DIFFERENTIATION IN KINDERGARTEN

A cognitive task analysis of kindergarten teachers' thinking and acting in providing early numeracy education

Master thesis

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Acknowledgment

In the past months I have been working on this master thesis as my final project for the master *Educational Science and Technology* at the University of Twente. As a primary school teacher, I experienced the complexity of differentiation within the classroom. Although I strived for differentiation, I struggled with putting it into practice. I now had the chance to gain deeper insight in what a teacher should do and know in order to differentiate. Resulting in the fact that I am even more convinced of the complexity of differentiation.

I want to use this acknowledgement to thank all the people that helped me in my search for expert teachers. A special thanks goes to all the participating teachers and subject matter experts. They were very welcoming, enthusiastic, and inspiring. I enjoyed being in their classrooms and to listen to their visions on differentiation.

Finally, I want to thank my supervisor Marieke van Geel for her guidance, suggestions and feedback. Our appointments always motivated me to move on with my final project.

Lobke Vreman

Summary

Teaching in kindergarten is a complex task. Above average teacher qualities are needed to effectively manage and align the, most often, multi-grade classes. Many kindergarten teachers specified differentiation as difficult to put into practice. Research shows that not all (beginning) teachers master the required, advanced teacher skills needed for differentiation. It is desirable that teachers are supported in developing these skills. Van Geel et al. (2019) presented a differentiation skill hierarchy, overview of knowledge and it's related complexity factors. This overview can be used for developing training and assessment of effective differentiated instruction. This study aims in gaining insight in the skills, knowledge, and complexity factors of differentiation in kindergarten during early numeracy activities.

The teacher skills needed for differentiated early numeracy education in kindergarten can be divided into four stages: preparing a theme, preparing the day, during the day, and after school. Within these stages different teachers skills are describes. The presented skills differ from the teacher skills needed in primary education, due to the differences in organisation of these types of education. More similarities can be found in the needed knowledge. Like in primary education, kindergarten teachers need subject matter knowledge and knowledge of their students. New is knowledge about the development of 4-to-6 year olds. Similarities can also be seen in the complexity factors diversity or group composition and (lack of) school support. The described skills, knowledge and complexity factors in kindergarten show strong similarities with other theories about differentiation in kindergarten.

Overall, the skills hierarchy for kindergarten and primary education do differ from each other, due to the differences in how education is organised in both contexts. But, the underlying teacher skills, knowledge, and the complexity factors are comparable.

Keywords: differentiation – kindergarten – cognitive task analysis – early numeracy

1. Introduction

Teaching in kindergarten is a complex task, since most kindergarten classes in the Netherlands are a combination of K0, K1 and K2. Above-average teacher qualities are needed to effectively manage and align these heterogeneous multi-grade classes (Inspectie van het Onderwijs, 2018). An additional complexity factor is the fact that most children start attending kindergarten the day they reach the age of four. This creates a situation in which 4-year olds enter kindergarten throughout the year (Mooij, 2000), and teachers have to adapt their education several times a year. Every time a new child starts attending school, the teacher has to get to know the child and monitor it's development, so that the teacher can adapt his education to the child's educational needs. Many kindergarten teachers specified dealing with differences as difficult to put into practice (Santangelo & Tomlinson, 2012) and research showed that not all kindergarten teachers master the required advanced teacher skills (Doolaard & Harms, 2013). Remarkable, since differentiation, or taking differences between students into account and adapting instructions to students' needs, is part of a teachers' job description (PO-raad, 2018). This demonstrates that there seems to be a need for improvement of differentiation teacher skills in kindergarten (Dijkstra, Walraven, Mooij, & Kirschner, 2017).

Little research has been done into differentiation in kindergarten. However, more research is available about differentiation in primary education. Roy, Guay, and Valios (2013) define differentiation as "an approach by which teaching is varied and adapted to match students' abilities using systematic procedures for academic progress monitoring and data-based decision-making" (Roy et al., 2013, p.1187). This variation can be made in content, process, and product, based on student's readiness, interests, and learning profile (Tomlinson & Allan, 2000). When applied well, differentiation is seen as 'a cornerstone of effective instruction' (Parsons et al., 2018, p.206). Nevertheless, research conducted by the Dutch Inspectorate of Education showed that the majority of beginning (0-3 years) primary school teachers does not feel confident about their differentiation skills. They do not feel prepared to systematically monitor their students' progress and to offer effective differentiated instruction. School leaders and inspectors share this opinion with the beginning teachers (Inspectie van het Onderwijs, 2015).

It is desirable that teachers are supported in developing the necessary, complex teacher skills for differentiated instructions. Unfortunately, an overview the needed teacher skills for differentiation was lacking. Differentiation research often focussed on differentiation strategies, grouping, and cooperative methods, but these approaches are not the core of differentiation. Without insight in expert teachers' thinking and acting in differentiation, it is hard to provide effective support in acquiring these skills and to determine to what extent a teacher masters the needed skills (Keuning et al., 2017). In order to get insight in the needed teacher skills for effective

differentiated instruction Van Geel et al. (2018) conducted a cognitive task analysis (CTA) for differentiated math instruction in primary education in the Netherlands. This resulted in a differentiation skill hierarchy containing four chronological stages: preparing lesson period, preparing lesson, enacting lesson, and evaluating lesson. Each stage included multiple teacher skills. Besides the hierarchy, an overview of the needed teacher knowledge and the related complexity factors was given. This is a relevant and helpful insight for developing training and assessment of effective differentiated instruction (Keuning et al., 2017).

This study aims at gaining insight in the skills and knowledge needed for differentiation in kindergarten along with it's possible complexity factors. Early numeracy activities will be used as research context, since early numeracy is stimulated through a variety of activities such as group instructions, puzzles, songs, games, small group instructions, individual play, and daily routines like counting the number of children. During all these activities teachers have to monitor the students´ learning processes, and to gain insight in the children's development. This variety of activities probably contributes to the complexity of teaching kindergarten. Teachers need the competence to use and develop analysing and assessing methods in order to be able to differentiate, but not all (beginning) kindergarten teachers feel prepared to do so (Inspectie van het Onderwijs, 2015). Choosing early numeracy as research context also offers the possibility to compare the results with Van Geel et al.'s (2018) results for differentiated math instruction in primary education in the Netherlands. In order to facilitate this comparison, the results will be presented in a skill hierarchy with its related knowledge and related complexity factors.

2. Conceptual framework

2.1 Differentiation

Kindergarten and primary school teachers in the Netherlands are expected to differentiate learning activities (PO-raad, 2018), which is one of the most challenging teacher tasks, especially for beginning teachers (De Neve, Devos, & Tuytens, 2015; Inspectie van het Onderwijs, 2015). Teachers have to take differences in educational needs into account, caused by variation in students' cultural background, home language, socio-economic background, pace, interests, learning profiles, learning motivation, cognitive capacity, and social skills (Struyven, Coubergs, Gheyssens, & Engels, 2015). In order to deal with these differences, teachers need the competence to offer goal-oriented activities in which subject matter is processed, and the competence to differentiate instructions and activities based on students' differences in level and characteristics (Bussemaker, 2017). In short; every teacher should be able to differentiate, and has the responsibility to offer good education to all students (Prast, Van de Weijer-Bergsma, Kroesbergen, & Van Luit, 2015). Yet, the majority of the beginning teachers does not feel prepared to do fulfil this task (Inspectie van het Onderwijs, 2015).

Differentiation can be defined as "an approach by which teaching is varied and adapted to match students' abilities using systematic procedures for academic progress monitoring and data-based decision-making" (Roy et al., 2013, p.1187). This implies that teachers have to monitor the students' learning progress, in order to determine educational needs. This process is also referred to as cognitive or readiness-based differentiation (Prast, Van de Weijer-Bergsma, Kroesbergen, & Van Luit, 2018) and based on the idea that learning occurs in learning activities within a student's zone of proximal development (Vygotsky, 1978, in Prast et al., 2015). Since the zone of proximal development differs per student, a teacher has to vary in his education as well.

The variation in teaching can be made in content, process, and product, based on a student's readiness, interests, and learning profile (Tomlinson & Allen, 2000). Tomlinson (2008) adds that differentiation takes place within the classroom and should be integrated into lessons. Teachers should 'use a flexible approach in space, time, materials, grouping, and instruction' (Tomlinson, 2008, p.4). Differentiation is responsive, meaning it happens when it is needed. When differentiation is applied effectively, students will achieve on a higher level than without differentiation (Tomlinson, 2008).

In practice different strategies are being used to implement differentiation in the classroom. The effects of these strategies are still inconclusive (Deunk, Smale-Jacobse, De Boer, Doolaard, & Bosker, 2018). Frequently, differentiation in primary education is organised in homogeneous within-class ability grouping (Prast et al., 2018). For example when teachers cluster same level or same interest students, adapt exercises to students' level, adapt the amount of feedback or support to the

cognitive level of students, challenge the bright students, or personalize the amount of work time per student (Suprayogi, Valcke, & Godwin, 2017). Grouping can create an opportunity for differentiation, but 'grouping alone is not enough [*for differentiation*] and should be accompanied by differentiated teaching practices' (Deunk et al., 2018, p.42).

A small positive effect for differentiation in kindergarten and primary education was found when differentiation was integrated in a supportive context in the form of a computer-assisted environment or a broader school reform. Tieso (2003) adds that grouping can be an effective strategy when the grouping is temporally, and complemented with an effective, modified and differentiated instruction. Notable is the fact that the overall effect of differentiation is positive, but not to all subgroups of students. Differentiation had a significant negative effect on low-achieving students' results and no significant effect for average and high-achieving students (Deunk et al., 2018). This effect is most likely caused by the fact that teachers do group their students, but do not combine the grouping with differentiated teaching practices. Most probably caused by the lack of support or education in this complex task (Deunk et al., 2018).

The perceived complexity of differentiated education is also caused by the interference of complexity factors. For example by the content of the lesson, group composition, school support, curriculum material, and data regarding student achievement and progress skills (Van Geel et al., 2019). But also limited preparation time, teachers' heavy workload, lack of motivation or doubt of successful implementation of differentiation (Nicolae, 2014), inadequate professional development, negative classroom behaviour, demands for substantial content coverage (Rock, Gregg, Ellis, & Gable, 2008), and teaching experience (Suprayogi et al., 2017) contribute to the perceived complexity of differentiation. At last, the level of self-efficacy to implement differentiation relates with the actual chance of implementing, the higher the self-efficacy the more likely a teacher will implement differentiation (Wertheim & Leyser, 2002).

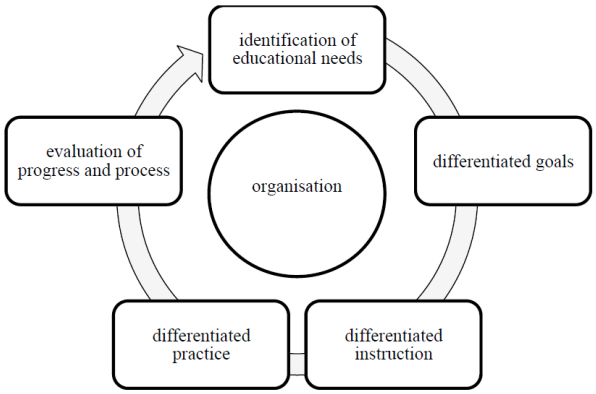
2.1.1 Teacher skills and knowledge in primary education

Effective teachers excel, among other factors, in differentiation (Prast et al., 2018). But what knowledge and skills do teachers need for effective differentiated instruction? Most definitions of differentiation underline the importance of monitoring learning progress and adapting instruction (Prast et al., 2015). For example Vogt and Rogalla (2009) who say that effective teachers are skilled to adapt their teaching to the needs of their students, also referred to as possessing 'adaptive teaching competency'. This adaptive teaching competency consists of four components. *Advanced diagnosis of student learning* and a *variety of teaching methods* are comparable to the general description of differentiation skills. Besides these factors, they add *extensive subject knowledge* and *effective strategies of classroom management.* When a teacher does not master these four components,

implementing differentiation will be challenging (Prast et al., 2018).

Organisation, or classroom management, is also included in the *Cycle of differentiation* for general primary education teachers (figure 1.1; Prast et al., 2015). This model was created after eleven mathematical experts in the Netherlands achieved consensus about a set of strategies for differentiated math instruction in primary education. The experts placed Organisation in the centre of the cycle, since differentiation can only be effectively implemented within a good organisational structure. A 5-step cycle is placed around Organisation, containing: identification of educational needs, differentiated goals, differentiated instruction, differentiated practice, and evaluation of progress and process. In this cyclic process differentiated instruction and differentiated practice can take place at the same time. Differentiated instruction refers to whole-group, small group or individual instructions within the class, and differentiated practice refers to the moments when students work on a specific task, individually or in groups (Prast et al., 2015).

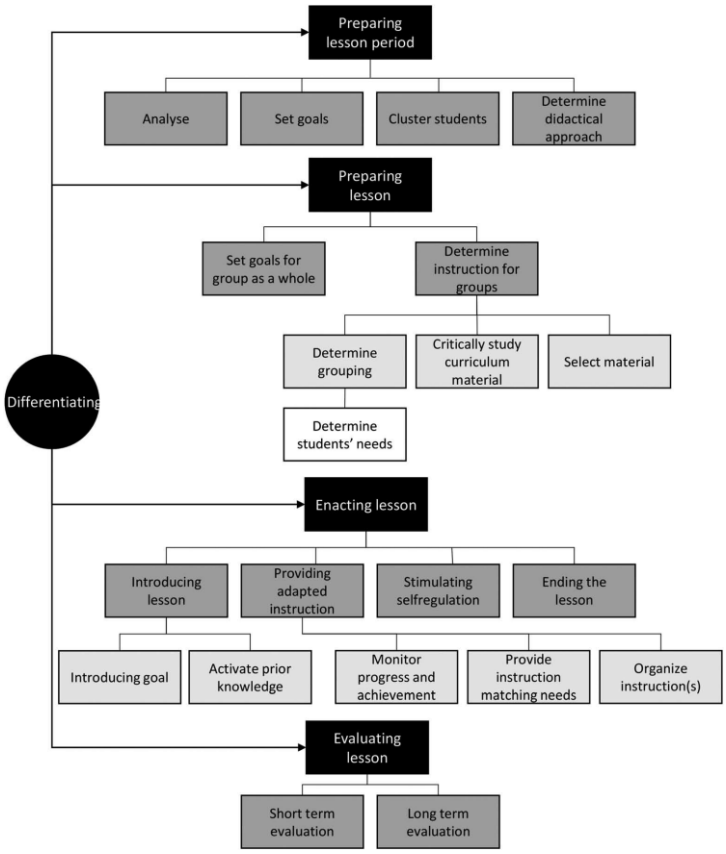
Figure 1.1 Cycle of differentiation. Reprinted from "Readiness-basded differentiation n primary school mathematics: expert recommendation and teacher self-assessement" by E.J. Prast et al., 2015, *Frontline Learning Research, 3*(2), p. 98.



The *Cycle of differentiation* gives an overview of the different teacher tasks in differentiation. It remains unclear what the specific skills and knowledge are a teacher should master in order to implement differentiation. Van Geel et al. (2017) conducted a cognitive task analysis (CTA) in differentiated math instructions in Dutch primary education, which resulted in a more detailed overview of differentiation and the needed teacher skills with its related knowledge. After conducting the CTA they were able to create a skill hierarchy for differentiated math instruction in Dutch primary education. *The differentiation skill hierarchy* (figure 1.2) consists four chronological stages: preparing a lesson period, preparing a lesson, enacting lesson, and evaluating lesson. Within these stages the needed teacher skills are presented. The skills in a horizontal line have a temporal relationship. The lower level skills enable the higher level. In addition to the differentiation skills, teachers need two types of knowledge: knowledge about the students and subject matter knowledge

(Van Geel et al., 2019). More research is needed to determine whether this hierarchy is generalizable to other context, for example kindergarten.

Figure 1.2 Differentiation skill hierarchy. Reprinted from "Capturing the complexity of differentiation" by M. Van Geel et al., 2019, *School Effectiveness and School Improvement, 30*(1), p.10. Copyright 2018 by Taylor & Francis Group.



2.1.2 Teacher skills and knowledge in kindergarten

Like primary school teachers, kindergarten teachers should adjust their teaching according to the needs of individual children in their classrooms (Dijkstra et al., 2017). Research on differentiation often focussed on primary education and above, with a lot of attention for low achieving children. Less literature about differentiation in kindergarten is available.

Similar to primary education, differentiation in kindergarten involves differentiation in content, process, product and learning environments, based on students' readiness, interests, and learning profile (Tomlinson & Allen, 2000). Dijkstra et al. (2017) formulated three key points for effective differentiation specifically addressing early childhood education. At first, differentiation starts with regular monitoring of levels and progress, so teachers can meet individual needs. Besides that, a substantial understanding of the curriculum and learning goals per subject area is needed. Only then, teachers are able to evaluate the learning process and define further learning steps. Finally, beliefs and practices of the teachers and de school system need to fit differentiation,

otherwise differentiation has no chance to be executed effectively. Research in early childhood reading education showed positive outcomes for differentiating in homogeneous small-group reading instructions (Hong & Hong, 2009).

The context of kindergarten differs from primary education, amongst others due to new children start attending school throughout the school year. This is caused by the fact most Dutch children start attending kindergarten by the age of four. Frequently, they end up in a multi-grade group in which K0, K1 and K2 are combined. At this age, children already vary on different characteristics, for example in terms of cognitive and socioemotional development, and socio-economic and cultural background (Dijkstra, Walraven, Mooij, & Kirschner, 2016). Children in kindergarten can differ in their levels of psychological development and performance between two to seven years of age (Hermanns et al., 2005 in Mooij, Dijkstra, Walraven, & Kirschner, 2014).

Dijkstra et al. (2017) pointed out that differentiation in kindergarten is not self-evident. Since kindergarten is, like in primary education, generally organised according to age, most educational activities are adapted to the average level (Mooij et al., 2014). In many classrooms, children with different ability levels are offered the same early numeracy activities, which causes underachieving high-ability children and children lagging behind (Dijkstra et al., 2017). "This non-fit is responsible for many cognitive, social, emotional, behavioural, and motivational problems of children who function either clearly below their age mates or at a higher level than them. The more a child deviates from the group [..] the more problems the child usually encounters" (Mooij et al., 2014, p.530). The non-fit might be caused by the fact that many teachers specified differentiation as difficult to put into practice (Santangelo & Tomlinson, 2012). The complexity is caused by the unwillingness of teachers to change, lack of needed differentiation skills, lack of monitoring skills, and teacher's uncertainty. This indicates a need for improvement of differentiation teacher skills in kindergarten (Dijkstra et al., 2017).

2.1.3 Conclusion differentiation

In sum, differentiation in both kindergarten and primary education are not self-evident. Differentiation is a complex teaching task, containing advanced teaching skills on top of teachers' basic teaching skills like classroom management and general pedagogy (Deunk et al., 2018). This makes differentiation one of the most challenging teacher tasks, especially for beginning teachers (De Neve et al., 2015). Within the task of differentiation teachers have to take conscious and reasoned decisions in their teaching, both proactive and reactive (Denessen & Douglas, 2015, in Stollman, Meirink, Westenberg, & Van Driel, 2019). Proactive decisions when preparing a lesson, and reactive differentiation when teachers have to use their knowledge and beliefs spontaneously in taking decisions during the lesson (Stollman et al., 2019). Three focus points are important in

particular for kindergarten teachers: regular monitoring of students' level and progress, substantial understanding of the curriculum and learning goals, and beliefs and practices of the teachers and school have to fit differentiation (Dijkstra et al., 2017). Taking the right decisions and applying effective differentiation can be hindered by internal and external complexity factors, for example inadequate professional development (Rock et al., 2008), lack of motivation, workload (Nicolae, 2014), low level of self-efficacy (Wertheim & Leyser, 2002), school support, and group composition (Van Geel et al., 2019).

2.2 Early numeracy in education

In kindergarten, teachers help children to develop a mathematical basis in order to prepare children for math in primary education. For example counting, splitting numbers into equal parts, recognising patterns and shapes, measuring, and understanding relationships. These early math skills are the best predictor for later success in math and future jobs (Codding, Chan-Iannetta, George, Ferreira, & Volpe, 2011).

Math and numeracy skills are present in everyday situations and activities. For example, when children have to share their food, search for fitting clothes, or describe the possible location of a missing toy. Math helps to understand the world around us (Bouwman & Kaskens, 2018). These everyday situations in and outside the school context offer a possibility to learn math knowledge and skills. But, in order to actually reach development, a teacher is needed to support and guide these situations (Mulder & Houtsma, 2016). Just waiting for spontaneous, everyday math situations is insufficient as the basis for early numeracy in kindergarten. Teachers have to offer goal-oriented activities as well (Bouwman & Kaskens, 2018; Torbeyn et al., 2002).

In the Netherlands, schools are obliged to cover the national educational goals. However, schools do have the freedom to determine how they want to reach these learning goals. Schools can, for example, choose their own materials, structure, methods and didactics (Ministerie van Onderwijs, Cultuur en Wetenschap, 2006). The Dutch learning goals for early numeracy in kindergarten are split into six domains: number sense, number skills, measure, geometry, understanding relationships, and proportions (SLO, 2018). It is possible to work with fixed curriculum materials, but most Dutch schools and teachers decide to work in the form of meaningful theme´s in which students' curiosity and involvement are triggered (Mulder & Houtsma, 2016). In this approach the national learning goals are the starting point for developing education (Van der Aalsvoort, Bootsma, & Odendaal, 2014), fixed curriculum materials, websites, and experience are used as sources for designing theme based learning activities.

In kindergarten a great variety of activities are used to encourage early numeracy development (Van der Aalsvoort et al. 2014). For example whole-group instructions, small group

instructions, individual instructions, and pair work or individual work in (math) play corners within or outside the classroom, or even on the playground (Mulder & Houtsma, 2016). Subject matter is not offered within a fixed amount of time, but offered in different activities throughout the day (Van der Aalsvoort et al., 2014). This variety of activities makes the context of early numeracy more complex to study than the context of math instructions in primary education.

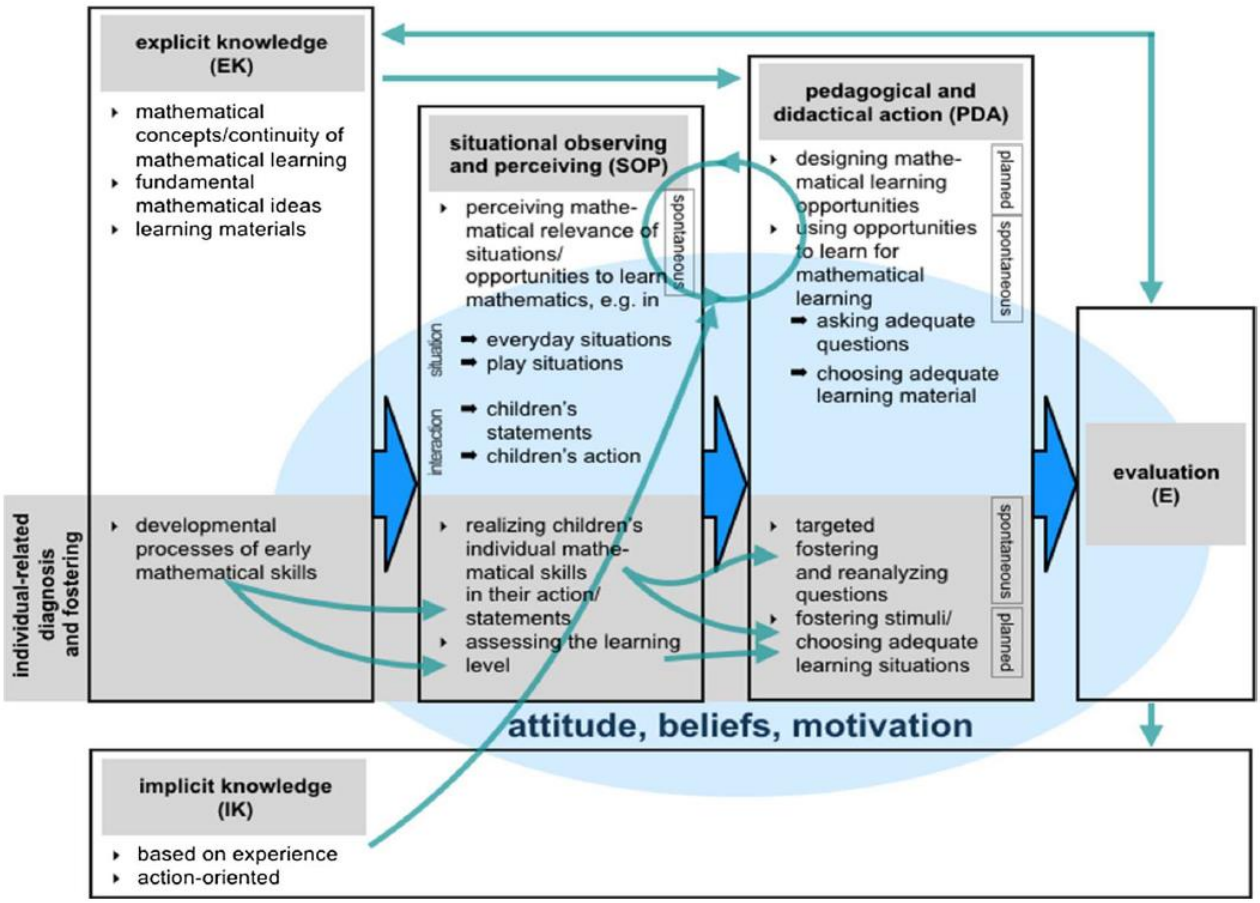
2.2.1 Teaching early numeracy

Early numeracy in kindergarten is not only taught in formal school-like learning situations such as whole-group instructions, but also in informal, every day or play situations. The knowledge and skills a kindergarten teacher needs to be fully prepared to these formal and informal math situations, differ from that of primary school teachers (Gasteiger & Benz, 2018). Gasteiger and Benz (2018) developed a domain-specific model for teachers' knowledge and skills necessary for effective early mathematics education. *The Model of professional knowledge and skills for early mathematics education* (figure 1.3) is based on a theoretical analysis, and contains a full overview of the needed professional knowledge for educating early numeracy in kindergarten. The final model is based on three widely accepted core principles of early mathematical education (figure 1.3). The first core principle is to focus on central, fundamental ideas of mathematics (Sarama & Clements, 2009). The second, is to create creative and challenging learning situations in order to stimulate problem-solving and mathematical discussions (Seo & Ginsburg, 2004, in Gasteiger & Benz, 2018). Natural everyday learning situations are viewed as the most effective context for these creative and challenging learning tasks (Gasteiger, 2015). The third is to observe and register the students' learning progress. Only then it will be possible to guide students in their further learning and to stimulate mathematical development (Nguyen et al. 2016). The model presents the needed professional knowledge into five boxes: explicit knowledge, situational observing and perceiving, pedagogical and didactical action, evaluation, and explicit knowledge (Gasteiger & Benz, 2018). All of the boxes are shortly explained below.

In the first box explicit knowledge (EK) is displayed. EK stands for the knowledge of mathematical concepts and ideas in kindergarten (Gasteiger & Benz, 2018) , for example geometry and counting (SLO, 2018). Teachers should also 'know the most important developmental processes of early mathematical skills' (Gasteiger & Benz, 2018, p.111). The second box, situational observing and perceiving (SOP), describes the skills needed to recognize spontaneous situations as mathematical situations and to turn these situations into learning situations. Since natural learning is considered as the most effective learning context (Gasteiger, 2015), teachers need to be able to recognize learning situations in everyday situations or play situations (McCray, 2008 in Gasteiger & Benz, 2018), 'in order to recognize children's individual mathematical abilities and levels of learning'

(Gasteiger & Benz, 2018, p.112). The third box shows the needed pedagogical and didactical skills (PDA). Kindergarten teachers need advanced pedagogical and didactical skills to create learning opportunities. For example by asking questions or choosing reasoned learning material. The fourth box focuses on evaluation. A teacher's reflection on his students' learning process and progress, can help to design future learning activities. Finally, a critical reflection can also lead to implicit knowledge (IK) (Gasteiger & Benz, 2018). Since pre- or in-service teacher training does not fully cover all needed mathematical content for effective math education, kindergarten teachers construct their own knowledge which is based on experience and action-oriented (Ginsburg, 2016; Gasteiger & Benz, 2016). The implicit knowledge is used to create spontaneous mathematical learning situations, and to take decisions. Reflection and evaluation of these mathematical situations unconsciously contribute to the construction of (new) implicit knowledge, which then interferes with the SOP and PDA (Gasteiger & Benz, 2018). Over time, implicit knowledge can turn into explicit knowledge (Gasteiger & Benz, 2016).

Figure 1.3. Model of professional knowledge and skills for early mathematics education Reprinted from "Enhancing and analyzing kindergarten teachers' professional knowledge for early mathematics education" by H. Gasteiger and C. Benz, 2018, *Journal of Mathematical Behavior, 51,* p.111. Copyright 2018 by Elsevier.



2.3 Research questions

Before improvement of teacher knowledge and skills can be provided, a deepened insight in the skills, knowledge, and possible complexity factors for differentiation in early numeracy in kindergarten is needed. This study aims at gaining this insight by answering the following research questions:

What are the differences and similarities between the teacher skills, knowledge, and complexity factors for differentiated math instruction in primary education and for differentiation in early numeracy in kindergarten?

- Which skills are required for differentiation in early numeracy in kindergarten?
- What kind of knowledge is needed for differentiation in early numeracy in kindergarten?
- Which factors contribute to the complexity of differentiation in early numeracy in kindergarten?

A cognitive task analysis will be conducted to determine, analyse, and structure the needed teachers skills, knowledge, and possible complexity factors (Van Geel et al., 2019). The results will be presented in a skill hierarchy and an overview of the needed teacher knowledge and possible complexity factors. The hierarchy and overview can be compared to the results for primary education (Van Geel, et al., 2018), which will lead to a deeper insight in the skills needed for differentiation and whether the results are generalizable to the context of kindergarten. Besides that, the overview can be used as input for professional development.

3. Method

3.1 Research design

A qualitative study was needed to find answers to the research question, since literature yields little information about differentiation in kindergarten. Qualitative research offers the opportunity to learn from teachers through exploration, and to understand the process of differentiation in kindergarten (Creswell, 2014). In this study a cognitive task analysis (CTA) was performed, comparable to the CTA conducted by Van Geel et al. (2019). A CTA is suitable for processes containing mental decisions that cannot be observed (Clark, 2014), in this case 'for obtaining insight into the actions and reasoning of teachers when performing the complex task of differentiation' (Van Geel et al., 2019, p.5). The CTA contained a combination of classroom observations and semi-structured interviews. These methods are informal, offer the possibility for flexibility, and deliver qualitative data (Creswell, 2014) which will help to explore and understand differentiation in kindergarten.

In order to be able to compare the results for kindergarten teachers with the skill hierarchy for differentiated math instruction in primary education of Van Geel et al. (2018), and to ensure the focus on how differentiation was performed in practice, the procedure for CTA as performed by Van Geel et al. (2018) was used. As is presented in table 3.1, the first four steps of the CTA steps were partly copied and applied: (1) collect preliminary knowledge, (2) identify knowledge, (3) apply focused knowledge elicitation methods, and (4) analyse and verify data. Van Geel et al. (2018) described a fifth step in the CTA procedure: format results for intended application. This step is removed from this study's research design, since designing a teacher training program is beyond the reach of this study

In the first step, a literature study was conducted. The results of this step were used to determine the study's procedure. In the second step, the decision was taken to use the same representation of results as in Van Geel et al. (2018) to enable comparisons between differentiation in primary education and in kindergarten. This means the results will be presented in a skill hierarchy accompanied by an overview of the related knowledge and complexity factors. In the third step interviews based on classroom observations were conducted to obtain insight in expert teachers' thinking and reasoning when differentiating. The results of these interviews were further deepened in an expert teacher meeting. In the fourth and last step, data from the interviews and expert meeting were analysed and included in a skill hierarchy. Subject matter experts were asked to verify this first draft of the skill hierarchy.

Tabel 3.1 CTA steps based on Van Geel et al. (2018, p.5)

Steps according to Clark et al. (2008)	In current study
Step 1: Collect preliminary knowledge	- Literature study - Classroom observations and video recording to identify differentiation situations
Step 2: Identify knowledge	Similar representation of results as in Van Geel et al. (2018): skill hierarchy, required knowledge, and complexity factors.
Step 3: Apply focused knowledge elicitation methods	- Semi-structured interviews based on classroom observations (stimulated recall) - Expert meeting with teachers
Step 4: Analyse and verify data acquired	- Iterative qualitative analysis of data from observations, interviews, expert meeting with teachers - Meetings with subject matter experts

Following the four CTA steps of Van Geel et al. (2018) led to four techniques that have been conducted in practice: classroom observations, interviews based on the classroom observations, expert meeting with teachers, and subject matter expert meetings. In the next paragraphs, the participants, procedure, and data analysis of these three methods will be described.

3.2 Participants

3.2.1 Classroom observations and interviews

Teachers considered to be experts in differentiation were approached via the professional network of the researcher and of researchers from the ELAN department of the University of Twente. The initial number of participants was eight, with the option to add more participants when saturation of data wouldn't be reached after eight observations and interviews (Saunders et al., 2018). Since the eighth classroom observation didn't provide new information, saturations was reached and no new observations and interviews were held.

In order to collect data that covered multiple perspectives, the maximal variation sampling strategy was used. This is a non-random sampling strategy in which the researcher intentionally selected participants that differ on certain characteristics (Creswell, 2014). In selecting the participants, their age, education, work experience, work experience in kindergarten, and school area were used to compose a diverse group of participants. As can be seen in table 3.2, this strategy led to a group of eight expert teachers who varied in teaching experience, school areas, working hours, and education. They also had a few characteristics in common. All expert teachers were female, and none of the teachers uses fixed curriculum materials for early numeracy education. All teachers use the

general, national learning goals as a starting point for developing early math activities within a meaningful theme, generally in cooperation with their kindergarten colleagues.

Table 3.2. Characteristics of expert teachers

	Age	Teaching experience	Experience in kindergarten	Fte	Education	Group composition	Number of students	School area
Teacher 1	31	10	8	0,6	Pabo SECE* + PD	1-2	25	Rural
Teacher 2	57	37	35	1	KLOS	0-1-2	26	Urban
Teacher 3 ^{E}	55	33	25	0,6	KLOS + PD	0-1-2	18	Urban
Teacher 4 ^{E}	51	26	26	1	Pabo + PD	0 & 2	21	Rural
Teacher 5	36	11	11	0,69	Pabo SECE	1-2	24	Rural
Teacher 6 ^{E}	60	30	29	0,5	KLOS	1-2	14	Rural
Teacher 7	27	6	5	0,6	Pabo SECE	1	25	Urban
Teacher 8	57	36	30	1	KLOS + PD	2	28	Urban

Teacher X^{E}= present at Expert meeting

SECE = Specialisation Early Childhood Education (Pabo)

PD = professional development: Post-hbo training Early Childhood Education

3.2.2 Expert meeting with teachers

All teachers were invited to the expert meeting, but only teacher 3, 4 and 6 were present. Notable is the fact that these teachers had at least 25 years of experience of working in kindergarten. The other teachers did not have the opportunity to participate in the expert meeting because of other appointments or the distance between their school and the location of the expert meeting.

3.2.3 Subject matter experts

For the subject matter expert meetings in July 2019, two subject matter experts were recruited via the researcher's professional network. The first expert was a teacher educator responsible for the math modules about kindergarten and early numeracy. Besides that, she is part of a team of teacher educators, responsible for the specialisation in early childhood education. The second subject matter expert was a part-time teacher and a specialist in young childhood education working for a schoolboard. In her task as specialist, she coaches teachers in how to develop meaningful education and how to deal with differences within the classroom.

3.3. Procedure

3.3.1 Classroom observations and interviews

Since early numeracy is offered in a variety of activities throughout the day, expert teachers were video recorded and observed for one entire morning. During this morning, the focus was on the teacher and all math related activities. The researcher had a nonparticipant role in the classroom, and took fieldnotes of the observed math related activities and differentiation situations. The researcher used an observation framework to ensure she focused on differentiation when observing.

The observation framework consisted of the description of within-classroom differentiation as presented in the conceptual framework: *The variation in teaching can be made in content, process, and product, based on a student's readiness, interests, and learning profile (Tomlinson & Allen, 2000). Besides that, differentiation takes place within the classroom and should be integrated into lessons. Teachers should 'use a flexible approach in space, time, materials, grouping, and instruction' (Tomlinson, 2008,* p.4). This definition reminded the researcher of the specific situations she was looking for.

For each observation, two iPads were used to film an overview of the classroom. During the observations, all early numeracy activities took place within the classrooms, therefore the IPads didn't have to be moved. Only teacher 6 organised an outdoor early numeracy activity. Since no WIFI was available outside, the activity was video recorded with the help of the researcher's smartphone. At the end of each morning, the researcher selected three to ten fragments in which the teacher applied differentiation. These fragments were used as input for the interviews.

During the interviews an interview scheme with prewritten topics was used (Appendix A) to ensure all topics would be covered in the interview. Besides that, the semi-structured interview left room for follow-up in-depth questions to gain a deeper insight in the teacher's reasoning and decisions when differentiating (Cresswell, 2014). All teachers gave permission to record and transcribe the interviews.

The semi-structured interviews consisted of three parts. In the first part questions were asked to gain a detailed picture of the teacher's characteristics. These questions were divided in questions about personal characteristics, group composition, and their approach for kindergarten education. In the second part of the interview, three to eight fragments were viewed and discussed. Through stimulated recall insight was gained in the teacher's reasoning and choices when differentiating. The researcher asked general, open-ended questions. For example 'what did you do in this situation?', 'can you elaborate on that?', 'for what reason did you make this choice?', 'what did you need to make this choice?'. In the third part, ten topics around differentiation were discussed: differences between students, preparing a theme, preparing the day, activities during the day, evaluating the day, monitoring, materials, vision and support in the school, complexity factors, and the differences and similarities between differentiation in kindergarten and primary education. After all three parts of the interview were discussed, the audio recording was stopped. Then the researcher invited the teachers to the expert teacher meeting, thanked the teachers for their time, and offered a gift card as a 'thank you'.

3.3.2 Expert meeting with teachers

The expert meeting with teachers took place on June 18, 2019, on a central location. During the meeting, the expert teachers discussed the process and complexity of differentiation in kindergarten. First, the researcher presented the four stages of differentiation based on Van Geel et al.'s (2017), adapted to the first results of this study: preparing a theme, preparing the day, during the day, and after school. For each stage the teachers were asked to write down all the activities they undertake on a yellow post-it. After that, all teachers were given the opportunity to give a oral explanation, to clarify their activities and then stick the post-it to the poster of the stage in question. The researcher then gave the teachers the opportunity to react to each other's notes, and asked questions to further deepen the explanations, for example by asking 'can you explain why?', 'what do you need in order to do so?', and 'how have you developed this skill?'. After that, the teachers were asked to write down the skills or knowledge they need in order to execute the activities as described on the yellow post-its. Then again, the teachers had the opportunity to discuss and supplement each other's notes, and again the researcher asked questions to deepen the explanations. The expert meeting was video recorded to facilitate a detailed description of the discussed activities, skills, and knowledge.

3.3.3 Subject matter expert meetings

The subject matter expert meetings were individual meetings taking place in the experts' office. The researcher presented the first draft of the skill hierarchy with the overview of needed knowledge and possible complexity factors. The subject matter experts got the chance to verify the first draft of the skill hierarchy and to provide extra information in order to specify the standards for acceptable performance. The researcher's focus was on subject matter specific knowledge and skills by asking questions like 'what knowledge does a teacher need in order to do so?', 'what subject matter content does a teacher apply in this phase of differentiation?', 'what skills does a teacher need in this phase?', and 'do you miss any skills in this phase?'. Both expert meetings were recorded.

3.4 Data analysis

The qualitative data was analysed in an iterative process parallel to the data collection. This means the results of the interviews were presented in a first draft of the skill hierarchy combined with an overview of knowledge and complexity factors. This first draft was input for the expert teacher meeting. Then, the results of the expert teacher meeting were included in the second draft, which formed the input for the subject matter meetings.

3.4.1 Classroom observations and interviews

The audio recordings of the interviews were transcribed in order to facilitate a detailed analysis. Goal

of the analysis was defining general themes and behavioural patterns mentioned by two or more teachers. This was done by dividing fragments of the interviews over the four stages of differentiation adapted to the context of kindergarten: preparing a lesson period, preparing a lesson, enacting a lesson, and evaluation (Van Geel et al., 2019). This is a deductive form of coding, because quotes were placed under these theory based pre-formulated codes, the stages of differentiation. The coding within these stages was inductive. All quotes received a nonpredetermined code that summarized the content of the quote. Every new code was written down. When all interviews were coded, the quotes and its codes were reviewed to see whether codes could be merged or had to be added. After that, the researcher grouped quotes with the same code. When a code was applied to the quotes of two or more teachers, the content became part of the skill hierarchy.

In the third part of the interview, the following 10 topics were discussed: differences between students, preparing a theme, preparing the day, activities during the day, evaluating the day, monitoring, materials, vision and support in the school, complexity factors, and the differences and similarities between differentiation in kindergarten and primary education. These topics were used to deductively code the teachers' answers. And again, the quotes within these topics were coded inductively.

The last step of the data-analysis was to separate the needed teacher skills, and knowledge and the possible complexity factors. This analysis led to a first draft of the skill hierarchy which was used as input for the expert meeting with teachers.

3.4.2 Expert meeting with teachers

During the expert meeting, teachers were asked to write down all the activities they undertake within a specific stage of differentiation on a yellow post-it, and the skills or knowledge they need to be able to execute these activities on a pink post-it. After the meeting these notes were digitalised per stage of differentiation. Besides that, the researcher watched the video of the expert meeting, and listened to the teachers' explanation to their notes. All explanations that were not already part of the first draft of the skill hierarchy were written down next to the digitalized post-its and taken into consideration for the second draft of the skill hierarchy. When two or more teachers agreed on an explanations, the idea was included in the skill hierarchy.

3.4.3 Subject matter expert meetings

Lastly, the audio recordings of the subject matter expert meetings were listened to. All the suggestions for adaptations or additions to the skill hierarchy were written down, and compared to the transcriptions of the interviews and the output of the expert meeting with teachers. When a teacher mentioned this aspect as well, the suggestion was included in the final version of the skill hierarchy.

4. Results

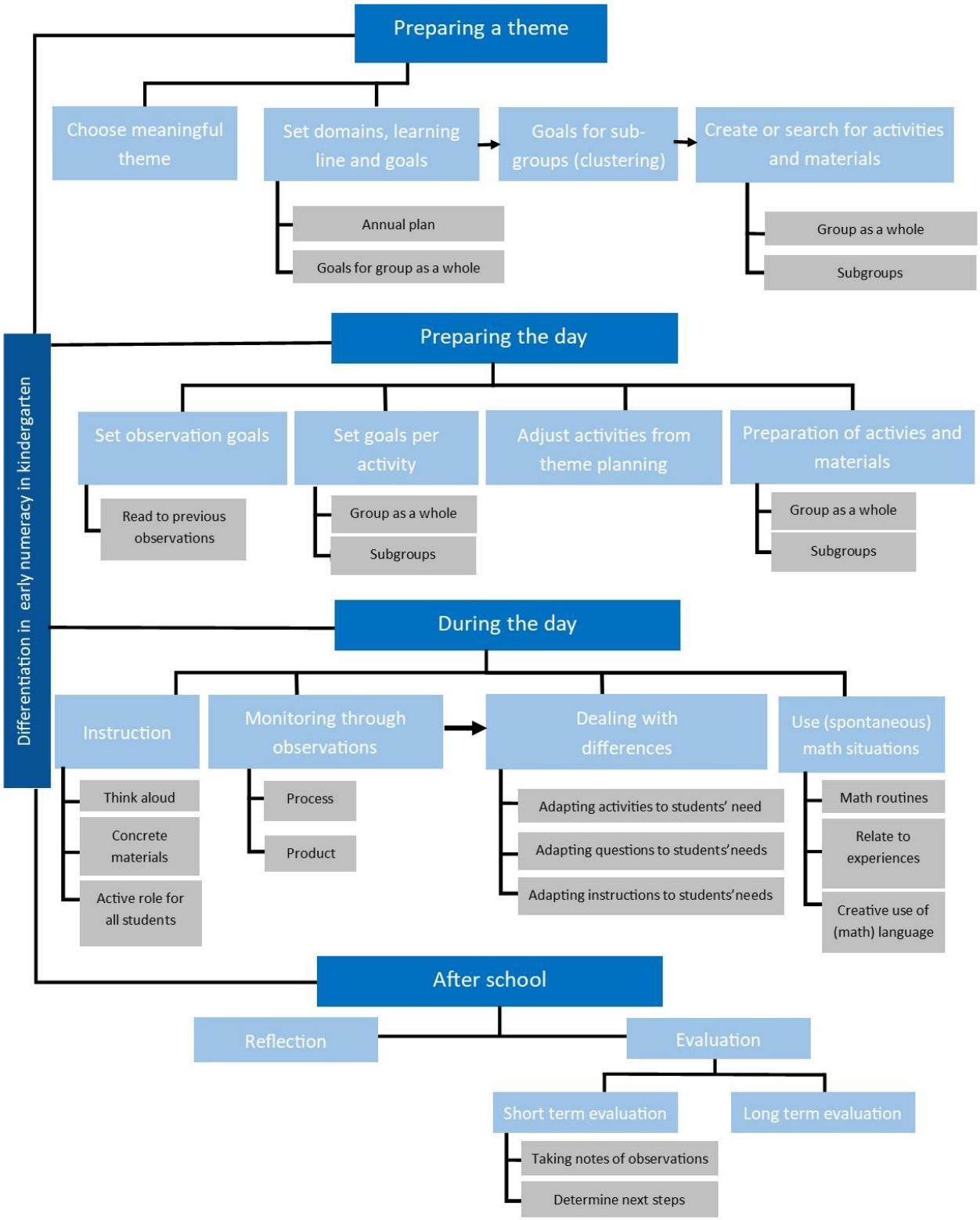
In this chapter the results of the practical research are presented. In the next paragraphs the needed skills, and knowledge for differentiation in early numeracy activities in kindergarten will be described, together with its complexity factors.

4.1 Skill hierarchy

The skills needed for differentiation in early numeracy activities in kindergarten, are presented in a skill hierarchy comparable to Van Geel et al.'s (2018) skill hierarchy. Their skill hierarchy was divided into four stages of differentiation: preparing lesson period, preparing lesson, enacting lesson, and evaluating lesson. During the data analysis, it became clear that these stages were not directly applicable to the context of kindergarten, since early numeracy is offered in a variety of activities throughout the day instead of separate lessons. Therefore the stages of differentiation are reformulated for kindergarten into: preparing theme, preparing day, during the day, and after school, as can be seen in figure 4.1.

All the skills mentioned by two or more expert teachers are placed in the skill hierarchy. Within each stage of differentiation, separate skills are presented. The skills presented next to each other and not attached to each other, can be executed separately in random order. The skills above one another and attached to each other have a vertical relationship. The lower skills attached to a higher skill, are conditional for the higher placed skill.

Figure 4.1 Differentiation skill hierarchy



4.1.1. Preparing a theme

A lot of teacher time is spend on preparing a meaningful theme. All the expert teachers mentioned that they start with choosing fitting domains and goals to a meaningful theme. The teacher educator (subject matter expert) emphasized that a theme and the learning goals should naturally fit: '*a teacher should prevent a non-fit between a theme and the goals. When a teacher chooses hospital as a theme, she should think of the natural situations that happen within this theme. In this case, the best domain to pick would be 'measuring', which fits doctors and the hospital.*'.

All expert teachers set goals in their theme preparation. Two expert teachers brought up they choose goals within an annual plan, four teachers mentioned they set goals for the group as a whole and two of them mentioned goals for subgroups or individuals. Since no fixed curriculum materials were used to reach these goals, teachers have to find or develop learning materials themselves, which is the third skill in this stage. Activities like whole-group instruction, small group instruction, individual play, games, routines, math areas, and songs are used to reach the determined goals. It depends on the size of the school, but if possible, teachers work together with their colleagues to develop a theme and fitting activities, as teacher 7 explained: *'We work together with our colleagues from the parallel groups, so all colleagues from K1 together. Before a theme starts, we have multiple meetings to discuss what we want to work about, and which goals to set'*. Good to know is that a theme preparation always offers the possibility to adapt goals or activities to one's own group. And again, teachers already think about how to adapt the activities, materials, and math areas to the students' needs. A teacher has to prepare activities for the group as a whole and for subgroups. Teacher 4 told that differentiation has a prominent role in her theme preparation: '*Yes, before starting this theme [building] I already prepared the building cards. Researcher: So you already prepared how to simplify or to make it more difficult? T4: Yes, everything is prepared and ready to use. Sometimes I work with a subgroup of children who need extra attention, so I already look for the possibilities to offer them this extra instruction.'.* The activities can be created by the teacher herself or inspired on fixed curriculum materials or other teachers' work (colleagues or online).

The last skill in this stage is to cluster students. When the goals are set, five expert teachers told that they cluster students on their level of achievement. Most often with the help of previous observations or a standardized test.

4.1.2 Preparing the day

A lot of activities, materials, and math areas were already prepared in the theme preparation. Therefore, less time is spent on preparing the day. Focus shifts from developing education in the first stage, to adapting this design in this second stage. Three expert teachers mentioned they determine for themselves what goals they want to monitor that day. When these observation goals are set, it is

also important to read previous observations. During the expert meeting with teachers, all three teachers told they read previous notes to determine the children's' zone of approximal development.

Another skill is to set goals per activity. This goal seems to overlap with setting goals in the previous stage, but one expert teacher and a subject matter expert emphasized the importance of setting goals again in this stage. The overall goals for the group as a whole, and for subgroups were set per theme. For the preparation of a specific day a teacher has to be able to set specific goals for this specific day, since is not possible to apply all the theme's goals in one day. Besides that, a theme takes multiple weeks to finish, so classroom observations may be reason to repeat a goal or skip a goal. Again, these goals have to be set for the whole group and for subgroups. As a subject matter expert told: 'when things are not written down, it is easy to forget'. Teacher 4 uses her preparation time to specify her goals for the whole group: *'This week my goal is that all children who play with K'nex use a building card to build something on their own. Last week they built spinning tops. That is fine, it helped them to explore the material themselves. But this week, I want them to work more goal-oriented.*'

Most activities were already prepared in the theme preparation. But as mentioned with the previous skill, it is possible a teacher finds out an activity is too easy or takes too much time. Three expert teachers mentioned it is important a teacher has the skills to improve the pre-set activities and to adjust the materials to the needs of his group, for example like teacher 7 did: '*Today is the first time I offered the numbers 10 to 20. Primarily for the children who are already far in counting. Last week I observed most children during a math activity, and I found out most of them already know the numbers to 10. That's why I added the new numbers, although they do not know them yet, let's see how far they can get, or I will help.'*.

The last skill *is preparing activities and materials*, as mentioned by five teachers and underlined in the expert meeting with teachers. To be fully prepared for the next day, this preparation has to be done for the group as a whole and per subgroup. Like teacher 6 does: '*After school, I prepare the next day's activities very consciously. What do I need for which (sub)group?*'. Most time is spend on preparing the small group activities, since these were mostly left open in the theme preparation to have the opportunity to react to the children's specific needs.

4.1.3 During the day

In this stage, four main teacher skills are presented with the related subskills. These skills are put into practice in a variety of activities. The presented skills are applicable in for example whole-group instruction, but also in small-group instruction, individual guidance, play situations, cooperative learning, or playing in (math) areas.

Four teachers emphasized the importance of effective instruction. Approaches mentioned by

two or more teachers and in the expert meetings, were modelling (think aloud), the usage of concrete materials, and an active role for all students. Teacher 3 explained the relation between the importance of concrete materials and the development of 4-to-6 year olds: '*When I tell my students they are going to practice dividing together with a classmate at the table (instead of in a whole group instruction), I can see their enthusiasm. These children need to do activities themselves, they need experiences to learn. Only then the new subject matter will not be forgotten.'* The importance of providing effective instruction was further underlined in both expert meetings.

A big teacher task during the day is *observing or monitoring* the students' progress. This can be done by taking a look at the delivered product or the learning process. Teacher 6 describes both types of observations: *This student looked a bit dreamy during the whole-group instruction. He did not really pay attention, I had to ask for his attention several times. His attention easily wanders, he is very dreamy. [=observing learning process]. So I wanted to check whether he captured the new subject matter or not (…) In my head I think about what things he knows or can [= observing product], and then try to get him one step further. But he couldn't this time. This means I now have to stop, otherwise it gets to difficult for him. This is the reasoning in my head when differentiation. I am always searching for a student's zone of proximal development.*

All eight teachers described multiple examples of differentiation situations. During the day, teachers have to do lot of 'on-the-spot' differentiation by adapting activities, questions, and instructions to students' needs. By doing this, a teachers takes differences between students into account. The adaptations can already be prepared in the theme or day preparation, or be a result of recent observations. Seven teachers described how they ask different level of questions, for example teacher 7: *'In this whole group instruction, I asked the K0-students questions like which number of fruits is the most or least, and all the other students got questions about the exact number of fruit.'*. Besides that, seven teachers explained they not only differ in level of single questions, but also adapt activities or assignments to the students' needs. When an activity is adapted, the teacher has different expectations about this student's product: '*It think it is important to help all children one step further. That is why I offered all the different assignments. When students are not able to execute the assignments individual, I or another student will help. It is important all students are challenged, but do have experiences of success. Like today, I asked some students to build with concrete materials, other students already use abstract pictures, use the 25-grid or even the 100-grid.' (teacher 4).* Finally, four teachers described how they adapt their instruction to the needs of their students. During the day, they decide to explain subjectmatter again or in a different way to help the children lacking behind. For example, teacher 8: '*The children playing with water, were just having fun and not using the tools to measure water. As soon as I saw this happening, I decided to participate in their play. I showed and talked about the amount of water I saw and how I could use*

the measuring tools, in the hope they would take over these actions'. These three types of adaptations were included in the skill hierarchy because they are broadly supported by quotes of multiple teachers. Besides that, it was verified in the teacher expert meeting and by both subject matter experts.

Finally, a teacher has to be able to see math everywhere. With the help of math routines, relating to experiences and a creative use of language, a teacher can trigger learning and build in a lot of repetition. Aspects that fit the natural learning of 4- to 6-year olds. This skill was only one teacher during the interviews, but was strongly emphasised during the teacher expert meeting and by both subject matter experts. Therefore, it is included in the skill hierarchy.

Noteworthy is the fact that five teachers mentioned they can only put the skills in this stage into practice with an efficient classroom management. Classroom organisation can be seen as a prerequisite for differentiation during the day.

4.1.4 After school

After school, two skills are very important: reflection and evaluation. During the interviews only teacher 4 explained how she uses her time after school to reflect: '*Every day I ask myself 'How about today? Am I content?; What am I going to do tomorrow? What would I do different next time?'. For example after today, I would turn the chair, so the children can see the buildings better*.' Since the importance of reflection was emphasized during the expert meeting with teachers, this skill was included in the skill hierarchy.

All teachers did agree on short term evaluation. All eight teachers mentioned they take notes of their observations. Six of them also take decesions about the next learning steps to take, like teacher 3: *' The next step for them would be to rotate and flip the image. Those two boys who were creating a sword, also the new boy, they fulfilled a very complex task. That surprised me. I like this, so I will see what happens next time'*. Regarding long term evaluation, five teachers used their classroom observations to cluster students: Teacher 6: *'I use my observations from whole group instructions, individual work, and play. We take notes of our observations, most of the days we take notes, and then we will discuss who needs to be challenged more'*. Some schools also use the results from standardized tests to cluster children in subgroups. The formed subgroups of students are input for a next theme preparation with the same goals.

4.2 Knowledge

Just having the skills as presented in the skill hierarchy, is not enough to differentiate. The analysis of the interviews with expert teachers, the expert teacher meeting, and the interviews with subject

matter experts led to a description of 3 types of conditional knowledge: knowledge about students, knowledge about the development of 4- to 6-year olds, and subject matter knowledge.

4.2.1 Subject matter knowledge

In discussing the four stages of differentiation (Van Geel et al., 2019), one type of knowledge was mentioned in all stages: knowing the six domains of early numeracy and the educational curriculum for each domain. When a teachers knows what is expected in K1 and K2, he can set goals, deal with differences, offer help, and evaluate students' progress. Since most kindergarten teachers in the Netherlands develop their education within a meaningful theme, the domains and educational curriculum are also used to determine the activities and materials to insert in such a theme. This means a kindergarten teachers also needs a repertoire of activities, ideas, and materials to be able to develop his education. The more experienced a teacher, the bigger the repertoire gets. A teacher can build this repertoire by using fixed curriculum materials as a source, searching for ideas online, or observing a colleague's work.

Besides subject matter, the experts emphasized the importance of knowing general, evidence-based pedagogical approaches. For example the taxonomy of Bloom, knowing how to model and think-aloud, how to scaffold, and how to use the 'handelingsmodel', a frequently used Dutch teaching model for math education. Only with this knowledge, a teacher will be able to offer effective differentiation.

4.2.2 Knowledge about students

All experts underlined the importance of knowing your students. On the one hand, knowing every student's level of achievement and their zone of approximal development. It is important a kindergarten teacher knows where every student stands in each domain. A teacher can adapt the activities, questions, and instructions to the student's needs with the help of this insight. On the other hand, a kindergarten teacher needs to know his students' individual educational needs, which are not all math specific. Think of a child's social-emotional development, language, independence, personal interests, concentration, and working pace. With a sufficient understanding of a child's achievement in different development areas, a teacher will know when signals are alarming or not.

4.2.3 Knowledge about the development of 4- to 6-year olds

A kindergarten teacher should know that the development of a 4- to 6 year old is different from the development of children in primary education. This specific development has consequences for how to fill in education in kindergarten. First of all, the development of a 4- to 6-year old increases in leaps. It is possible a child is not ready for a certain learning goal yet, but will be in six weeks. Besides

that, these children learn by doing, experiencing, dealing with concrete material, and by repeating. All of this should be done within a meaningful topic to relate to a child's experiences.

4.3 Complexity factors

The expert teachers experienced a couple of factors that contributed to the complexity of differentiation. First, differentiation can get more complex due to the number of students, and the variation between these students. The more levels within a group, the more difficult differentiation gets. As a result teachers get the feeling they cannot take the individual needs of all students into account, which produces a feeling of frustration. Major differences between students can also be caused by the number of 4-year olds entering kindergarten throughout the schoolyear. As teacher 4 described: '*When a new child joins our class, I have to spend sufficient time to guide the new student. Then, in the new child's first week in our class, a lot of my attention goes to this child. Does he know where to sit, does he know how to manage, what is he doing all morning? This asks a lot of my time, leading to less time for the rest of the group*.'

Besides the number of students, multiple expert teachers underlined the importance of good classroom management. When activities are badly organised, and students do not know what to do, students will continue to ask you questions which leaves less time for differentiation. At last, the expert teachers mentioned the lack of guidance as a complexity factor. Differentiation is a complex teacher task without a 'one-size-fits-all' approach. When the teachers encounter a problem, most of them ask their colleagues or the academic coach for help. Some teachers added that they would like to have the opportunity to see how other schools deal with differences and to get inspired, but do not have the possibility to do so.

5. Conclusion and discussion

In this chapter a conclusion will be drawn on the basis of the results from the literature study and the cognitive task analysis. Then the value for practice and research will be described. The chapter ends with a description of the study's limitations and suggestions for future research.

5.1 Conclusion

Overall, the skills needed for differentiated early numeracy education in kindergarten correspondents with the skills needed for differentiated math instruction in primary education. The deviation into four stages of differentiation is similar, only the names are adapted to practice in kindergarten. The differences and similarities per stage will be described below.

5.1.1 Skills required for differentiation in early numeracy in kindergarten

Preparing a theme

In the first stage of differentiation, preparing a theme, kindergarten teachers need five skills: teachers need to be able to choose a meaningful theme, set domains and learning goals (in an annual plan, and whole-group goals), set goals for subgroups, and create math areas, activities and materials (for group as a whole and for subgroups). A similarity with primary education (Van Geel et al., 2019) is that both teachers have to be able to set goals and cluster students. A difference is that kindergarten teachers pay more attention to how to reach the set goals in practice. They have to choose a meaningful theme and create activities, materials and a learning environment in which children can learn. This specifically belongs to the context of kindergarten, since most teachers develop their own education within a meaningful theme, where primary school teachers use more fixed curriculum materials.

Another difference is the skill *analysing*, as mentioned by primary school teachers. This difference might be caused by the fact that primary education merely relies on test results to measure student achievement instead of the everyday observations kindergarten teachers use. The last difference is determining a didactical approach. This was not mentioned by the expert kindergarten teachers. Overall, the skills needed in this first stage of differentiation are very similar for kindergarten and primary education. The few differences are primarily caused by differences in how education is structured in both contexts.

Of course, not all other studies about differentiation used the allocation in four stages of differentiation like Van Geel et al. (2019) and this study did, which makes a comparison with other studies complicated. What can be seen are some similarities with the *Model of professional knowledge and skills for early mathematics education* (Gasteiger & Benz, 2018). This models also

states that a teacher has to be able to design mathematical learning opportunities, and to choose adequate learning materials. Selecting a meaningful theme can be seen in *perceiving mathematical relevance of situations.* Setting goals, and clustering students are not explicitly named in their model.

Preparing the day

Multiple similarities can be found between the skill hierarchy for primary education (Van Geel et al., 2018) and for kindergarten. The first needed skill for preparing a math lesson in primary education is *set goals for group as a whole,* which can also be found in the skill hierarchy for kindergarten teachers. Another similarity is *determine instruction for groups* in primary education and *prepare activities and materials.* Compared to primary school teachers (Van Geel et al., 2019), less time is spent by kindergarten teachers on preparing a specific day. According to the expert teachers, kindergarten teachers have to set observation goals and read through the notes of previous observations in order to gain insight in students' learning progress and their zone of approximal development. The rest of the skills are built on what was already done in the theme preparation. Teachers set specific goals per activity, both whole-group goals and goals for subgroups. Next to that they adjust the activities from the theme planning and prepare activities and materials needed for the next day. Primary school teachers use their preparation time to critically study curriculum material, determine grouping, and selecting materials.

Gaining insight in the students' learning progress, for example by reading notes and setting observation goals, is also emphasized in other studies. Dijkstra et al. (2017) stated that differentiation in kindergarten starts with regular monitoring of levels and progress, and the cycle of differentiation starts with *identification of educational needs* (Prast et al., 2015).

During the day

According to the experts in this study, a kindergarten teacher needs four main differentiation skills during the day: instruction with set strategies, monitor through observations, deal with differences and use of (spontaneous) math situations. These skills are comparable to skills emphasized in other models. For example Vogt and Rogalla's (2009) competency of advance diagnosis of student learning (monitoring) and a variety of teaching methods and Gasteiger and Benz's (2018) core principle of observing and registering students' learning progress. Differentiated instruction and differentiated practice are also emphasized in the *Cycle of differentiation* (Prast et al., 2015). Notable is that this model also emphasizes differentiation when students on specific tasks, individually or in groups, by adding *differentiated practice*. The skill hierarchy also matches Dijkstra et al.'s (2017) first key point for differentiation: regular monitoring of levels and progress. Besides that the skills match the basic ideas for offering effective early numeracy education with offering goal-oriented activities (Bouwman & Kaskens, 2018) and the skills to be fully prepared to formal and informal learning situations

(Gasteiger & Benz, 2018), since everyday learning situations are viewed as the most effective context for creative and challenging learning tasks (2015). This skill hierarchy for differentiation in kindergarten as created in this study, seems to be a combination of skills as presented in studies.

In this third stage, multiple differences can be seen between the skill hierarchy for primary education (Van Geel et al., 2018) and for kindergarten. These differences are mostly caused by the fact that math in primary education is (most often) taught in separate math lessons, and early numeracy education is offered in a variety of activities throughout the day. The skill hierarchy for primary education contains four main skills. First, introducing the lesson by introducing the goal and activate prior knowledge. These skills cannot be found in the skill hierarchy for prior knowledge. The same goes for stimulating self regulation and ending the lesson.

More correspondence can be found with the skill *providing adapted instruction* in primary education. This skills is divided into the subskills monitor progress, provide instruction matching needs and organize instructions. Monitoring is also part of the needed skills in kindergarten, although kindergarten teachers primarily use observation to monitor the students' learning process and results, instead of formal student work as in primary education. *Provide instruction matching needs* and *Organize instructions* are clustered under *deal with differences* in kindergarten. This skill not only consists of adapting instruction to student's need, but also of adapting (individual) activities and adapting questions, which can be applied in all kinds of activities.

Next to that, kindergarten specific skills can be seen in skill hierarchy for differentiation in skill hierarchy: *use (spontaneous) math situations* by math routines, relating math to experiences, and creative use of language. These skills match with the many on-the-spot adaptations kindergarten teachers do during the day based on their observation, and the fact that 4-to-6 year olds learn by play. Spontaneous moments are used as an opportunity to stimulate math development and react to students' needs.

After school

In the last stage of differentiation, kindergarten teacher need to following teacher skills: reflection and evaluation. Evaluation is split into short term evaluation (take notes of observations and determine next steps) and long term evaluation. Personal reflection was not specifically mentioned in literature about differentiation, evaluation was. A lot of attention goes to *evaluation of progress and process* (Prast et al., 2015), evaluating the lesson (Van Geel et al., 2018), and the use of monitoring to define the further learning steps (Dijkstra, et al., 2017; Gasteiger & Benz, 2018). This shows a strong theoretical basis for the skill *evaluation.* A teacher needs to evaluate in order to take data-based decisions and define further learning steps. It is possible *Reflection* is also part of the term evaluation in these studies, since both terms are related.

Reflection is not mentioned in the skill hierarchy for differentiation in primary education (Van Geel et al., 2018), evaluation. A big similarity between the hierarchies is that evaluation is divided in short term and long term evaluation. The only difference is the specification of short term evaluation in kindergarten into taking notes and determining further learning steps, caused by the importance of observations in kindergarten and the responsibility a kindergarten teacher has in developing his own education.

5.1.2 Knowledge required for differentiation in early numeracy in kindergarten

The cognitive task analysis led to a description of three kinds of knowledge needed for differentiation in early numeracy in kindergarten: (1) subject matter knowledge early numeracy, (2) knowledge about students, and (3) knowledge about development of 4- to 6 year olds.

A lot of similarities can be found between the needed teacher knowledge for differentiation in kindergarten and in primary education (Van Geel et al., 2019). First of all, knowledge of students is very important. In order to adapt education to students' needs, a teacher needs insight in their levels, their zone of approximal development, and pedagogical needs. The expert kindergarten teachers emphasized the need of insight in all development areas, so a teacher has a complete picture of a child's development. Another similarity is subject matter knowledge. Teachers need a substantial understanding of math and the curriculum. In kindergarten greater emphasis was put on the importance of having a repertoire of ideas, activities, and materials per math subject. The same goes for knowledge of pedagogy.

The main difference is the extra type of knowledge in kindergarten: knowledge about the development of 4- to 6-year olds. The expert teachers and subject matter experts underlined that pre-schoolers learn by doing, experiencing, and repeating. They need activities with concrete materials within a meaningful topic. The emphasis might be caused by the Dutch school system. Kindergarten is part of primary education, which implies that teachers are certified both kindergarten and primary school. In practice, many teachers do not feel prepared (enough) to teach kindergarten and lack knowledge about a young child's development. This might cause the expert teachers' emphasis on knowledge of a 4- to 6-year old's development.

The importance of subject matter knowledge was also emphasized in several other studies. Vogt and Rogalla (2009) underlined the importance of extensive subject knowledge and a variety of teaching knowledge. As did Dijkstra et al. (2017) who specified the subject matter knowledge into knowledge of the curriculum and learning goals in order to be able to set goals and evaluate the learning process. Even more detailed are Gasteiger and Benz (2018). They split subject matter knowledge into explicit knowledge of mathematical concepts, fundamental ideals and learning materials and implicit knowledge based on experience. This implicit knowledge specifically belongs to

the context of kindergarten, since pre- or in-service teacher training does not fully cover all needed mathematical content for effective math education. This corresponds with having a repertoire as the expert teachers mentioned. Over the years, teachers build their own repertoire of ideas, activities, and materials per learning goal.

The category *knowledge about students* is mentioned in several studies, both in kindergarten (Dijkstra et al., 2017) and in primary education (Van Geel et al., 2018). What seems to be different is the category *knowledge about development of 4- to 6-year olds*. Most teacher experts and the subject matter experts in this study underlined the importance of knowing how these children learn, therefore it ended up as a separate category. The difference with other literature might be caused by the fact this type of knowledge can also be classified as pedagogical and didactical knowledge, as Gasteiger and Benz (2018) did.

5.1.3 Complexity factors for differentiation in early numeracy in kindergarten

Van Geel et al. (2018) mapped out the complexity factors for differentiated math instruction in primary education. When these factors are compared to the complexity factor for differentiation in kindergarten a few similarities can be seen. First, the group composition in the form of diversity. The specification of number of grades and students with special educational needs were not explicitly stated by the expert teachers. This doesn't mean it not part of the complexity in kindergarten, since both term might be covered by the term 'variety'. Another similarity is school support. Both kindergarten teachers and primary school teachers mentioned this.

Some differences can be found too. The expert teachers did not mention content of the lesson, curriculum material, and data regarding student achievement and progress as complexity factors. This might be caused by the differences in how education is shaped in both sectors. In kindergarten, subject matter is less complex, teachers use less or no fixed curriculum materials, and frequently use their own observations for monitoring students' learning process and progress instead of paper tests. Teachers are used to systematically monitor their student's learning and creating their own education, it is part of their job and therefore not mentioned as complexity factors.

In literature, several factors contributing to the complexity of differentiation in kindergarten were described. First of all, group composition. The fact that most kindergarten classes are multi-grade classes with 4-year olds entering the group throughout the school year, contributes to a varied group and thereby the complexity of differentiation. Besides that, subject matter is offered in a variety of activities. This implies that kindergarten teachers have to organise multiple goal-oriented math activities, and monitor their students' learning process and progress. The expert teachers in this study did not appoint the number of activities as a complexity factor. Although group composition is recognized as complexity factor, specified by the expert teachers into the number of

students, variation within the group and the number of 4-year olds entering the group. Two factors added by the expert teachers are bad classroom management and lack of education and guidance. These two factors relate to the complexity factors Dijkstra et al. (2017) described. They state that a lack of differentiation skills and monitoring skills contribute to the complexity of differentiation.

5.2 Value for practice and research

The results of this study are valuable for both practice and research. Many kindergarten teachers specified differentiation as difficult to put into practice (Santangelo & Tomlinson, 2012), and research showed that not all kindergarten teachers master the required advanced skills (Doolaard & Harms, 2018). This means there seems to be a need for improvement of differentiation skills in kindergarten (Dijkstra et al., 2017). To develop professional guidance, insight was needed in the required skills, knowledge and complexity factors for differentiation in early numeracy in kindergarten. This study resulted in such an insight, which now can be used to design pre-service or in-service professional development trajectories. Besides that is easier to assess whether a teacher masters the required knowledge and skills, which is useful for people like school leaders, teacher educators, and inspectors. The outcomes of this study are also valuable for research, because it contributed to a deeper insight in the required skills and knowledge for differentiation in kindergarten, and the applicability of the CTA to study differentiation in various educational contexts.

5.3 Limitations and future research

A few limitations can be determined for this study. First, the number of experts in the expert meetings. In this study eight expert teacher participated, but only three of them were able to join the expert meeting with teachers. Extra kindergarten teacher were approached to join this meeting, but this did not lead to extra participants. The same applies to the number of subject matter experts. Only two experts participated and it was not possible to gather a meeting with both experts at the same time. As a consequence, subject matter experts did not have the opportunity to discuss their opinions or experiences with each other, like the expert teachers did. Experts participated in the study in their own time after school, which also reduced their availability.

Another limitation is the fact that the teachers were only observed for one morning. A suggestion for future research would be to observe and speak to teachers at least two consecutive days. This offers the opportunity to gain insight in how teachers apply the defined further learning steps in the next day. Another way to improve the sample is to add teachers from the western half of the Netherlands, to fully cover the context of Dutch kindergarten. The last limitation is that only one researcher conducted and analysed this study. The deployment of two researchers would offer the possibility for them to discuss results and create a skill hierarchy together, which will contribute to the quality of the hierarchy.

In this study eight teachers from traditional kindergarten education participated. It is not known whether these results are generalisable to other contexts like Montessori. Suggestion for future research would be to repeat the research within that context in order to find out whether the skills, knowledge and complexity factors are context specific or general. The same can be done by researching other subject matter, for example language development.

5.4 Final conclusion

Early numeracy education in kindergarten and math instructions in primary educations in the Netherlands are two contexts for differentiation, that differ from each other due to the way education is organised in both contexts. With the help of this study's results, it can be said that the contexts differ from each other, but that the underlying teacher skills, knowledge, and complexity factors for differentiation are comparable.

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Content Appendix

Appendix A: Instrument interview

START INTERVIEW

Ik heb een interview voorbereid, bestaande uit **drie onderdelen**:

1. Algemene vragen om persoon en klas in beeld te brengen.
2. Bekijken filmfragmenten en deze bespreken
3. Vragen over omgaan met verschillen in groep 1-2.

Doel interview: inzicht krijgen in de beslissingen die gedurende deze lesochtend gemaakt zijn op het gebied van differentiatie. Waarom zijn deze beslissingen gemaakt? Dit zijn overwegingen die in het hoofd gemaakt worden. Doel van deze onderzoeksmethode (CTA) is het terughalen van deze gedachtes, zodat anderen hier van kunnen leren. Welke vaardigheden en kennis moet een leerkracht hierbij inzetten?

Duur interview: Gemiddeld duurt het interview een uur.

Toestemming audio-opname: Wordt alleen gebruikt om interview uit te kunnen werken en focus op het gesprek te leggen i.p.v. op aantekeningen maken.
Ik kan de uitwerkingen toesturen, zodat eventueel delen weggehaald kunnen worden.

ALGEMENE VRAGEN

Persoonsgegevens

Respondent nummer: ……..

Sekse O vrouw O man O zeg ik liever niet

Leeftijd: ……..

Onderwijservaring in jaren: ……..

Onderwijservaring gr. 1-2 in jaren: ……..

Fulltime of parttime baan: O fulltime O parttime (……. fte)

Opleiding: O KLOS O Pabo specialisme jonge kind

O Pabo met specialisme oude kind O Anders:……

Beschrijving klas

Groepsgrootte: ……..

Groepssamenstelling: ……..

Kenmerken populatie: ……..

Onderwijs groep 1-2

Thematisch onderwijs?	O ja	O nee
Leerlingvolgsysteem?	O ja, namelijk ……..	O nee
Methode voor rekenontwikkeling?	O ja, namelijk ……..	O nee

FILMFRAGMENTEN

Start

Vanmorgen heb ik opnames gemaakt van de (reken)activiteiten in groep 1-2. Focus lag hierbij op u als leerkracht. Tijdens deze ochtend heb ik tijdstippen genoteerd waarop er naar mijn idee sprake was van differentiatie. In de middag heb ik een aantal fragmenten van deze tijdstippen geselecteerd. Dit zijn verschillende momenten, maar de overeenkomst is dat ik zie dat u als leerkracht een beslissing neemt. Deze fragmenten wil ik gebruiken om terug te halen welke beslissingen er tijdens de verschillende activiteiten zijn genomen en waarom.

Met terugwerkende kracht hardop denken

Vragen:

- Wat doe je hier?
- Waarom doe je dat? / waar is dat op gebaseerd?
- Waar let je op?
- Met welke ander informatie combineer je deze observatie?
- Welke plannen had je vooraf?
- Wat pas je aan tijdens de les? Op basis waarvan?
- Wat dacht je hier?
- Wat gebeurt er al je … doet?
- Wat doe je met de informatie verkregen uit…?

VRAGEN ONDERWIJS IN GROEP 1-2 & DIFFERENTIATIE

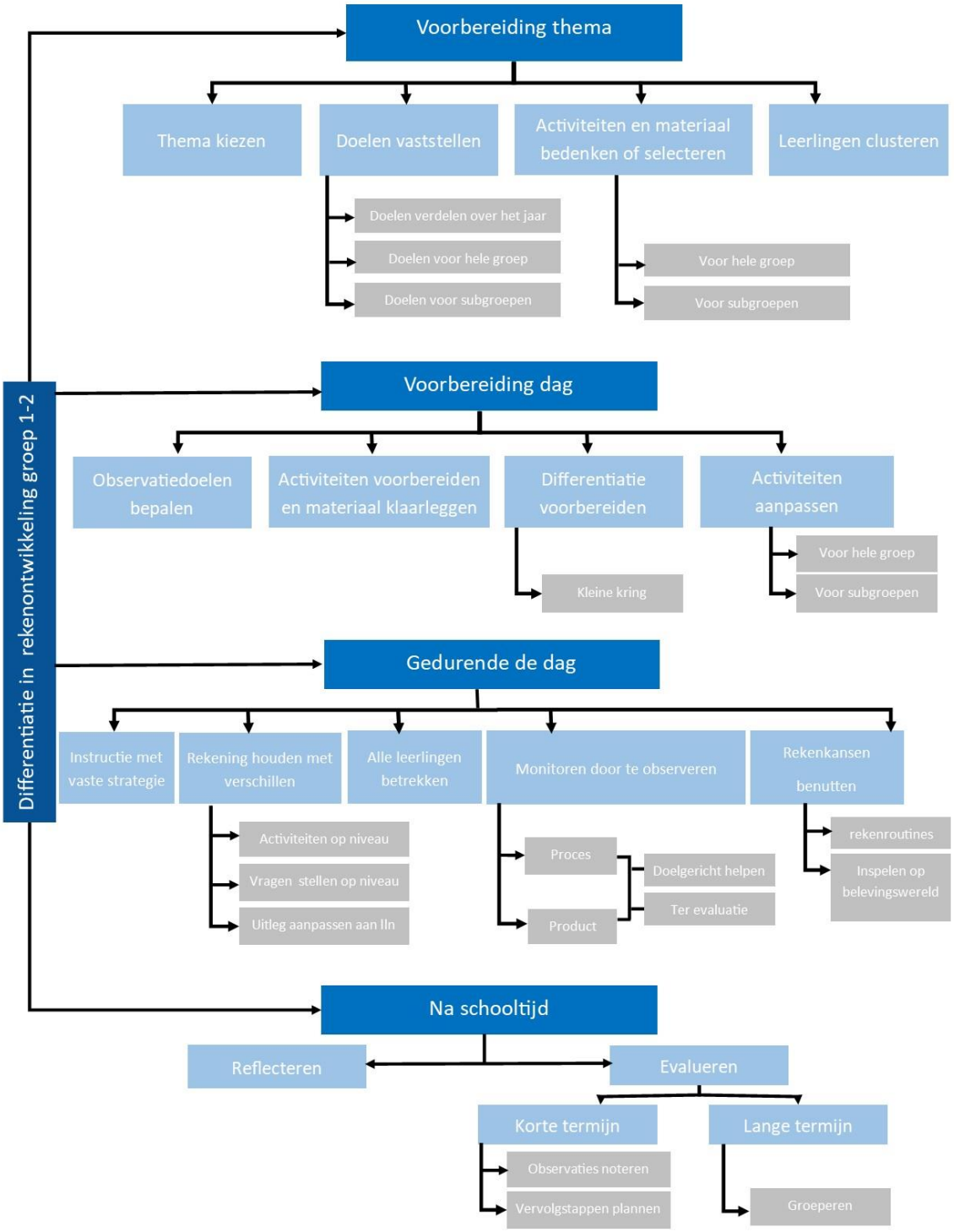
1. Welke verschillen moet een leerkracht in groep 1-2 rekening mee houden?
2. Voorbereiding thema/periode
3. Voorbereiding dag/les
4. Tijdens de les
5. Na de les
6. Monitoring (=tijdens/na de les?)
7. Materialen
8. Afspraken binnen de school/ondersteuning
9. Belemmeringen Wat maakt de situatie complex/makkelijker?
10. Verschillen en overeenkomsten met groep 3 t/m 8.

AFSLUITING

- Aanvullende opmerkingen/iets wat je nu nog te binnen schiet?
- Uitnodiging expertmeeting op Iselinge

- Nog meer leerkrachten?
- Bedanken voor deelname (presentje?)

Appendix B: First draft skill hierarchy and overview knowledge and complexity factors



Kennis van..

➔ Per leerling inzicht in:

- Voortgang op leerlijn

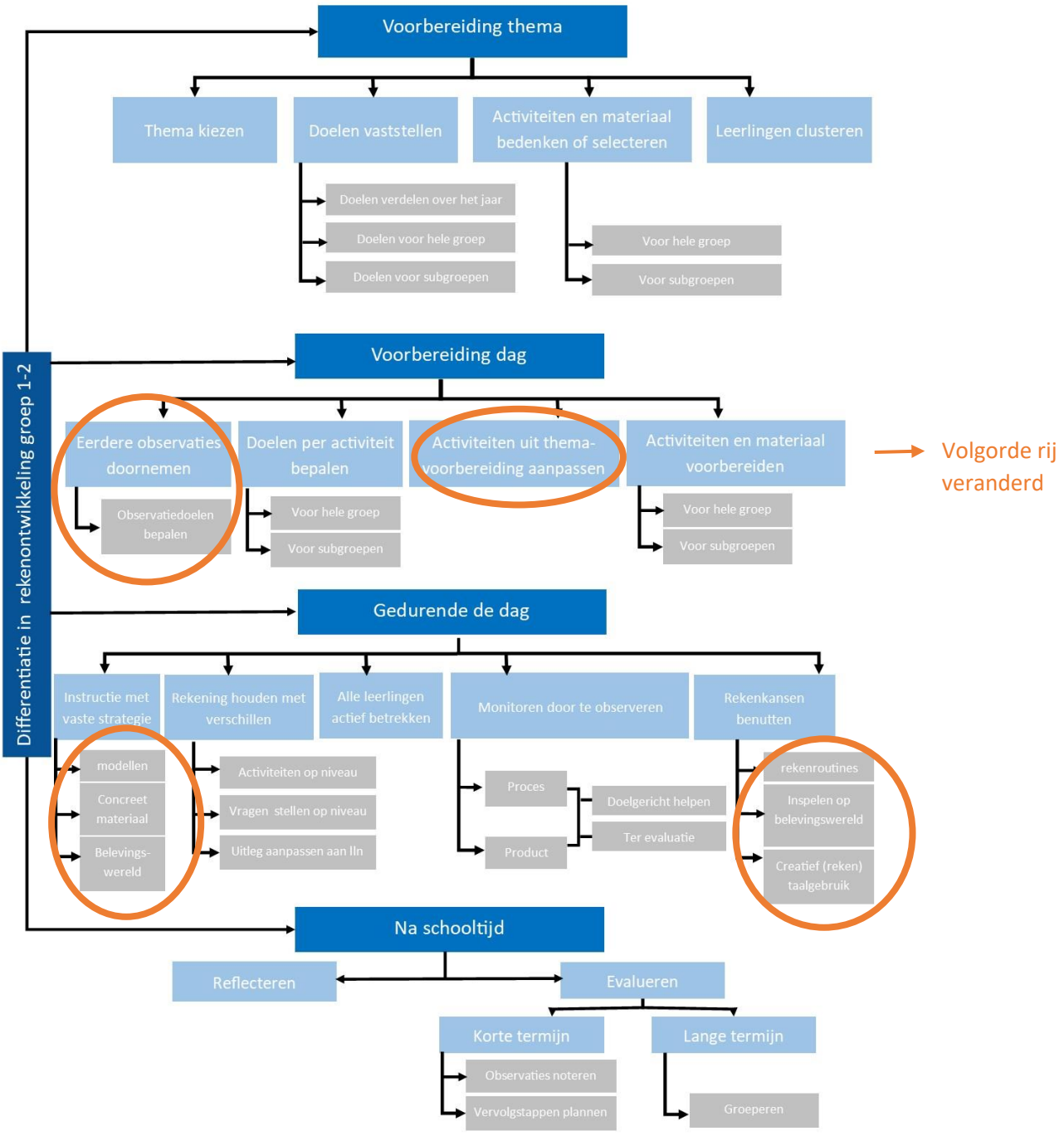
- Sociaal-emotionele ontwikkeling
- Taalvaardigheid
- Zeflstandigheid
- Interesses
- Concentratie
- Tempo
- Voorkeursaanpak

➔ Vakinhoudelijke kennis:
- Domeinen, leerlijnen en doelen (weten wat je van gr. 1 of groep 2 kunt verwahchten.
- Streef- een functioneel niveau
- Kennis van (mogelijkheden) materialen en activiteiten per leerlijn
- Reken-/didactische kennis: handelingsmodel, hogere orde vragen, modellen, scaffolding
- Ontwikkeling kleuter (grillig, sprongsgewijs, wanneer kun je wat verwachten?)

Complexity factors:

- Groepssamenstelling (hoeveelheid variatie)
- Aantal leerlingen
- Tijd
- Klassenmanagement
- Ontbreken van begeleiding

Appendix C: Second draft skill hierarchy (after teacher expert meeting)



Kennis van..

➔ <u>Per leerling inzicht in:</u>

- Voortgang op leerlijn
- Sociaal-emotionele ontwikkeling
- Taalvaardigheid
- Zeflstandigheid
- Interesses
- Concentratie
- Tempo
- Voorkeursaanpak
- Inzicht in alle ontwikkelingsgebieden per lln. Kent lln de kleuren niet, maar kan hij wel tellen, dan geen probleem. Anders zorgelijk.

➔ <u>Vakinhoudelijke kennis:</u>

- Domeinen, leerlijnen en doelen (weten wat je van gr. 1 of groep 2 kunt verwahchten.
- Streef- een functioneel niveau
- Kennis van (mogelijkheden) materialen en activiteiten per leerlijn. Repertoire aan activiteiten en materialen hebben. Bouw je op door te kijken bij anderen, te ervaren en op internet te kijken.
- Reken-/didactische kennis: handelingsmodel, hogere orde vragen, modellen, scaffolding
- Ontwikkeling kleuter (grillig, sprongsgewijs, wanneer kun je wat verwachten?)
- Belang van herhaling kennen
- Belang van belevingswereld
- Weten waar je op moet letten bij observatie: is lln betrokken? Lukt het? Taakgericht? Is het ook de opdracht? Hanteert een lln een strategie of is het trial & error?
- Weten dat een kleuter zich ontwikkelt door te doen, te ervaren, te handelen en door constant te herhalen.

Complexity factors:

- Groepssamenstelling (hoeveelheid variatie)
- Instroom
- Aantal leerlingen
- Tijd
- Klassenmanagement (regel en routines, zorg dat leerlingen jou zo in mogelijk nodig hebben)
- Ontbreken van begeleid