, 2001; Kosel et al., 2021), and they tend to focus on all their students and seem to monitor students' understanding during instruction continuously, check students with difficulty more often during instructions and make minor or major adjustments to instructions based on teacher's knowledge of pedagogy and student ability (Danielson, 2007; Hollingsworth & Ybarra, 2017; Kosel et al., 2021). This checking for understanding is beneficial for both the student and the teacher. It gives teachers a real-time overview of what students already know, can fill gaps during the instruction itself, gives the teacher space to speed up or slow down the pace and re-teach in direct response of student behaviour (Hollingsworth & Ybarra, 2017).

Experienced teachers are likely to have formed practice-related cognitive schemata that guide their viewing during giving instructions (Heitzmann et al., 2019). It results in expert teachers showing shorter fixation durations, more task-relevant fixations and fewer fixations on task-redundant areas and this contributes to good classroom management (Levin & Nolan, 2014). Novice teachers do not naturally focus their viewing on student cues; in contrast, they focus on other classroom aspects, such as disruptive student behaviour and therefore do not use signals demonstrated by students to make adjustments in instructions (Jacobs et al., 2010; Sherin & van Es, 2005; Star & Strickland, 2008). Research by Stockero et al. (2017) into noticing shows that the quality of noticing visual cues of students can be improved by using effective interventions in teacher training, resulting in novice teachers who tend to be more focused on individual students' thinking, novices who are better able to assess this thinking and determine which adjustments to make in instructions.

Summarizing, the quality of noticing and interpreting relevant cues seem to be important for instructional decision-making and these skills seem to develop through teaching experience. Nevertheless, it is not yet known whether teachers guide their screening consciously or subconsciously based on prior knowledge about students to notice important cues, neither do we know if teachers deliberately direct their focus on certain students. In addition, as far as known, there is no research available on which cues teachers consider to be most important to interpret student understanding with the aim to modify instructions and make instructional decisions (Chaudhuri et al., 2022).

1.7 Instructional Decisions

Teachers make countless decisions during instruction, something which the untrained eye will not notice quickly at first. Teachers gather information during earlier stages of lesson preparation (preparing a lesson period, prepare the lesson itself, evaluating previous lessons, and information gained from former teachers). In addition, as Kohler et al. (2008) stated, teachers aim to notice student cues to inform them on student learning and progress, hence use this information to make instructional decisions on the spot. They combine all collected information in earlier stages of the lesson preparation and during the instruction itself to make instructional decisions that is most appropriate for that type of students with certain needs. For example, teachers identify remarkable aspects of classroom situations they observe during instructions and combine these observations with knowledge on students obtained through examining student work in earlier stages to determine student needs and decide on an appropriate instructional decision (van Es & Sherin, 2008). Observed cues are therefore the basis for further course instructions. While observing cues, teachers use both verbal and nonverbal forms of signals to react in the moment (Jacobs et al., 2010). Although it is exceedingly difficult for novice teachers to observe visual cues in their early career, research shows beginning teachers can expand their expertise with support. Santagata et al. (2007) proved novice teachers can develop in identification of learning goals, make connections between student learning in relation to learning goals, and choose alternative teaching strategies to accomplish those goals after a teacher training program.

Teachers decide in a split second to whether or not the instruction has to be adjusted based on the visual cues they observe within a student. These instructions can be modified by adjusting learning materials, learning resources, time, goals and the teaching style. Table 2 gives an overview on the alternative teaching strategies during modified instructions (Suprayogi et al., 2017).

Table 2

Alternative Teaching Strategies

Alternative teaching strategy	Examples of adjusting instructions
Adjusting learning material	The teacher adjusts the amount of material
	The teacher adjusts the difficulty level of the material
	The teacher adjusts the processing equipment
Adjusting learning resources	The teacher imbeds different learning resources (e.g. visual representation of the content, auditory support, concrete material, hands-on activities)
Adjusting time	The teacher adjusts instructional time
	The teacher adjusts processing time
Adjusting goals	The teacher adjusts learning goals that are in line with expectations for different students
	The teacher adjusts curricular goals on individual goals of students
Adjusting teaching style	The teacher uses different wording to explain content
	The teacher models a solution strategy
	The teacher uses scaffolding
	The teacher uses different kinds of questions to provoke thoughts

Note. Partially adapted from ‘’Teachers and their implementation of differentiated instruction in the Classroom,’’ by M. N. Suprayogi, M. Valcke and R. Godwin 2017, *Teaching and Teacher Education, 67,* p. 293. Copyright 2017 by Elsevier.

1.8 The Current Study

Teachers aim to differentiate their instructions adapting the various needs of students. DI takes place throughout different stages of instruction. For differentiation to be effective, teachers make use of relevant student cues observed during instructions and combine this with knowledge about students to inform them about the performance of students on the learning material in order to make appropriate instructional decisions. Experienced teachers in particular seem to be able to effectively notice these cues and interpret student needs at certain moments during instructions. Especially noticing cues in mathematics instructions is highly important, since differences between students increase while students experience difficulty mastering the abstract concepts of mathematics and earlier developed mathematical concepts serve as a foundation for further development. Although research suggests noticing student cues seems to be crucial in corresponding students’ needs as closely as possible, little is known about the way teachers (sub)consciously and deliberately control their

viewing behaviour in order to make use of these cues during DI. This research aims to find out whether teachers direct their viewing behaviour towards certain types of cues and which types of cues teachers consider to be the most important to inform them on student progress. In addition, research suggests that teachers make extensive use of knowledge about students to best fit DI to the needs of these students. Different studies provided an overview of the extensive student knowledge teachers gather in order to meet the learning needs of students. However, it is not examined how this knowledge is related to the cues teachers observe during instructions and how teachers use this knowledge to make interpretations about the observed cues in order to inform them about student progress while performing DI. This study uses an exploratory approach and attempts to determine how student knowledge relates to the different cues teachers observe during DI. It involves examining teachers' interpretation of observed cues in relation to the knowledge about students. Finally, it is examined which instructional decisions teachers consider to be most effective based on the abovementioned interpretations teachers make about student progress. As far as known, in current literature there is no insight into the way teachers deploy well-considered instructional decisions based on determining student needs on the spot while performing a DI.

Considering the absence of knowledge on the way teachers (sub)consciously and deliberately collect information about student progress through observing visual cues, how they interpret this information based on pedagogical student knowledge and the kind of decisions they make subsequently to adapt their instruction on student needs, the following research question will be examined: 'How do primary school teachers observe and interpret (non)verbal cues of students to inform them on student progress and consequently decide on an appropriate teaching strategy to enhance a differentiated mathematics instruction?' with the following sub-questions:

1. How do teachers direct their viewing behaviour in elementary classrooms during a differentiated mathematics instruction to notice (non)verbal cues from students in grade 2-5?;
2. Which (non)verbal cues do teachers consider to be most important for making instructional decisions?;
3. Which pedagogical student knowledge do teachers use to differentiate?;
4. Which instructional decisions do teachers use on the fly in a differentiated mathematics instruction?.

The intention of answering these questions is to provide insight into the reason experienced teachers are successful in quickly interpreting different cues they use to organize their differentiated instruction as effectively as possible. These insights can be used for further research with the intention of providing teachers in training or novice teachers with more targeted viewing advice and insights into the necessary knowledge to make valuable interpretations of students' progress during

differentiation in order to shorten the process in which teachers develop the necessary experience to quickly observe, interpret and apply valuable student information.

2. Method

2.1 Research Design

In order to examine how primary school teachers use (non)verbal cues of students to monitor progress and consequently select an appropriate teaching strategy with the aim to differentiate, a mixed methods explanatory sequential design is used. A mixed methods design offers the opportunity to acquire a more enhanced insight into the research question compared to solely one of the study designs, since both type of data complement each other and additionally result in more suggestions for future studies (Caruth, 2013). In this study, teachers' viewing behaviour was first quantified by coding them manually into the different nonverbal and verbal cues. The extent to which certain cues occurred was determined through the total fixation duration and visit counts by eye tracking equipment. The collection of this quantitative data was used during stimulated recall in-depth interviews to stimulate teachers to explain the extent to which certain cues have been used as discovered in the first quantitative phase and is therefore explanatory and sequential (Toyon, 2021). In addition, during the interviews, teachers were asked to explain their instructional decisions based on their earlier observed cues amongst students.

A mixed methods explanatory sequential design entails several phases: (1) deciding on theoretical considerations, (2) establishing an approach for research, (3) collecting quantitative data, (4) analysis of quantitative data, (5) collecting qualitative data driven by quantitative result, (6) analysis of qualitative data, and (7) reporting on results (Toyon, 2021). This research used the theory found on different types of cues as described in Table 1 in the first chapter. Qualitative data obtained through eye tracking was used to classify cues into either nonvisual or visual cues. Subsequently, the data served as a starting point throughout the interviews. Teachers were asked to explain what they observed, how they interpreted these cues based on the knowledge they had about students and the sort of instructional decisions in line with the instructional decisions as described in Table 2 they decided on. Chapter 3 provides an overview on the results.

2.2 Research Context

The study occurred at a regular primary school in the Netherlands. The primary school was selected due to convenience. Students at this school are placed in grades composed with same-age students. In addition, the school uses level groups in mathematics education, at which students with same performance levels are grouped for mathematics instructions. All grades work with the teaching textbook 'Wereld in Getallen' version 5. The population of students mainly consisted of generally high-achieving students with highly educated parents.

The study was conducted during the months April to July. It appears from literature that teachers must have extensive knowledge about students for proper instructional decisions. The teacher collects this information by closely observing and questioning students and monitoring students' work (Admiraal et al., 2020; Van Geel et al., 2019). Since this research took place later in the school year, it was assumed that most of the participating teachers in this study were able to collect considerable information about the students in their class. One of the teachers has been appointed later in the school year.

2.3 Participants

In total, 18 teachers were asked to participate, of which 2 declined due to eye problems and 1 teacher declined without a reason. Fifteen teachers were willing to participate voluntarily. Initially, the intention was to base the number of participants on the saturation that would occur during the coding of the interviews. During interview studies, researchers will search for data saturation to justify sample size (Francis et al., 2010). Due to technical problems with the eye tracking material, merely 5 recording attempts were successful. One of the recordings was used to familiarise the researcher with eye tracking material and was not included in the interviews due to the long processing time of the video material. Merely 4 of the recordings could be used in the interviews. The participants were selected through criterion sampling (Palinkas et al., 2015) and invited by means of an information letter (Appendix A) via e-mail to participate in this study. The teachers were selected on basis of the years of work experience as a teacher in primary education. All teachers with a minimum of two years of work experience were invited to participate in the study. It was considered that teachers with at least two years of work experience could focus more on teaching methods instead of organizational matters in the classroom (Levin & Nolan, 2014). All teachers, with exception of participant 4, worked in the same grade from the start of the school year and therefore had the opportunity to get to know the students well.

The group of participants consisted of three women and one man, ranging in age between 28 and 42 years old and the years of working experience varied between 3 and 21 years. The teachers were working in grade one up to and including grade five. They all completed teacher training and have also followed various in-depth training or courses. Table 3 provides an overview of the teacher characteristics.

Table 3

Overview of Characteristics of Teacher Participants

	Sex	Age	Years of working experience	Employed in
Participant 1	Female	36	15	Grade 5
Participant 2	Male	28	3	Grade 5
Participant 3	Female	37	16	Grade 1
Participant 4	Female	42	21	Grade 5

Although the research mainly focused on teacher behaviour, the facial expressions of students, student behaviour and student work were also examined and used to provide insight into which cues teachers used for instructional decisions. After the teachers gave permission, the parents of students were informed about the study through an information letter (Appendix B). A total of 97 students participated, of which 45 boys and 52 girls. The students ranged in age between 7-12 years. Both high-achieving and low-achieving students were included in the study.

2.4 Data Collection and Analysis

2.4.1 Eye Tracking

Eye tracking is a method for examining viewing behaviour, eye movements and eye fixation. It is considered to be an excellent instrument to investigate cognitive processes (Lappi, 2015). In a paper by Holmqvist et al. (2022) different ways of eye tracking are compared, of which the Pupil-Corneal Reflection (P-CR) method currently dominates the eye tracking market. P-CR eye tracking uses infrared light to determine visual focus of the eye. This study used binocular video-based P-CR eye tracking glasses since wearable eye tracking encouraged teachers to move freely and turn their head in all possible directions (Hooge et al., 2022). In a dynamic environment, such as a classroom, moving and looking around the classroom to notice visual cues of students is very important, thus using these glasses made it possible to investigate teacher's viewing behaviour while they performed their daily task. The Tobii Pro Glasses 3 also recorded the instructional lesson with high-definition

(HD) solutions, the recordings of 25 frames per second and an integrated microphone. These glasses provided the opportunity to use binocularly eye tracking, which combines the left and right eye signal by measuring the average focus of the synchronous data samples from both eyes and this improved accuracy (Cui & Hondzinski, 2006).

The device used infrared light to produce a reflection on the cornea in the eye and this was recorded by the eye tracker, which resulted in a frequency and duration of the participant looked at certain objects, called fixation count and fixation time (Holmqvist et al., 2022). A fixation can be defined as a moment in eye tracking where the eye is relatively still and is able to process information from students at the same time (Chaudhuri et al., 2022). Figure 2 displays an example of a fixation of one of the participating teachers, in which the red line represents the eye movement and the red circle shows the fixation of the eyes. The fixations were subsequently used to determine the teachers' targeted observations.

Figure 2

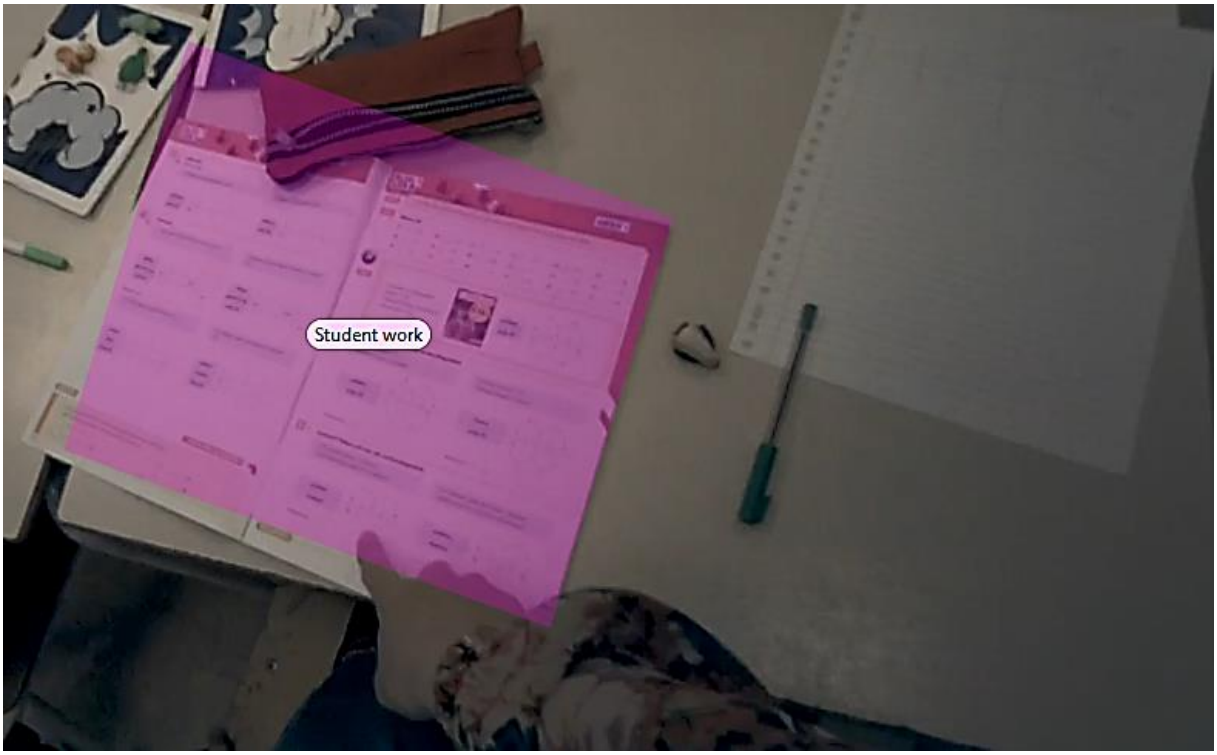
Example of a Fixation of One of the Participating Teachers

The glasses gave the opportunity to record the mathematical instruction as well and provided analysing data through corresponding designed software. With use of the Tobii Pro Lab (v.1.145)

software, the researcher coded all the automatic registered fixations by the eye tracking software in the video material manually into the different cues of students in mathematics instruction. The framework of van Amelsvoort et al. (2013) as displayed in Table 1 was used to classify these cues into so-called Areas of Interest (AOIs). Since several AOIs were dependent on the teacher's interpretation, the researcher decided to combine certain cues. For example, for assigning the code 'frustration' or 'pride', teachers normally use their knowledge about students to interpret the observation. Additionally, due to the distance between the teacher and student at times, it was not always clear whether the teacher was looking at the student's face or body. For these reasons, the researcher used the code observing the face/body. For instance, the researcher used the following codes for observing the AOIs: student face/body, observing writing, student raising a hand, student work, task redundancy, student behaviour, writing an answer, and conversation with the teacher. Figure 3 shows an example of a manually coded AOI targeted at the work of a student.

Figure 3

Example of a Manually Coded AOI in One of the Recorded Lessons



The AOIs were ascertained through the fixation count and fixation time (Holmqvist et al., 2022). The longer and more frequently the teacher fixated on a certain cue, the more important the

teacher considered the cue to be. After the mathematical instruction, the researcher selected interesting fragments on which the teacher was fixated on a certain cue and showed these fragments to the teacher in the interview at a later moment. For example, in a fragment, the teacher showed that they looked at the student work for a certain amount of time, the researcher coded this fragment into a nonverbal observed cue and selected this fragment to be relevant to show in the interview afterwards. During the selection process of the relevant fragments, the researcher aimed to select at least one fragment of all the different AOIs in every recording. By examining the fixation count and fixation time for the relevant cues in the eye tracking material, it can be determined which cues appeared to be the most interesting for teachers. All recordings lasted between 19 and 30 minutes.

2.4.2 Stimulated Recall Interviews

Stimulated recall interviews were conducted to collect detailed and thorough information about the decisions teachers made during the mathematics instruction. During these interviews, teachers were asked to explain observations of student cues, the interpretation of these cues and instructional decisions through stimulated recall. By means of looking at their own instructional lesson, stimulated recall gave teachers the opportunity to view themselves in action to recall their own thoughts and decisions at that moment (Nguyen et al., 2013). In the interviews, teachers were asked to review the manually selected fragments by the researcher consisting of certain student cues.

For conducting the interviews, interview schedules were drawn up with semi-structured in-depth questions so that data could be collected in a qualitative manner and both researcher and participants could give directions to the interview (Baarda et al., 2021). The interviews consisted of a flexible structure, however were guided by a basic topic list and three recurring questions in each fragment: (1) what did you observe with the student during this fragment?, (2) what interpretation did you make as a result of this observation?, and (3) what instructional decision did you make next in your instruction? (Boyce & Neale, 2006), see Appendix E. The open ended questions gave the researcher the opportunity to ask for explanation of the observed cues, the interpretation of these cues with the necessary pedagogical knowledge of teachers, and instructional decisions teachers made. In addition, the interviews were used to identify the alternative strategies used by the teachers. The teaching strategies as shown in Table 2 were used to code these strategies. Teachers were encouraged to make suggestions for the video fragments themselves.

All interviews were recorded by a dictaphone on an iPhone and immediately restored in a password oriented online environment. The interviews were conducted with a maximum of 1 day after the instructional lesson and in total over a period of 3 months. The recorded interviews were first

automatically transcribed verbatim using AmberScript software and were checked afterwards by the researcher for accuracy. Through the use of Atlas.ti software all interviews were coded in 3 ways by open, axial and selective coding. Through open coding, different codes were attached to certain text fragments from the interview, by which the codes indicated the main theme for each fragment. To code the noticed cues, the cues as described in Table 1 are used (e.g. moaning, asking a question). Table 4 provides examples of the used codes during the different phases of coding the interviews. Moreover, the entire coding scheme is included in Appendix F. To increase reliability of the research, the entire coding scheme is provided with examples in the interviews.

Table 4

Examples of Codes (Non)verbal Cues

Example in interview	Code(s)	Category	Overarching category
M. looked at me. (…) A questioning look	Questioning	Affective state	Nonverbal
In the meantime, I am checking J.'s exercise book.	Writing an answer	Student work	Nonverbal
They also make noise at that moment.	Disruptive behaviour	Behaviour	Nonverbal
R. said she did not know.	Conversation with the teacher	Conversational function	Verbal

To code the alternative teaching strategies, the codes are used as described in Table 2 (e.g. scaffolding, modeling a solution strategy), of which examples are given in Table 5. The coding scheme concerning the used alternative teaching strategies is in its entirety appended in Appendix G. Subsequently, assigned codes were compared and merged into the overarching themes as described in Table 1 and 2 (verbal/nonverbal cues and adjusting time/adjusting teaching style). Finally, a coding scheme was drawn up in which the verbal and nonverbal cues as described in Table 1 was compared

with the instructional decisions as described in Table 2. By composing separate coding schema for all teachers, the similarities and differences can be displayed.

Table 5

Examples of Codes of Alternative Teaching Strategies

Example in interview	Code(s)	Overarching category
I noticed that the first calculations were actually quite good, so I increased the difficulty of my calculations again to accommodate that.	Adjusting difficulty level	Adjusting learning material
We perform instructions with half the group three times a week and then we actually have the weakest students. That is a small group, there are still ten. And we do a lot more with concrete material.	Imbedding different learning resources	Adjusting learning resources
When the students looked at me and when they did not raise their hands, I thought: I don't think this works at all. I'll go back to where I was. Then I'll start the instruction all over again.	Adjusting instructional time	Adjusting time
I also think modeling because they no longer knew what I was talking about.	Modeling a solution strategy	Adjusting teaching style

2.5 Procedure

2.5.1 Procedure for Participants

Each participating teacher was asked to prepare a basic mathematics instruction of between 10 and 30 minutes where previously offered teaching material is re-instructed. In this way, teachers could make proper instructional decisions based on student knowledge and knowledge about the subject-matter beforehand. The teachers were asked to prepare this instruction in the same way as they normally do and to write down briefly what instructional decisions they made before the instruction took place with the goal of discussing this at a later time in the interview. To write down these instructional decisions, teachers were asked to use the differentiation skill hierarchy by Van Geel et al. (2019). To ensure the teachers would teach similar as usual, there was no consultation between researcher and teachers about student knowledge before the instruction took place.

Before using the eye tracking glasses a brief instruction was given to the teachers. The Tobii Pro Glasses 3 was adjusted as desired in order to meet the wishes of the teacher by making adjustments with nostrils, an adjustable cord behind the head to secure the glasses, and adding extra prescription lenses in case teachers wears glasses in normal life. After placing the Tobii Pro Glasses 3 on the head, a one-point calibration was used for recording gaze and to ensure optimal accuracy (Holmqvist et al., 2022) for every participant. For calibration, teachers were asked to perform a small initial task of looking at one pre-defined target that was presented in front of them. When the teachers fixated at the target, the eye tracking glasses registered the relative positions of features for each calibration point. The eye tracking software itself determined which segment of data is used for calibration. After calibration, the eye tracking glasses presented the accuracy of the calibration. With sufficient accuracy, the study continued. When the researcher deems the accuracy insufficient, recalibration was performed. After the instruction took place, the recording of the Tobii Pro Glasses 3 was stopped by managing the accompanying controller application and immediately exported to a computer running the Tobi Pro Glasses 3 controller application.

With a maximum of one day after the instructional lesson, the participating teachers took part in an interview. All interviews lasted between 39 and 68 minutes. This interview was performed in the classroom where the teacher works. Only the researcher and the teacher were present in the room to stimulate a confidential environment. When both the teacher and researcher were seated at a table, permission was requested to make recordings with a dictaphone. After permission, the teacher was thanked again for participating in the study. It was also discussed that all recorded material is confidential and destroyed five years after completion of the study. The purpose of the study was mentioned again and the structure of the interview briefly discussed, including maximum length of time, types of questions, and viewing of the video recordings. It was emphasized the teacher could speak freely.

Although the researcher had devised semi-structured questions in advance to shape the interview, the teacher was also told they were encouraged to contribute certain knowledge and information. Subsequently, the selected video fragments were viewed one by one and the teacher was asked about the perception of visual cues, reasoning for instructional decisions, the instructional decisions based on the observed visual cues, and the relation between instructional decisions and student knowledge. After viewing all fragments, the researcher thanked the teacher for participating. It was stated that the teacher may ask at any time to listen to the recording or to have it destroyed.

Interviewing gave the opportunity to make recordings, so that the research material could be followed and checked. After the analysis, participants were asked whether the study's interpretations and conclusions matched their perspectives. This guaranteed that a correct interpretation has been given to the views of the participant (Baarda et al., 2021).

2.5.2 Ethical Considerations

Eighteen teachers were initially asked to participate in this study and invited by means of an information letter (Appendix A) via e-mail. The information letter explained the selection of the participants, aim and method of the research. A consent form was sent with this email, which was completed by all the participants. The letter obtained information about how to transcribe, store and retain data. This was also explained before the eye tracking and interviews.

After the teachers gave permission (Appendix B), the parents of students were informed about the study through an information letter (Appendix C). The letter explained the purpose of the study, method of research, data collection and the removal of the collected data. Parents were asked to fill in a written consent form (Appendix D) and to return it to the teacher. The course of events in this study, including the information letters and consent forms were approved by the Ethics Committee of the university of Twente (EC case number 221352).

Video recordings of teachers in the classrooms were stored in the database of the university. The videos were secured with an untraceable password. The transcripts of the interviews were anonymised. Personal data is not reported in the research report. With compliance for the GDPR Act, the legal aspect in this study is sufficiently insured.

3. Results

In this section, both quantitative and qualitative results of the research are presented using the results of the eye tracking data and interviews by following the previously described methodology. The first paragraph provides a description of the mathematical instructions, in which the teachers briefly reported on the several instructional decisions they made beforehand. Second, the data obtained from the eye tracking is described to provide insight into the instructional decisions teachers made during enacting the instruction itself, hence to answer the following research question: 'Which (non)verbal cues do teachers consider to be most important for making instructional decisions?' The goal of examining this data is to determine the type of cue that seemed most interesting for teachers to decide on ad-hoc instructional decisions and additionally to examine the similarities and differences between teachers in terms of viewing behaviour. Subsequently, data obtained from the interviews was used to reason the interpretation of certain observations, since observing cues considering the affective and cognitive state (e.g. facial expressions and body language) was dependent on the interpretation of teachers. For example, teachers had to reason whether they focused on observing body language or facial expressions during certain observations. It was used to answer the following questions: 'How do teachers direct their viewing behaviour in elementary classrooms during a differentiated mathematics instruction to notice (non)verbal cues from students in grade 2-5?', 'Which pedagogical student knowledge do teachers use to differentiate?', and 'Which instructional decisions do teachers use on the fly in a differentiated mathematics instruction?'. In the interviews, teachers were asked to argue the kind of student information they used to interpret certain observed cues during the eye tracking videos and the subsequent instructional decisions they made.

3.1 Instructional Decisions in the Differentiated Instruction Made Beforehand

The teachers briefly reported on the instructional decisions they made before enacting the differentiated instruction itself. All teachers instructed on a lesson goal which was already offered to the students in an earlier lesson. Participants 1, 2 and 4 divided the group within sub-groups, in which students were classified based on their performance level. ***Participant 1*** instructed on a goal in which a ratio table was presented with multiplication and division. The goal had been instructed once before. The teacher assumed the students already had some knowledge about the lesson objective. The group included both students with excellent performance in mathematics and a group of students dependent on instruction as well. In her preparation, she assumed that she could repeat the goal and quickly get the high-performing students to work independently and could focus on the instruction-dependent group. ***Participant 2*** mainly provided instruction to students who performed excellently and also students who required short and concise instruction. The teacher offered a lesson in which students repeated multiplication with decimals. Based on preliminary testing of the goals, the teacher has

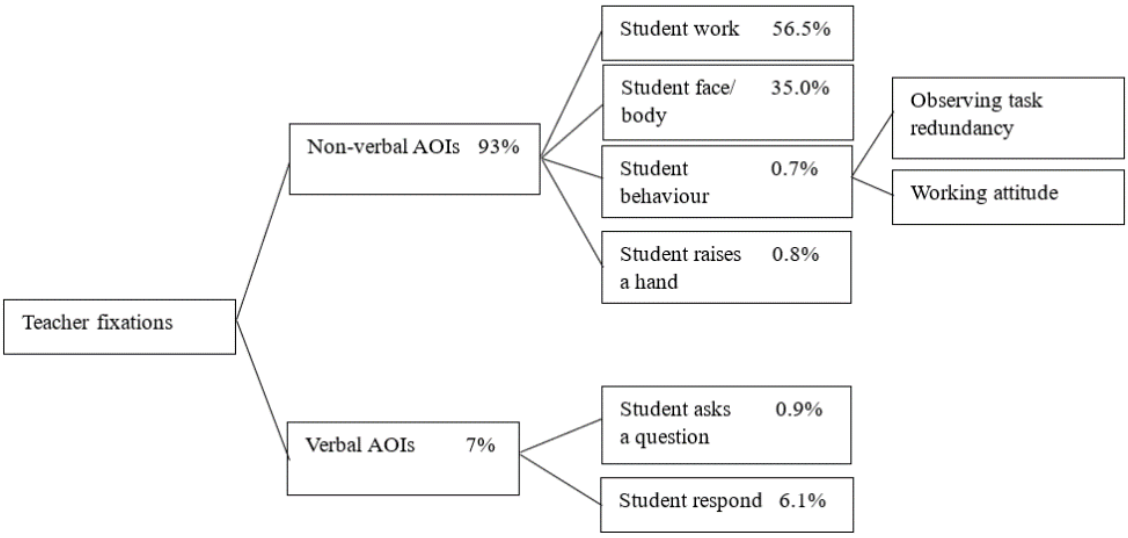
decided to put a number of students work independently without instruction. ***Participant 3*** instructed on students performing at all levels. The differences in performance between students were enormous. The teacher instructed the students to place numbers up to and including 100 in the correct position on the number line. This was an inserted repetitional lesson, since the teacher felt that students could use more practice. Based on previous lessons with the same lesson objective, the teacher made the choice as to which students were allowed to work without instruction and which students had to participate in the instruction. ***Participant 4*** instructed the column-by-column division. The group mainly consisted of students who have difficulty with mathematics. She took this into account in the preparation of the lesson. Students worked on the lesson objective in earlier lessons.

3.2 Noticing Cues During the Instruction

To decide on which (non)verbal cues teachers considered to be most important during the instruction itself for making instructional decisions, eye tracking data was analysed. The interview data subsequently adds depth to these observations, since teachers explained the reason why they were focused on a particular cue. Analysis of the eye tracking showed teachers used both nonverbal and verbal cues. A total of 8 different codes were used to report on either nonverbal AOIs or verbal AOIs, as depicted in Figure 4.

Figure 4

Areas of Interest of the Participants During Mathematics Instruction



On average, 93.0% of the total number of fixations were aimed at observing nonverbal AOIs, and no more than 7.0% of the total number of fixations were aimed at observing verbal AOIs. In general, most teachers acquired most information from observing nonverbal cues. At the same time, teachers differed in this regard, as shown in Table 6. Those teachers who started at the beginning of the school year with their students (P1, P2 and P3) were more focused on nonverbal AOIs. The teacher that started later in the school year (P4) focused more frequently on verbal AOIs.

Table 6.

Percentage of Number of Fixations Within Participants and on Average

		% number of fixations P1	**% number of fixations P2**	**% number of fixations P3**	**% number of fixations P4**	**% average number of fixations**
Nonverbal AOIs	Student work	49.4	54.9	60.4	15.7	**56.5**
	Student face/body	41.8	40.7	25.1	19.3	**35.0**
	Student raises a hand	0.0	0.0	3.1	4.3	**0.8**
	Student behaviour	2.0	1.3	0.0	15.7	**0.7**
Verbal AOIs	Student asks a question	2.5	0.5	0.3	2.1	**0.9**
	Student respond	4.3	2.6	11.1	42.9	**6.1**

3.2.1 Nonverbal Cues

Within the nonverbal AOIs, teachers were mostly focused on student work and students' faces/bodies. For fixations regarding to the work of students, teachers focused at both the work in the students' exercise books and the work on small erase boards. All teachers used small erase boards in their instruction to make students write their calculation or answer of an exercise in the instruction.

Furthermore, analysis of the eye tracking recordings showed that teachers were also focused on the students' faces/bodies. Teachers were focused on these type of cues 35.0% of the total observations on average. The distinction between observations focused on the students' faces and body language was not made in the eye tracking analysis, however in the interviews teachers were asked to explain the observations they made within students' faces and/or bodies. In their responses, teachers indicated they often combined these two cues to estimate how students performed with regard to the lesson objective. In the interview with participant 2, the researcher asked for the observation within the student.

> **R**: '*So you actually notice that L. did not give the right answer either. How do you see this with L.?'*.
> **P2**: '*Because I know L. well from my own group, but I often see a doubting attitude in L. He gets a bit of a questioning look on his face. His shoulders slump a bit, and he looks from the instructional board to erase board, to the instructional board and back again more often. Well, you know, those are actually all signs that I can tell he is doubting his answer. And if I know that he doubts his answer, it means that he does not always get the answer right either.*'.

In summary, teachers made use of the cue 'student work' the most, followed by focusing on the cue 'student face/body'. Therefore, checking the work of students seemed the most interesting for teachers. Additionally, teachers argued they combined the observations of the students' faces and bodies with the intention of estimating student progress.

3.2.2 Verbal Cues

In general, most of the participating teachers did not seem to be as focused on perceiving verbal AOIs compared to nonverbal AOIs. Merely 7.0% of the total fixations were aimed at observing verbal AOIs. Within this category, teachers appeared to be focused mostly on a student respond. However, differences between the teachers can be established. The teacher assigned to the class at a later time in the year (P4) was more focused on verbal AOIs and to student responds in particular compared to the other teachers. This teacher was fixated on the student responds 42.9% of the total

fixations, consisting of responds to the teacher's questions. In her instruction, this teacher frequently made the students verbalise the steps they used to work on the lesson objective. In the interview, the researcher asked the following.

> **R**: '*(..) Do you notice something within him, that he finds it difficult?'*
> **P4**: *'Yes, not quick to answer, so to speak. In itself, that processing takes a little longer in his head. That it is not fully automated. That he has difficulty naming it quickly.'*.

To summarize, teachers did not seem to obtain extensive information from verbal cues compared to nonverbal cues. Within the verbal AOIs, teachers tended to focus more on student responses than questions of students. Additionally, the teacher with the least knowledge about students appeared to make more use of student responds than the other teachers, suggesting that the extent to which teachers obtain student knowledge influences the cues they were focused on.

3.3 Viewing Behaviour

Considering teachers appeared to be fixated on student cues, data from the interviews were used to examine how teachers (sub)consciously and deliberately directed their viewing behaviour to notice these (non)verbal cues from students. All teachers mentioned they consciously controlled their viewing behaviour towards 5 different areas, presented in order of importance: student work, students' faces, students' body language, students with certain characteristics and task redundancy.

3.3.1 Student Work

During the interviews, teachers mentioned in 28 utterances they observed student work. In order to observe the work of students, teachers reported to consciously directed their focus towards the work of certain students. They were either fixated on the occurrence if students wrote or did not wrote something down. Furthermore, teachers argued the information students wrote down offered them insights into how individual students mastered the lesson material. For instance, one of the teachers indicated that using the erase boards gave her a quick insight into the individual progress of students about whom she had certain prior knowledge.

> **R**: '*Yes, you spend a little more time thinking about a number of students after this fragment. You looked at her erase board a little longer*.'.
> **P3**:*'Yes to J. J. finds it difficult. And F., I know, also finds that difficult. And S. I know he can*

do it, but he does not always show it. So with him it is mainly a matter of checking: does he do what I ask him to do?'.

Next to interpreting the work of a single student, observing the work of several students caused the teachers to make instructional decisions for the whole group of students. For example, one of the teachers (P1) mentioned she could sped up her instruction based on what students wrote on their erase boards.

R: '*You notice that you go through it* [the instruction] *faster'.*
P1: '*That is because, I think, with the erase boards they understood. They also understood it with that first calculation. Then I thought: well, I think I can get through it faster now.'*.

Summarizing, all teachers indicated that they consciously directed their viewing towards the work of certain students in order to estimate how these specific students were performing in relation to the lesson objective.

3.3.2 Students' Faces

Next to observing the work of students, teachers mentioned to check the students' faces at several moments during the instructions. A total of 17 codes were assigned to observing students' facial expressions. Throughout the interviews, teachers were asked to argue and interpret the facial expressions they observed. In doing so, teachers were asked what features they observed within the face of students and how they interpreted this. They mentioned facial expressions such as: surprise, satisfaction, cheerfulness, pride, furrowed eyebrows and frustration. In one of the interviews, the researcher asked the teacher to reason for the observation within a student's face.

R: '*Do you consciously look at something within the students?'*.
P1: *'I looked at the students' faces. They were amazed. They looked surprised. They knew… I felt like they did not know what I was talking about.'*.

When assessing student progress based on students' facial expressions, teachers referred always to the knowledge they had about the students. All four teachers stated that they consciously observed students' faces to assess whether the students understood the instruction.

3.3.3 Students' Body Language

During the interviews, teachers additionally made frequent use of observing students' body language in order to monitor student progress. In 16 assigned codes they mentioned several observations of body language, for example: the presence or absence of a raised hand, looking into the air, sitting incorrectly on a chair, sitting slumped, an active attitude, leaning backwards, restlessness, a doubtful attitude and slumping shoulders. In the following fragment, participant 3 targeted her viewing towards one of her students, since she already noticed remarkable body language within this student.

> **R**: '*What makes you conclude that he finds it difficult? Or that he made a mistake?*'.
> **P3**: *'Yes, I already saw it. I saw him leaning back and he wanted to grab something and I thought: something is happening there. While the rest are just sitting there, just working. And then you see him too: his head goes back and forth. He has a bit of hair, he puts it in front of his head. (…) And here I also saw that he noticed it himself. Half the time he does not realize he is wrong. Then he thinks: o, that is going well.*
> **R**: '*How did you see this?*'
> **P3**: '*Restlessness within himself*.'.

This teacher consciously observed this student in the fragment in order to be able to estimate, based on the body language, how this student is performing with regard to the lesson objective. The other teachers appeared to possess extensive student knowledge as well to decide on students' needs based on the body language of students.

3.3.4 Students with Known Difficulties

In 14 utterances, teachers indicated that observations were targeted towards students with certain characteristics in order to estimate how the student was performing in relation to the lesson objective. Analysis of the interviews showed that teachers were mainly focused on students with a lack of concentration and focus and a delay in working pace. One of the teachers mentioned she consciously directed her viewing towards a certain student of which she knew had difficulty to concentrate and focus on the instruction.

> **R**: '*Precisely, and do you consciously give him a turn at this moment?'*
> **P4**: *'Yes, for a moment, really, do you understand it now, and that he shows a little more involvement*.'.

This teacher remarked that these characteristics were not always associated with student performance. In this example, the teacher argued that the student is not a low achieving student, however she checked on him based on certain characteristics.

> **P4**: '*No, he is not very weak, no, no, no. But just to get involved in the work and just to have that concentration*.'.

The working pace of students was also mentioned by teachers several times. It mainly consisted of students with a slow pace of working. One of the teachers referred to one of the moments she observed the work of students with a delayed working tempo. Because of the knowledge she had about the students, she consciously observed their work.

> **R**: '*All right, so the working tempo of the students?'.*
> **P1**: '*Yes, because of the students I just walked by, they do not go to work. You have to put them to work.*'.

Recapitulating, throughout the interviews, teachers mentioned they consciously checked the work of students with mainly a lack of focus and concentration and a delayed working tempo more often to either examine if they were involved with the instruction and whether they understood the lesson material.

3.3.5 Task Redundancy

During the interviews, two out of the four teachers (P2 and P4) indicated that they were focused on students who exhibited task redundant behaviour. Both teachers remarked that their focus was drawn onto certain students, since they exhibited task redundant behaviour during the instruction and this distracted the teachers. Participant 2 seemed to find this behaviour particularly disruptive to his instruction. In the interview, the participant answers the following remark from the researcher.

> **R**: *'Then you look very briefly at the next student.'*.
> **P2**: '*I'm still looking at R. to check. Then my gaze goes to O. to check and then to K. And K. catches my eye, and I now put her on the other side of the class, because she also tries to draw attention to herself several times at the beginning of the lesson. Or talk through the instruction, throw in comments. That is known. K. is in my own class and is just a girl who has difficulty with that. But her behaviour by disrupting my instruction every time I am busy, led me to putting her at a different side of the classroom at that moment. She did not like this either. I checked her regularly after that. I also saw that she found it difficult to pick up the instruction again.'*.

Both teachers did not indicate that they used this behaviour to assess whether students find the lesson material challenging. In contrast, participant 4 mentioned she was focused on a group of students who showed task redundancy, although she indicated she was only focused on this group of students since the behaviour distracted her. She explained that she did not use this behaviour to assess their progress. The following passage briefly illustrates this.

> **R**: '*You actually see that you are watching the video that you are playing on the screen and that your gaze is focused on a number of students. Is it consciously that you are looking at these students?'*.
> **P4**: *'Yes, they also make noise at that moment. They are easily distracted and that naturally attracts my attention*.'.
> **R**: *'So that is actually more behavioural than you think cognitively: I have to keep an eye on these students?'*.
> **P4**: '*It is behaviour indeed, yes*.'.

Nevertheless, the teachers mentioned that the students described in the fragments above, appeared to exhibit this task redundancy more often. However, the teachers do not use this behaviour as a source of information to determine student progress.

3.4 Pedagogical Student Knowledge

The data obtained from the interviews was used to decide on which pedagogical student knowledge teachers used in order to differentiate mathematics instructions. During the interviews, teachers often referred back to the knowledge they acquired about students. A total of 92 quotations had been assigned to student knowledge. In 61 utterances, teachers mentioned observations within facial expressions and body language during their instruction with the goal of composing student knowledge and determining students' needs. Furthermore, in 31 utterances teachers referred to the performance level of students, which is according to teachers based on analysing student results on tests and the lesson material. Teachers argued they constantly made use of combining all this information to determine what students needed at certain moments during the instruction.

3.4.1 Facial Expressions and Body Language

The most frequently mentioned type of student knowledge concerned a combination of the facial expression and body language. The teachers always used their prior knowledge about students gained in earlier moments to interpret the facial expressions and body language of students during their instructions. Participant 1 argued in the interview she made the decision to make students work

independently further on the lesson objective in their exercise books based on the signals she received from students during her instruction and put this into perspective with her prior knowledge about these group of students. She decided the students could work independently.

> **R**: '*I want to play the fragment. But at a certain point you say to the students: you can continue working independently. Is there something you observe during the lesson? Do you look at the students, do you look at the body language?'.*
> **P1**: '*yes, the students are satisfied and look happy. Yes, it's not happy. Yes, looking satisfied with the work and that I can see how the work was made. That I also look at the exercise books.*'.

The researcher asked for more detail about the prior knowledge the teacher had about these students.

> **R**: '*And then you actually choose to let go of the students and guide them less.*'
> **P1**: '*Because I think this group of students can do that. Because this group performs at that level that could or should be able to do that*.'.

All teachers reasoned that every observation they make and decided on instructional decisions, at all times was put into perspective with the prior knowledge they had about students. They argued that they interpreted the needs of students based on a combination of facial expressions and the students' body language.

3.4.2 Performance Level of Students

A second source of information that teachers reported to use in their observation strategies and decision making was performance on (curriculum tests and) student monitoring systems. All teachers systematically used results on various tests to estimate how students generally performed on mathematics and how they performed on the lesson objective. The teachers used data from CITO tests to classify students into different performance levels. Based on CITO tests for mathematics, in which the performance of students is compared to the average of students in the Netherlands, students are classified into four levels. These teachers considered the results on this test leading in classifying the students in level groups, of which participant 2 was asked during the interview.

> **R**: '*(…) So you looked at the CITO scores and you actually also looked at the student characteristics for a number of exceptions. You have also used, for example, data from the mathematical teaching method themselves?'*.
> **P2**: '*Yes, they also play along. The tests in the mathematical method were used as additional support for determining the groups. But the CITO test results really determine how the*

children scored. This also indicates that we had to shuffle the groups around halfway through the school year because the children scored slightly less or slightly better. For example, two students in my group, no, three students, returned to the other group and two from the other group came back to me.'.

Furthermore, teachers mentioned to use information obtained through the individual processing of the lesson material. The teachers reported to use observations of student work on the lesson material to determine to what extent individual students understood the lesson material and to determine the needs of specific students at that moment. One of the teachers mentioned she decided which students should participate in the instruction based on the preparation of the lesson period.

R: '*And in your instruction that you gave yesterday, do you take different students in the instruction every time?'.*
P3: '*(…) No, I just look at the block preparation for each lesson to see who should participate. We keep track of this during those tests and then determine who participates. I do not think you miss anyone because of that. And I have S. for example. He actually always participates in the instruction simply because he then focuses, otherwise he just fills in something. And this is actually the same case with N.'.*

In conclusion, the performance level of students seemed to be of importance during the preparatory stages of differentiation and guided as a basis for further preparation of lessons with certain lesson objectives.

3.5 Instructional Decisions

To report on the instructional decisions teachers made on the fly during the differentiated mathematics instructions, data from the interview was used. Throughout the interviews, teachers referred to instructional decisions in 60 utterances. In total, 16 different teacher strategies had been referred to, as shown in Table 6. Adjusting the time, teaching style and learning material were mentioned most frequently. The following paragraphs explain which examples of adjustments occurred most often. The teachers reasoned that they believed certain instructional decisions were most effective for a certain student in certain circumstances.

Table 6

Reported Teaching Strategies during Differentiated Mathematics Instructions

Teaching strategy	Examples of adjusting instructions	Amount of strategy used
Adjusting learning material	Difficulty level of instruction	6
	Difficulty level of work	2
	Amount of material	2
Adjusting learning resources	Imbedding different learning resources	4
Adjusting time	Extended instruction	3
	Processing time	1
	Instructional time	21
Adjusting teaching style	Using different wording	1
	Giving feedback	3
	Scaffolding	4
	Modelling	4
	Giving a hint	7

3.5.1 Adjusting Time

Teachers reported in 25 utterances they adjusted the time. Within this overarching strategy, they mentioned in 21 expressions to modify the instructional time. The participants indicated in the interviews that adjusting the instructional time on the one hand is about lengthening instructional time and on the other hand it is about accelerating instructions based on the signals they observe amongst students. For example, one of the teachers decided to take more time to instruct the students on the lesson objective. She argued she thought the students had retained more of the lesson material during the instruction the day before. She noticed from the students' answers they did not know what the lesson objective was about. The teacher (P1) decided she needed more instructional time. In the interview, the teacher mentioned the following

> **P1**: '*This was a new lesson period, so that really means a new topic and they had already received an instruction from V. [colleague] yesterday, so I had assumed that they would be able to do a little more. Afterwards, when I was instructing on the lesson objective, no. I assumed they could do more at that moment, but then I went back in my instruction a little more and then I looked and thought, well, then I have to explain a little more. I had assumed, because when I asked what they did yesterday, no one could give ma an answer, what they did. (…)'.*
> **R**: '*So you give a turn to a number of students. You actually hear an answer and you think, that does not actually make sense? So then you make a certain instructional decision, which means you start over and explain everything again. And you actually take more time for your instruction than what you had planned in advance?'*
> **P1**:*'Yes.'*.

Although teachers reported to lengthen the instructional time, they also indicated during the interviews that they sped up the pace of the instruction based on what they observed. Participant 3 referred to an observation on student work. She concluded that students were doing well in the instruction, and she decreased the pre-conceived instructional time.

> **R**: '*And what did you conclude from what you say at this moment?*'.
> **P3**: '*Well, that it went a lot better than before. I knew that some of them would not write down tens, but the neighbouring numbers. So I had to say that again. Well, I had already discussed it with some of them before. Things were going better now. (…).'*.
> **R**: *You are actually saying: I see in this short fragment that things are going better now.'*.
> **P3**: *'Yes, I thought I would do more calculations. And I think I even stopped after 3 or 4. (…).'*.

While teachers mentioned speeding up or slowing down the instruction, they always referred to the observations they made during their instruction. It indicates teachers observe signals they receive from students during instructions in order to make ad hoc decisions about the duration of the instructions.

3.5.2 Adjusting Teaching Style

Analysis of the interviews pointed out that teachers 19 times notified to adjust their teaching style. The following strategies were reported on most often: 'giving a hint', 'scaffolding' and 'modeling'. The teachers indicated that they gave hints to a group of students in general during their instruction, or specifically to one of their students whence they observed difficulties. The hints mentioned in the fragments were often short and focused on certain teaching material that students already mastered in advance. To illustrate this, a fragment of the interview with participant 3 is highlighted. From the student knowledge she possesses, the teacher knew where the pitfalls in the lesson could occur. She provided the students with a general hint to avoid this pitfalls. She observed from the work of students that the students performed better after providing this hint.

> **R**: '*What did you conclude from what you saw at this moment?'*.
> **P3**: '*I knew that some of them would not write down tens, but the neighbouring numbers. So I had to say that again. Well, I had already discussed it with some of them before. (…)'*.

While using the strategy 'scaffolding', the teachers mentioned they observed one of their students experienced difficulty with the lesson objective. They decided on the spot to scaffold the lesson material in order to guide their student towards the right answer. For instance, participant 1 observes the work of one student, reasoned during the instruction that he struggled with a calculation and decided to scaffold him towards the correct calculation. Before the researcher asked the teacher to describe this moment, the following fragment was replayed.

> **Fragment**: [*'What is wrong, M.? First divide it. What division did you make? (…) So you also divide the bottom by 2.'].*
> **R**: '*You are looking at M.'s work here, aren't you? And in doing so you actually make a decision. How are you going to help him in this case*?'.

Based on the prior knowledge the teacher had about this student, she realised what to expect from him and the way she could best help him in this fragment.

P1: '*Yes and also. Of course I have M.'s inside information. And what M. is like and M. is sometimes easy. He thinks: I can do it all. And he is dreamy and he doesn't always sit up straight, and he thinks I can do it all. So that's why I give that reaction to M. at that moment. It's not just about his work that he. But I know he can.'*.

Next to scaffolding and giving hints, teachers described they used modelling to exhibit an effective way to perform a calculation with the intention for students to imitate this way of solving the calculation. Teachers argued that modelling the lesson material is an effective way for students who construct new information and for students who encounter difficulties. During the interviews, teachers often called this 'guiding by the hand', since they explain step by step what students have to do, and demonstrate these steps for students to imitate them. Participant 1 experienced her students encountered difficulties during her instruction, decided to start the instruction over again and to model the lesson material. She described to guide her students by the hand in the following passage.

R: '*And guide them by the hand. What do you mean? Do you demonstrate things or do you ask questions, for example, to help students along the way?'*.
P1: '*And and. I also think it occurred because they no longer knew what I was talking about*.'.
R: '*So actually modelling?*'.
P1: '*Yes. And also afterwards I made them do the second calculation alone. Partly had it done alone and then tried it themselves. Because I think they could do it then. (…)'*.

When making use of the strategy adjusting the teaching style, teachers mentioned giving hints during instructions most often. These hints take little time, since they are often short in nature and based on the knowledge students already developed. Additionally, teachers utilised scaffolding and modelling as well. Modelling was applied for the entire group of students and for individual students experiencing difficulty regarding the lesson material as well. The teaching strategy scaffolding was mainly used for the individual student considering this student should be able to master the lesson material with a certain amount of guidance.

3.5.3 Adjusting Learning Material

The teachers pointed out adjusting the difficulty level of the instruction the most, in which they adapted the difficulty level of the learning material during the instruction. In total, 6 utterances were assigned to this code while analysing the interviews. The participants selected effective instructional materials during their instruction considering the needs of students. They mentioned increasing or decreasing the difficulty level of calculations they used during their instructions. In order to do so, teachers observed cues from students to make interpretations about their progress. Participant

2 specified he adjusted the difficulty level of his instruction based on the observations of students. At the end of his interview, the researcher asked him to specify the instructional decisions he made which were not already mentioned throughout the rest of the interview.

P 2: '*Well, the difficulty of course. I increased the difficulty level during the instruction*'.

In conclusion, teachers increased or decreased the level of the used calculations during their instructions, and this seemed the most used strategy within adjusting the learning material. The adjustment of the level of work and amount of material are mentioned less often by teachers during the interviews.

4. Conclusion, discussion and implications

4.1 Conclusion

This study aimed to determine (1) how teachers observed and interpreted nonverbal and verbal cues of students during a differentiated mathematics instruction in order to estimate student progress and (2) how teachers used these observations with the purpose of selecting and carrying out (alternative) teaching strategies to answer the following research question: 'How do primary school teachers observe and interpret (non)verbal cues of students to inform them on student progress and consequently decide on an appropriate teaching strategy to enhance a differentiated mathematics instruction?' The conclusion is based on the analysis of the eye tracking videos and the results of the interviews.

All teachers involved in this study mentioned the importance of the relationship between student knowledge and observing cues on the spot, interpreting student progress and instructional decisions. In order to decide on the needs of students and the corresponding instructional decisions, they always decided with the knowledge of the students in mind. To develop student knowledge and decide on student progress, the teachers mentioned they collected this information through test results, the performance of students in earlier lessons and during the instruction itself. Hence, teachers are continuously combining information gathered in the several stages of the differentiation skill hierarchy with the purpose of deciding for the most suitable instructional decision for students in certain circumstances.

In the interviews, teachers explained they consciously targeted their viewing towards students with known difficulties regarding the subject matter or students with particular characteristics. Within observations on students with these characteristics, they mainly focused on students with certain working pace, working attitude, concentration and uncertainty. Additionally, this study provides insight into the cues teachers considered to be most interesting. While focused on observing student cues during the instruction, analyses of the recorded instructions showed three out of four teachers were mainly (93% of the total observations measured) focused on observing nonverbal cues. The most common factors being observed by teachers consisted of: observing students' work, observing students' faces, and observing students' body language. Teachers considered observing the work of students to be most interesting. They observed written calculations and answers to a given question in order to monitor student progress while enacting a differentiated instruction. In addition, teachers observed the faces of students and the body language and interpreted the observations with the knowledge of students in mind. They were able to observe, interpret and accordingly make instructional decisions in a split second.

Furthermore, in this study differences in viewing behaviour between teachers can be established. In contrary to the teachers fixated on nonverbal cues, the one teacher appointed later in the school year was mainly focused on observing verbal cues. In 42.9% of the total fixations of this specific teacher, she was fixated on observing student responds. This teacher frequently made students verbalise the steps they used during the performance of calculations in order to estimate student progress. Hence, the knowledge teachers acquired about students is considered to play an important role in the type of cue teachers were focused on.

Also, based on the observations that teachers made and interpreting these observations in relation to the student knowledge they acquired, they were able to determine the needs of students during certain moments in the instructions. Teachers made adjustments to instructions that they could reason was the best decision for the student at that time. This study contributed to gaining insights into the instructional decisions teachers considered to be most helpful, since teachers reported on several instructional decisions more often. Teachers most often mentioned adjusting instructional time, giving hints, scaffolding and modelling. While adjusting instructional time, teachers shortened or lengthened instructional time based on what the students needed at that moment. On the one hand this is about extending the time whenever teachers noticed students needed more explanation about the lesson objective. On the other hand, teachers indicated they shortened instruction time while noticing students understood the lesson material. In this case, they made students start working independently faster than they planned or speeding up the pace of the instruction itself.

In addition, teachers used hints since this was easy to realise in a short amount of time and these hints can build upon students' existing knowledge. Teachers indicated that the given hints focused on certain pitfalls of students that were known to the teacher in advance. Moreover, teachers indicated they used scaffolding and modelling to guide students with certain difficulties to the correct answer. While using scaffolding, the teachers encouraged students to think out loud in order to guide them towards the correct answer. In modelling this worked reversed, since teachers were in the lead of explaining step by step what students had to do. Teachers demonstrated these steps in order for students to imitate them and learn effective mathematical strategies. In the interviews, teachers often called this 'guiding by the hand'.

In summary, teachers mentioned they consciously and deliberately guided their viewing towards observing mostly nonverbal cues of students with known difficulties regarding the lesson objective or students with certain characteristics in order to monitor student progress. While observing nonverbal cues, teachers were mostly focused on observing students' work, observing students' faces, and observing students' body language. In order to interpret these cues, teachers explained they always combined information gathered throughout the different stages of differentiation to develop student

knowledge with the aim of interpreting student progress based on observed cues. The instructional decisions that result from these interpretations are therefore always dependent on the combination of information about students regarding the performance on the subject matter and students with certain characteristics in mind. Teachers reported on using adjusting instructional time, giving hints, scaffolding and modelling the most.

4.2 Discussion

This study aimed to gain insight into how teachers perceive and interpret student cues during differentiated mathematics instructions in order to monitor student progress and make appropriate instructional decisions. The results of the study show teachers consciously notice cues from students during these instructions. Teachers focused on students with difficulty regarding the subject matter and students with certain characteristics. The type of cue teachers focused on differed between teachers. Three out of four teachers focused on observing nonverbal cues. They focused mainly on the work, the facial expressions and body language of students. In contrary, the other teacher focused on verbal cues. She seemed to get most information from student responses. Although teachers seemed to be fixated on different cues, all teachers used earlier gathered information about students to interpret the cues they observed and decided on the needs of the students on the spot. Subsequently, teachers made instructional decisions during the instruction on the fly they could justify based on all observations and interpretations. They mentioned to adjust instructional time the most, followed by giving hints, scaffolding and modelling.

In theory, teachers are considered to consciously notice students with expected difficulty more often (Berliner, 2001; Kosel et al., 2021). The study confirms teachers intentionally targeted their viewing towards certain students experiencing difficulties regarding the learning material and students with certain characteristics with the purpose of observing cues within students. In order to do this, theory suggests they observe both nonverbal and verbal cues (Jacobs et al., 2010; van Amelsvoort et al., 2013; van Es & Sherin, 2008), however this study shows differences in the type of cue that is being observed. It appeared three out of four teachers focused on observing nonverbal cues. One of the teachers in contrary seemed to be more focused at observing verbal cues. Available research on the differences of viewing behaviour between teachers would suggest novice teachers notice student cues in a different way compared to experienced teachers (van Amelsvoort et al., 2013). This study found no evidence to support this, though it suggests the differences can be attributed to the degree of student knowledge. The results in this research imply the degree of student knowledge determines the way in which teachers were focused on a specific type of cue. Specifically, teachers appointed at the beginning of the school year mostly focused on perceiving nonverbal cues. These teachers were

considered to have gathered more knowledge about their students. They seemed to be able to make quick interpretations of student progress based on the work, body language and facial expressions of students. The one teacher appointed later in the year had the most teaching experience, though had less time to develop knowledge on performances of students and specific student characteristics. Hence, it suggests besides analysing performances of students, getting to know the specific characteristics, behaviours and facial expressions that belong to specific students and how these specific factors relate to the students' understanding seems to be highly important for quickly interpreting student progress. Therefore, this study gains insight into the influence of the degree of student knowledge on the type of cue that seemed to be most informative for teachers during instructions in order to estimate student progress.

Teachers were supposed to have created a wide range of student knowledge and seemed to be mostly focused on perceiving nonverbal cues within students during the instruction itself. Specifically, they targeted to observe the work of students. The theory on identifying mathematical strategies of students aiming to resolve mathematical errors (Fernández et al., 2013) can be a possible explanation for these fixations. In order to attend to used strategies and interpret student progress, teachers could make use of the work of students to decide on issues regarding the lesson objective and decide on instructional decisions rapidly and effectively. In contrast, the teacher considered to have less knowledge of student on their performances and certain characteristics and how all these variables relate to their progress tended to focus more on verbal cues. Hence the teacher's lack of knowledge on student solving strategies asked for the teacher to interpret student progress based on verbalised student comments and this is supposed to take more time.

In addition, teachers with more extensive knowledge on student pedagogy check students with difficulty more often (Danielson, 2007; Hollingsworth & Ybarra, 2017; Kosel et al., 2021). Interpreting the students' facial expressions and body language could cause teachers to interpret student progress quickly and expand their knowledge on students and their needs at the same time. The study of Pabba and Kumar (2021) suggests that recognizing and interpreting facial expressions is about predicting student involvement and possible frustrations and consequently teachers can decide on the students' needs. The results of this study confirms this theory as teachers mentioned they were focused on student engagement during the instructions and were inclined to anticipate certain frustrations within students.

In order to develop insights on prior knowledge of the students and their specific needs, teachers confirmed they combined all information gathered in the several stages of differentiation (Van Geel et al., 2019). Throughout all the interviews, the teachers emphasized the importance of combining all this information to decide for appropriate instructional decisions on the spot (van Es &

Sherin, 2008). Considering these instructional decisions, this study is consistent with the different teaching strategies as examined by Suprayogi et al. (2017), yet teachers used certain strategies more often. Taking the variety of differences between students into account, teachers in this study decided on the spot which instructional decisions were most effective and could be carried out quickly without making too many adjustments to the prepared instruction. This could be an explanation of the reason why teachers lengthened or shortened the instructional time, gave hints, used scaffolding and modelling the most, since these adjustments could be used without making too many adjustments to previously prepared instructions and will probably be the quickest and easiest to arrange.

4.3 Limitations

This study used a mixed methods explanatory sequential design. Overall, this design offers the integration of both quantitative and qualitative methodologies which enhances the results that can be acquired. However, this type of research design concerns certain limitations that can evoke discussion. In this study, the interviews were based on the analysis of the eye tracking recordings. Analysing quantitative data before the start of the qualitative phase may have caused bias (Toyon, 2021). For example, manually coding teachers' focus during eye tracking data may have caused teachers to be influenced while viewing the selected fragments during the interviews. This may have affected the authenticity of the data. However, using quantitative data in the form of real-life recordings is considered to be an effective instrument of making certain thought processes explicit (Caruth, 2013; Sutton & Austin, 2015) . Next to this, the qualitative data from the interviews can additionally strengthen the quantitative data in the eye tracking recordings, since teachers were asked to reason their quantitative results.

In addition, during the selection of participants, selection bias may have occurred (Baarda et al., 2021). The participants were selected on the basis of a professional relationship between the researcher and the participants. This could have caused the participants to behave differently during the observation and recording compared to other times during instructions in their classroom. At the same time, the professional relationship may have made participants feel comfortable about being honest about their decisions and actions (Coleman, 2019).

Furthermore, at the start of this study, an attempt was made to convince teachers to participate in the study until theoretical saturation would occur to increase reliability and validity. Due to technical difficulties with the eye tracking equipment during the research, merely 5 recordings were successful. As a result, it is difficult to generalize the results from this study for a broader population of teachers.

4.4 Validity and reliability

In this research, both stimulated recall interviews and eye tracking were conducted to determine the visual focus of participating teachers noticing important cues from students and to examine the reasoning behind the decision-making strategies based on the observed cues. This section discusses the validity and reliability of the used methodologies.

Data from the eye tracking served as a foundation for the questions in the interviews. Hence, the research was structured through a mixed methods explanatory sequential design. Validity in this type of design involves validity of both quantitative and qualitative data. First, eye tracking provided insight into the viewing behaviour of teachers in the classroom as a dynamic environment and this data was used in the interviews in order to make teachers reason their observations, interpretations and instructional decisions. This study therefore used multiple approaches with the purpose of gathering the necessary information to answer the research questions in more detail and to critically analyse the findings. For this reason, the combination of analysing both type of data increases validity (Abowitz & Toole, 2010).

Next to this, teachers were asked to wear an eye tracking device during their instructions. Since teachers wore eye tracking glasses, they were encouraged to perform their mathematics instructions as usual. Hence, teachers were asked to perform a mathematics instruction as they normally would do and therefore it increases ecological validity (Andrade, 2018). While performing their instruction, teachers were not explicitly instructed on their gaze behaviour to ensure spontaneous visual focus. In addition, before the researcher decided to continue with the recordings, the accuracy of the eye tracking measurements were established as the eye tracker was calibrated. It was therefore considered the research matches with construct validity (Harezlak et al., 2014).

In addition, the research used the eye tracking data in the interviews. Teachers were asked to recall their thoughts during the recorded instructional lesson. To enhance the accuracy of describing their thoughts, the interviews were conducted as quickly as possible after the instruction. Furthermore, a basic topic list (Appendix G) was used in which the concepts of the founded literature was incorporated into topics and questions for the interview. Therefore, it is considered this research corresponds to the standards of criterium validity. Besides this participants were asked to review the transcripts of their interview to endorse the interpretation of the interviews. Moreover, using interviews in largely exploratory fields of research is considered to be logical (Gray, 2004).

4.5 Implications

Although the results of this study should be interpreted and followed with caution, it provides more insight into the way in which teachers consciously direct their viewing behaviour during

differentiated mathematics instructions in order to notice and interpret student cues with the aim of monitoring student progress. First of all, the findings in this study suggest the amount of pedagogical content knowledge and student characteristics teachers have acquired could influence the way in which teachers direct their gaze towards either nonverbal or verbal cues within students (Hattie, 2013; van Amelsvoort et al., 2013). The results showed that nonverbal cues in particular were considered important by teachers with more extensive student knowledge. These teachers mainly focused on the work of students in order to identify the mathematical strategies in a quick and effective way with the purpose of determining the progress of students (Fernández et al., 2013; Stockero et al., 2017). The study contributes to the literature in the field of the importance of gaining student knowledge throughout all the stages of differentiation in order for teachers to immediately decide on student progress while interpreting students' mathematical thinking and deciding on their needs for further instruction (Baumert & Kunter, 2013; Fernández et al., 2013; van Geel et al., 2019). Hence, this information can be used to focus on effectively expanding knowledge of students especially in mathematical teacher training and further development of teachers involved in practice for a longer period of time (Shing et al., 2015).

Another practical implication could be that beginning teachers can use the knowledge and expertise of more experienced teachers to direct their viewing behaviour towards observing cues to assess student progress in their early career. The results in this study confirm teachers indeed use student cues during differentiated mathematics instruction to check on the performance of students and consequently make conscious choices for appropriate instructional decisions that best fit with the needs of students. According to the literature on noticing these cues, expert teachers develop automations in their viewing behaviour to notice meaningful cues within students and decide on students' understanding and appropriate adjustments to the instruction that they reason matches the best with student needs (Berliner, 2001; Heitzmann et al., 2019; Kosel et al., 2021). Since teachers involved in teaching for a longer period of time expand their expertise in noticing through experience (Wolff, 2016), beginning teachers could improve their noticing skills while they start working with the help of more experienced teachers. For example, novice teachers can use more experienced teachers as a teaching buddy to enhance their teaching effectiveness with the use of co-teaching (Chanmugam & Gerlach, 2013). In co-teaching, two teachers work together while sharing responsibilities in instructions and reflect on their practices in collaboration (Beninghof, 2020). Co-teaching in mathematics education especially seems to be effective on teachers professional development on noticing (Borko & Potari, 2020).

Finally, the findings reported in the current study shed new light on the use of eye tracking to map teachers' gaze behaviour. Eye tracking is increasingly being used in the field of research to gain insight into the thought processes of teachers (Beach & McConnel, 2018). However, little was known

about the way in which teachers are directing their gaze behaviour towards certain areas. The results in this study suggest teachers consciously aim to observe important cues by directing their gaze specifically at certain students. Hence, these findings provide new insights into the viewing behaviour from teachers during differentiated mathematics instructions. As a consequence, this could be considered when overarching stakeholders, such as teacher trainers, will develop teacher training programs targeted at enhancing differentiated instructions. The use of an eye tracking device could be supportive in such a training to monitor the visual focus of the participating teachers and can complement results of the video observations used so far in teacher training (Star & Strickland, 2008). Based on data of both instruments, teacher trainers could give targeted viewing advice to teachers during differentiated mathematical instructions, resulting in teachers professionalising their noticing skills (Jacobs et al., 2022; Van Es & Sherin, 2008; Wyss et al., 2021).

4.6 Recommendations for Future Research

The current study can be interpreted as a first step in further research into consciously perceiving cues with the aim of making effective instructional decisions. Although the results of this study should be treated with caution due to the small sample size, the study suggests teachers do consciously use cues of students to inform them on student progress. Hence, noticing cues of students seems to be a skill teachers use while performing a differentiated instruction. Therefore, future research should focus on a broader and larger population to generalize the results of the research.

In addition, the results in this study suggest the degree of student knowledge influences the type of cue teachers were focused on. To either confirm or decline these results, more research is needed to examine the influence of pedagogical knowledge on cue perception in a larger study population. Specifically, future research could focus on examining how different types of student knowledge (e.g. student characteristics and performances of students regarding the subject matter) carries the most weight in interpreting student progress. Research into this area can contribute to a deeper understanding in the type and kind of student knowledge teachers should initially focus on while getting to know their students and additionally to the way in which teachers use and interpret the different types of cues in order to construct and interpret student needs effectively.

Next to this, existing research on noticing student cues while enacting a differentiated instruction show experienced teachers can notice student cues more efficiently and more quickly compared to novice teachers (Berliner, 2001; Kosel et al., 2021; Levin & Nolan, 2014). In this study, this theory cannot be confirmed in practice due to the small sample size. Although theories confirm the degree of experience seem to be influencing the teachers' viewing behaviour, future research could

therefore focus on the differences in viewing behaviour between experienced and inexperienced teachers. In doing so, it is interesting to focus on the effect between the level of experience and the way in which teachers are focused on either verbal cues or nonverbal cues to quickly observe, interpret and decide on students' needs.

Finally, further research into the ways in which automatic fixations will be detected with wearable eye tracking devices in a dynamic environment is desirable. Eye tracking devices use certain algorithms to establish fixations automatically. The algorithm decides on the participant's gaze remaining on a certain location to assure fixations (Niehorster et al., 2020). However, these algorithms are developed traditionally to detect signals during static stimuli, hence identifying fixations in dynamic environments is considered to be more challenging (Drews & Dierkes, 2024; Larsson et al., 2015). Merely a few studies examined fixations in head-mounted eye tracking devices (Drews & Dierkes, 2024). Therefore, future studies could focus on strengthening the theory on algorithms in eye trackers used in dynamic environments.

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Appendices

Appendix A. Information Letter for Participating Teachers

Informatiebrief:

Proefpersonen informatiebrief

‘Onderzoek naar kijkgedrag en instructiebeslissingen van ervaren leerkrachten in het basisonderwijs’

Geachte heer/mevrouw,

Leerkrachten in het basisonderwijs nemen tijdens instructies talloze beslissingen. Een belangrijke manier om passende instructiebeslissingen te kunnen nemen is het monitoren van begrip en voortgang bij leerlingen. We weten nog weinig over de manier waarop ervaren leerkrachten visuele informatie over leerlingen verzamelen tijdens instructies. Middels dit onderzoek willen we dit kijkgedrag en de passende instructiebeslissingen in kaart gaan brengen. Daarom vraag ik u vriendelijk om mee te doen aan dit onderzoek: ‘Expert teachers’ reasoning for differentiated instructional decision-making’.

Voor u beslist wel of niet deel te nemen aan dit onderzoek, is het belangrijk om meer te weten over het onderzoek. Deze brief geeft u extra informatie over het onderzoek. Bespreek dit gerust met mensen in uw omgeving. Heeft u na het lezen nog vragen? Dan kunt u terecht bij de onderzoeker. Verder in de brief vindt u de contactgegevens.

Wat is het doel van het onderzoek?
Het doel van het onderzoek is om het kijkgedrag van ervaren leerkrachten in het basisonderwijs in kaart te brengen om vervolgens op basis van de verkregen informatie over leerlingen instructiebeslissingen te kunnen maken.

Wat wordt onderzocht?
Er wordt onderzocht wat het kijkgedrag van leerkrachten in een instructieles is om te kunnen concluderen hoe leerkrachten visuele informatie over leerlingen verzamelen. Daarna wordt nagegaan op welke manier deze informatie wordt benut om passende instructiebeslissingen te nemen.

Hoe wordt het onderzoek uitgevoerd?

Als u interesse heeft om aan dit onderzoek deel te nemen, wordt u allereerst gevraagd om tijdens een basisinstructie van een rekenles een eye tracking bril te dragen. Deze bril brengt in kaart waar uw focus ligt tijdens de gegeven instructie en neemt tevens de instructie op. De onderzoeker zal middels software op basis van de focus bepalen welke video-fragmenten interessant zijn om verder te onderzoeken. Deze video-fragmenten worden op het initiatief van de onderzoeker op een later moment aan u voorgelegd. U bent vrij om tijdens dit moment ook zelf fragmenten aan te dragen. U wordt gevraagd te beargumenteren waarom uw focus op bepaalde momenten bij leerlingen of leerlingenwerk lagen en wat u precies heeft waargenomen. Daarnaast wordt gevraagd welke instructiebeslissingen heeft gemaakt op basis van wat uw visuele waarnemingen of de kennis die u vooraf al had over de leerlingen.

Wat wordt er van u verwacht?

Van u wordt verwacht dat u tijdens het geven van een basisinstructie in een rekenles een eyetracking bril zult dragen. Het afstemmen van de bril op uw comfort en het kalibreren zal wat tijd in beslag nemen. Na verwerking van de gegevens van deze bril wordt u op een later moment gevraagd deel te nemen aan een interview. Dit zal naar schatting 60-90 minuten duren.

Wat zijn mogelijke voor- en nadelen van dit onderzoek?

U zult zelf geen directe voordelen van dit onderzoek ervaren. Door dit onderzoek uit te voeren zullen mogelijk gerichte kijkadviezen aan beginnende en startende leerkrachten kunnen worden gegeven.

Tevens is de mogelijkheid aanwezig dat dit onderzoek advies kunnen geven voor toekomstig onderzoek. U zult het als spannend kunnen ervaren om opgenomen te worden tijdens een instructieles. De opgenomen gegevens zullen voornamelijk worden bekeken door de onderzoeker en in het interview door u als leerkracht.

Er zijn voor u geen risico’s verbonden aan het deelnemen van dit onderzoek.

Wat gebeurt er met uw gegevens?

Voor dit onderzoek is het nodig dat uw onderzoeksgegevens worden verzameld en gebruikt gedurende de uitvoer van dit onderzoek. De video-gegevens worden veilig opgeslagen in een database voorzien van een wachtwoord. Het interview naderhand wordt met uw toestemming opgenomen, getranscribeerd en gecodeerd. Alle gegevens blijven vertrouwelijk. Alleen ter controle van de wetenschappelijke integriteit van dit onderzoek kunnen sommige mensen toestemming krijgen om de

verzamelde gegevens in te zien. U kunt uw gegevens ten alle tijden inzien, laten vernietigen, corrigeren of opvragen. Uw gegevens worden na afronding van dit onderzoek vernietigd.

Wat als u niet wenst deel te nemen aan dit onderzoek?

U beslist zelf of u meedoet aan het onderzoek. Deelname is vrijwillig. Als u besluit niet mee te doen, hoeft u verder niets te doen. U hoeft niets te tekenen. U hoeft ook niet te zeggen waarom u niet wilt meedoen. Als u wel meedoet, kunt u zich te allen tijde bedenken en toch stoppen. Mocht u besluiten om mee te doen, dan wordt gevraagd het toestemmingsformulier goed door te lezen en te ondertekenen.

Wilt u verder nog iets weten?

Voor het stellen van vragen kunt u contact opnemen met de onderzoeker:

Sophie Kamphuis

E-mail: [removed]

Tel.: [removed]

Appendix B. Consent Form for Participating Teachers

Expert teacher's reasoning for differentiated instructional decision-making

- Ik heb de informatiebrief voor de proefpersoon gelezen. Ik kon aanvullende vragen stellen. Mijn vragen zijn voldoende beantwoord. Ik had genoeg tijd om over deelname te beslissen.
- Ik weet dat meedoen vrijwillig is. Ik weet dat ik op ieder moment kan beslissen om toch niet mee te doen of te stoppen. Daarvoor hoef ik geen reden te geven.
- Ik geef toestemming om mijn gegevens veilig te verzamelen, bewaren en gebruiken voor de beantwoording van de onderzoeksvraag van dit onderzoek.
- Ik geef toestemming dat mijn gegevens gecodeerd worden verwerkt.
- Ik weet dat alleen ter controle van de wetenschappelijke integriteit van het onderzoek sommige mensen toegang tot mijn verzamelde gegevens kunnen krijgen.
- Ik weet dat mijn gegevens na het afronden van dit onderzoek vernietigd zullen worden.

Ik geef toestemming om aan dit onderzoek mee te doen. ☐

Naam proefpersoon:

Handtekening:

Datum: __/__/__

Ik verklaar hierbij dat ik deze proefpersoon volledig heb geïnformeerd over het genoemde onderzoek.

Als er tijdens het onderzoek informatie bekend wordt die de toestemming van de proefpersoon zou kunnen beïnvloeden, dan breng ik hem/haar daarvan tijdig op de hoogte.

Sophie Kamphuis

Datum: __/__/__

Appendix C. Information Letter for Students

Informatiebrief leerlingen
'Onderzoek naar kijkgedrag en instructiebeslissingen van leerkrachten in het basisonderwijs'

Beste ouder(s)/verzorger(s),

Leerkrachten in het basisonderwijs nemen tijdens instructies talloze beslissingen. Een belangrijke manier om passende instructiebeslissingen te kunnen nemen is het monitoren van begrip en voortgang bij leerlingen. We weten nog weinig over de manier waarop leerkrachten visuele informatie over leerlingen verzamelen tijdens instructies. Middels onderzoek om mijn studie 'Educational Science and Technology' aan de Universiteit Twente af te ronden wil ik dit kijkgedrag en deze instructiebeslissingen in kaart gaan brengen. De leerkracht in de groep van uw zoon of dochter heeft toestemming gegeven om het kijkgedrag van de leerkracht te mogen observeren. Hoewel het doel van het onderzoek is om vooral de leerkracht te observeren, is de kans groot dat uw zoon of dochter bij deze observatie door videobeelden ook in beeld komt. Middels deze brief wordt toestemming gevraagd voor deelname van uw zoon of dochter aan dit onderzoek.

Voor u beslist of uw zoon of dochter wel of niet deel mag nemen aan dit onderzoek, is het belangrijk om meer te weten te komen over het onderzoek. Deze brief geeft u hierover extra informatie. Bespreek dit gerust met mensen in uw omgeving. Heeft u na het lezen nog vragen? Dan kunt u terecht bij de onderzoeker. Verder in de brief vindt u de contactgegevens.

Wat is het doel van het onderzoek?
Het doel van het onderzoek is om het kijkgedrag van leerkrachten in het basisonderwijs in kaart te brengen om vervolgens op basis van de verkregen informatie over leerlingen instructiebeslissingen te kunnen maken.

Wat wordt onderzocht?
Er wordt onderzocht wat het kijkgedrag van leerkrachten in een instructieles is om te kunnen concluderen hoe leerkrachten visuele informatie over leerlingen verzamelen. Daarna wordt nagegaan op welke manier deze informatie wordt benut om passende instructiebeslissingen te nemen.

Hoe wordt het onderzoek uitgevoerd?
Deelnemende leerkrachten wordt gevraagd om tijdens een basisinstructie van een rekenles een eye tracking bril te dragen. Deze bril brengt in kaart waar de focus van de leerkracht ligt tijdens de gegeven instructie en neemt tevens de instructie op. De onderzoeker zal middels deze focus bepalen welke video-fragmenten interessant zijn om verder te onderzoeken. Leerkrachten worden op een later moment gevraagd te beargumenteren waarom op bepaalde momenten de focus bij leerlingen of leerlingenwerk lag en hoe dit wordt gewogen om instructiebeslissingen te maken. Hierbij worden de video-beelden teruggekeken.

Op welke manier komt uw zoon of dochter in aanraking met dit onderzoek?
In dit onderzoek ligt de nadruk vooral in het observeren van leerkrachten. Wel wordt gekeken waar de focus van leerkrachten tijdens een instructie liggen ten aanzien van leerlingen of leerlingenwerk. De kans is dus groot dat uw kind in beeld komt tijdens het eye tracking onderzoek en de opname van de instructieles. Op basis van de waarnemingen van leerkrachten over de leerlingen in de groep wordt beargumenteerd welke instructiebeslissingen de leerkracht heeft gemaakt tijdens de les. Hiervoor worden de opnames zorgvuldig bekeken door de onderzoeker en gezamenlijk op een later moment nog eens terug gekeken door de eigen groepsleerkracht en de onderzoeker.

Wat zijn mogelijke voor- en nadelen van dit onderzoek?
De leerlingen zullen geen directe voordelen of nadelen van dit onderzoek ervaren. Er zijn voor de leerlingen geen risico's verbonden aan deelname van dit onderzoek.

Wat gebeurt er met de gegevens van uw zoon of dochter?
Voor dit onderzoek is het nodig dat video-gegevens worden verzameld en gebruikt gedurende de uitvoering van dit onderzoek. De video-gegevens worden veilig opgeslagen in een database voorzien van een wachtwoord. De opnames worden alleen bekeken door de eigen groepsleerkracht en de onderzoeker. Alleen ter controle van de wetenschappelijke integriteit van dit onderzoek kunnen sommige mensen toestemming krijgen om de verzamelde gegevens in te zien. Mocht dit het geval zijn, dan wordt u op de hoogte gebracht. Alle gegevens blijven vertrouwelijk. Alle gegevens worden na afronding van dit onderzoek vernietigd.

Wel of geen toestemming aan het onderzoek
Deelname aan dit onderzoek is geheel vrijwillig. Mag uw kind wel deelnemen aan het onderzoek? Lever dan het ingevulde toestemmingsformulier (met daarop wel ingevuld) dan voor 1 maart in bij de leerkracht van uw kind. Mag uw kind niet deelnemen? Lever dan het ingevulde toestemmingsformulier (met daarop niet ingevuld) ook in bij de leerkracht van uw kind. Mocht u aanvankelijk toestemming geven, maar gedurende het onderzoek uw toestemming willen intrekken, dan is dat ook mogelijk. Er hoeft geen reden aangegeven te worden waarom u uw toestemming wilt intrekken. Er zijn geen risico's bij het tussentijds beëindigen van de deelname.

Ethische toetsing
Het onderzoek is goedgekeurd door de facultaire BMS Ethiek Commissie van de Universiteit Twente. Deze commissie toetst of het onderzoek zich houdt aan de algemeen geldende wettelijke en/of ethische standaarden met het doel om de waarden, rechten en belangen van personen die deelnemen aan het onderzoek te respecteren. Om uw kinds privacy te waarborgen, wordt de naam van uw kind bij verwerking van de video-opname direct vervangen door een code. Alleen de onderzoeker kan met behulp van een sleutel deze code tot uw kind herleiden. Video-beelden worden nooit openbaar gemaakt, maar zijn alleen ter inzage van de onderzoeker en de groepsleerkracht gedurende het onderzoek. Naderhand worden alle gegevens vernietigd.

Wilt u meer weten?
Mocht u na het lezen van deze brief nog vragen hebben of wilt u extra informatie, dan kunt u altijd (voor, tijdens en na het onderzoek) contact opnemen met de onderzoeker via onderstaande contactgegevens.

Sophie Kamphuis
E-mail: [removed]

Appendix D. Consent Form for Parents of Participating Students

Toestemmingsformulier onderzoek kijkgedrag en instructiebeslissingen

- Ik heb de deelnemersinformatie gelezen. Ik heb voldoende ruimte gehad aanvullende vragen te stellen. Deze vragen zijn eventueel naar tevredenheid beantwoord. Ik had genoeg tijd om te beslissen of mijn zoon of dochter mee mag doen aan dit onderzoek.

- Ik weet dat deelname aan dit onderzoek geheel vrijwillig is. Ik weet dat ik op ieder moment kan beslissen om mijn zoon of dochter niet meer mee te laten doen aan het onderzoek. Hiervoor hoef ik geen reden op te geven.

- Ik weet dat mijn zoon of dochter in video-opnames in beeld kan komen. Ik weet dat de naam van mijn zoon of dochter gecodeerd wordt verwerkt. Op die manier wordt de privacy van mijn zoon of dochter strikt gerespecteerd.

- Als ouder/verzorger ben ik op de hoogte van bovenstaande punten. Met de ondertekening van dit informed consent, geef ik te kennen dat mijn zoon of dochter

o WEL
o NIET*
mee mag doen aan dit onderzoek naar kijkgedrag van leerkrachten tijdens instructies.

_____

Voor en achternaam zoon/dochter: _____

Groep: _____

Naam ouder/verzorger:

Handtekening: Datum: __/__/__

_____

Ik verklaar hierbij dat ik de ouders van deze proefpersoon volledig heb geïnformeerd over het genoemde onderzoek.

Sophie Kamphuis

Datum: __/__/__

Handtekening:

[removed]

***Kruis aan wat van toepassing is.**

Appendix E. Topic List of Interviews

Introductie Bedanken Toestemming voor opname Doel van het onderzoek Vrijwillige deelname Privacy Duur Opzet onderzoek Ruimte voor vragen	Allereerst nogmaals hartelijk bedankt voor deelname aan dit onderzoek. Voordat we gaan beginnen met het interview, wil ik vragen of ik toestemming heb om dit interview op te nemen. Dit maakt het voor mij makkelijker om alle data na de tijd te verwerken. Vandaag/gisteren heb je een instructieles rekenen gegeven aan groep __ . Daarbij heb je een eye tracking bril gedragen. De bril heeft geregistreerd waar de focus lag in de instructieles. Met behulp van software heb ik een aantal videofragmenten geselecteerd waarbij het duidelijk was dat een leerling of het werk van de leerling een grote mate van interesse had. Het doel van dit interview is om erachter te komen waarom leerlingen of leerlingwerk op bepaalde momenten voor jou van belang waren en welke beslissingen je vervolgens hebt gemaakt in de instructie. Hoewel ik je straks een aantal videofragmenten laat zien, wil ik je vragen om zelf ook situaties aan te dragen die volgens jou van belang zijn. Het interview zal ongeveer een uur duren. Ik wil graag nogmaals benadrukken dat dit onderzoek op vrijwillige basis en met toestemming van jou wordt afgenomen. Mocht je je op een later moment willen terugtrekken uit het onderzoek, dan mag dit te allen tijde en zonder een reden aan te geven.

	Heb je nog vragen voordat we beginnen met het interview?
Vragen Semi-gestructureerde vragen Ruimte voor eigen inbreng	Voordat we gaan kijken naar de videobeelden wil ik vragen hoe je de les hebt voorbereid. Van welke gegevens heb je gebruik gemaakt (bijvoorbeeld gegevens uit WIG, voorgaande leerkracht, cito-gegevens, eigen observaties)? Hoe heb je gegevens van de leerlingen gebruikt ter voorbereiding van je les? Welke keuzes heb je vooraf gemaakt ten aanzien van je instructie? Hoe heb je je instructie eventueel aangepast? We gaan nu kijken naar de videofragmenten. Daarbij stel ik je steeds dezelfde vragen: Denk eens terug aan het moment van je les. Wat heb je tijdens dit fragment waargenomen bij de leerling? Heb je hierbij gekeken naar het gezicht, lichaamstaal, dat wat de leerling zegt of het leerlingwerk? Welke interpretatie heb je naar aanleiding van deze waarneming gemaakt? Wat ligt volgens jou ten grondslag aan wat je waarneemt? (Waarom gedraagt de leerling zich op deze manier/waarom zegt de leerling dit/wat concludeer je op de manier waarop de leerling dit werk heeft gemaakt?) Welke beslissing heb je vervolgens gemaakt in je instructie? Welke aanpassingen heb je gedaan? Welke informatie heb je hiervoor gebruikt? Waarom maak je deze beslissing? Wil je dit uitleggen? Waren alle beslissingen volgens jou effectief? Waarom wel of niet? Welke beslissingen zou je in het vervolg hetzelfde nemen als je nu hebt gedaan tijdens je instructie? Waarom? Welke beslissingen zou je in het vervolg anders nemen? Waarom? Waren er belemmeringen bij bepaalde beslissingen? Zo ja, welke waren dit dan en waarom waren dit belemmeringen? Wil je zelf nog videofragmenten aandragen waarin jij beslissingen hebt gemaakt die niet zijn besproken?

	Nota bene: Bij de vragen over de instructiebeslissingen wordt nagegaan of de gekozen beslissingen overeenkomen met dat wat de literatuur aangeeft (aanpassen van materiaal, aanpassen van bronnen, aanpassen van tijd, aanpassen van doelen, aanpassen van manier van lesgeven). Wanneer de leerkracht zelf geen richting geeft aan wat er eventueel is aangepast, wordt hier specifiek naar gevraagd.
Afsluiting Opmerkingen of vragen Volgende stappen Bedanken	Zijn er dingen onbesproken gebleven die jij nog graag wilt bespreken? Heb je nog vragen over hetgeen besproken is? Ik zal het interview hierna gaan verwerken om te onderzoeken of er een relatie is tussen dat wat jij bij de leerling hebt waargenomen om hier vervolgens beslissingen in instructies te maken. Mocht je geïnteresseerd zijn in de resultaten, dan zal ik dit met je delen. Dank je wel voor je tijd.

Appendix F. Coding Scheme of Observed Cues

Overarching category	Category	Code(s)	Example in interview	Goal
Nonverbal	Affective state	Frustration	If they aren't frustrated.	Utterance has been coded whence teacher observed the facial expression of students
		Observing facial expression	But M. also has an expression that makes me think: you can see it in her face.	
		Students' eyes	In the eyes if they are not frustrated.	
		Questioning expression	He gets a bit of a questioning look on his face	
		Satisfaction	She is satisfied.	
Nonverbal	Cognitive state	Observing body language	His shoulders slump a bit, then he looks more often from the screen to the erase board, to the screen and back again.	Utterance has been coded whence teacher observed the body language of students
Nonverbal	Student work	Student work	I especially look at the erase boards, they really catch my eye. Whether the children are actually writing. I check the answers.	Utterance has been coded whence teacher observed the work of students
		Student progress	That is because, I think with the erase board they understood. They also understood it with that first calculation.	
Nonverbal	Behaviour	Focus	Really just to see if she's with me.	Utterance has been coded whence teacher observed something within the behaviour of students
		Student behaviour	I know that I have an eye on G. and S., but that is because they stand up.	
		Student involvement in work	They all were working.	
		Raising a hand	And so I just give her a turn, purely based on that she raises her hand to answer.	
		Working tempo	And it is especially the working tempo with this lesson.	
Verbal	Conversational function	Asking students a question	Yes, than I give him a turn	Utterance has been coded whence teacher observed conversations between students or students and teacher
		Answering questions	She answers that the long dashes are tens.	
		Students talking	But also what I just heard. That reaction from the children beforehand.	

Appendix G. Coding Scheme of Used Teacher Strategies

Category	Code(s)	Example in interview	Goal
Adjusting learning material	Difficulty level of instruction Difficulty level of work Amount of material	Well, the difficulty of course. I moved up a level during the instruction. Then I decided that I thought: oh, I will definitely do that very last assignment, and then also with certain students. The lesson material is a bit more extensive.	Utterance has been coded whence teacher mentioned adjustments in the learning material
Adjusting learning resources	Imbedding different learning resources	We do a lot more with really concrete material.	Utterance has been coded whence teacher mentioned imbedding different learning resources
Adjusting time	Instructional time Processing time Extended instruction Starting instruction over again	Then I have to explain something more. [*I am waiting one more minute*]. They had not finished the work. Afterwards I had two students at the instruction table who still found it difficult. Well, then I start over.	Utterance has been coded whence teacher mentioned adjustments in time
Adjusting goals	Evaluation of lesson Performance level of students	We have an assessment form per lesson, or per goal. We write down the names of the students who find it difficult. This group contains students which are high-achieving and the mediocre level.	Utterance has been coded whence teacher mentioned curricular goals, learning goals or expectations of goals in line with the student
Adjusting teaching style	Using different wording Scaffolding Modelling Giving feedback Repetition of teaching material Giving a hint	I did also use different wording in my lesson. Additional help I also think it modelling because they no longer knew what I was talking about. A tip and feedback and a tip on what she can do now, which might help her solve that final calculation. That's why I know: some extra repetition during the instruction. No I gave hints, gave a hint.	Utterance has been coded whence teacher mentioned adjustments within themselves