Seeing the Learner: Leveraging Potential

Through Formative Numeracy Assessment

Elizabeth Hansen

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Department of Special Needs Education Faculty of Educational Sciences

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ABSTRACT

It is the premise of this paper that math is highly proceduralized, continually builds on previous knowledge, that instruction needs to be facilitated, and most importantly, that consistent, ongoing formative assessment is necessary to shape effective numeracy instruction in the classroom. The desire to raise standards of numeracy is a stated national education priority for many nations (Wright, Martland & Stafford, 2006, pp.13). In an increasingly complex teaching context, information generated by formative assessment can be an important bridge in empowering teachers to reach all students (Dow, Hattam, Reid, Shacklock & Smyth, 2005). Achievement gaps in math are detrimental to young learners because they propagate the inequality that Norway so desperately works to avoid. Teachers play a pivotal role in lessoning learning gaps while also providing equal and quality early numeracy education for all. The aim of this study was to stimulate further and more widespread exploration of using formative numeracy assessments in Norway to anchor numeracy instruction that leverages the potential of all students in the complex and diverse classroom of today.

The purpose of this study was to explore formative numeracy assessment by using a translated version of the Vermont, USA’s Mathematics Primary Number and Operation Assessment (PNOA) in four first-grade Norwegian classrooms. It also aimed to contribute to the greater understanding of the role of formative numeracy assessment in regards to the teaching learning process. The experience of the participants was explored in relation to how or if it affected their perceptions of numeracy instruction in Norway. Also considered was if formative numeracy assessment could be a catalyst for equipping Norwegian teachers with the information needed to bring them closer to the learner.

The findings from the study indicated that the PNOA provided teachers with information on their pupil’s early understanding of number that they would not otherwise have had until midyear. Teachers reported feeling empowered by knowing so much so early, and having the one to one time to see their learners. The study shed light on what seemed a lack of common goals around early numeracy in first grade as well as limited experience of using ongoing formative assessment to monitor and shape math instruction in the classroom. Teachers reported uncertainty in how to actually teach from the PNOA findings, especially in what all
referred to as classrooms of diverse needs and abilities. In closing, the experience of using the one to one formative numeracy assessment did bring these teachers closer to their learners.
FORWARD

This study stemmed from a desire to explore teaching tools that could assist educators in understanding the learner as an individual. The work of Lev Vygotsky resonated early in my studies at the University of Oslo, specifically his view of the teacher/learner relationship. Pertinent to his work was how adults arrange young students learning experiences for the purpose of development. This study, while very exploratory in nature, hopes to shed light on how the teacher and the learner relationship can be enhanced through one to one formative numeracy assessment.

I would first like to thank Sandi Stanhope, my mentor teacher and a pivotal force behind the development of the Primary Number and Operations Assessment from Vermont, USA. Sandi has consistently supported me and shared her professional wisdom both as an assessment developer and as a master teacher.

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1 INTRODUCTION

1.1 Background and Context

Numeracy provides the ability to plan, to challenge, and to predict: it reveals the power to reason and unlocks the language of nature” (Steen, 1990, pp.229). There is a persistent need to create a numeracy for all within a system of mass education which in essence aspires for equality for all. Of the many challenges embedded in the educational aspects of numeracy today, is the assumption that all students can follow one designated numeracy curriculum with one method of instruction. This approach violates the basic principle of education (Miller & Mercer, 1997). This is because educators now know that learners differ in fundamental ways when acquiring number sense such as prior knowledge, ability, learning styles and strategies, interests, motivation, and cultural and social backgrounds. Of all the learning differences, prior knowledge is recognized as one of the most powerful resources on which to build learning, specifically around early numeracy (OECD, 2010, pp.16). Therefore, with the increasing emphasis on equal education for all and given that it is understood that knowledge is transmitted but also individually constructed, the importance of the teacher learner relationship has never been more evident (Wells & Claxton, 2002, pp.267.)

Today’s teachers face the challenge of meeting the academic needs of all students, those with specific learning disabilities, those at risk due to lack of motivation to learn, those who come from culturally and linguistically diverse backgrounds and those who are gifted and talented. To adapt and modify instruction to meet these diverse needs there is a growing need to understand and examine the relationship between assessment and learning (Wells & Claxton, 2002). A range of methods are incorporated in assessment for evaluating learning and ability, including examinations and formal testing often referred to as summative assessments and oral and less formal classroom based assessments or formative assessments.

Teachers are professionals who make judgments and decisions within a complex and uncertain classroom environment and these judgments and decisions also guide their classroom (Stern & Shavelson, 1981). Through careful observation of a student during formative assessment teachers can determine the most advanced ability of the learner and use this to tailor future instruction (Wright, Martland & Stafford, 2006). Emphasized is that what each individual learns through instruction is governed in part by that student’s ability and
prior experience. It is also shaped by the compatibility of the student’s attributes as a learner and the instructor’s teaching style. Classroom teachers possess innate beliefs that in effect organize and shape their instructional behaviors (Borko, Shavelson & Stern, 1981). With student success largely dependent on the teaching approach, teaching and formative assessment can become a cyclical process for continuous improvement of instruction (Greenstein, 2010).

Central to this study is the understanding that there is a difference in the numerical knowledge of students when they begin first grade. Evidence reflects that these numerical differences often increase over time and that students’ who begin schooling as low numerical attainers, tend to remain there without the use of formative assessment to target intervention and focus instruction (Wright, Martland & Stafford, 2006). Research and experience tell us that students with a mathematics learning disability (MLD) have poor understanding of number concept and number system (Gilmore, McCarthy, & Spelke, 2010), skills that are the foundation of higher order mathematical skills (Jordan, Glutting, & Ramineni, 2010). Also emphasized in the research is the critical role that progress monitoring and assessment based decision making should play in the delivery of effective remedial number instruction (Watson & Gable, 2012, pp. 183). Early number sense can be a powerful predictor of later numerical outcomes and early screening of ability can be used to provide early predictors and support for numeracy interventions, to prevent children from falling behind in school (Gersten, Jordan & Flojo, 2005). The major tenant of formative numeracy assessment is the strategic adaptation of numerical instruction to meet individual needs, as learners become more visible, teaching becomes more effective.

### 1.2 Purpose

In Norway public schools are responsible for integrating and accommodating the needs of a greater diversity of the pupil population (Clark, Dyson, & Millward, 1995). The Norwegian Education Act stipulates that teaching must be adapted in a way that it will be inclusive for all students, that individual needs are responded to within the mainstream classroom and that students who do not achieve satisfactory learning outcomes have a right to special teaching arrangements (regjeringen.no). This is based on developing a one school for all that can facilitate the conditions of learning for all children, regardless of background and aptitudes (Nilsen, 2010). Also stressed in the act is that effort be made at all levels of the education
system to identify the students who are not making satisfactory numerical learning progress early as numerical disparities are not only detrimental for individual success but also project poorly for a nation’s future. While ideals of adapted and inclusive education seem to have broad and growing support among teachers there continues to be major limitations in meeting the natural variations of the abilities of the student (Nilsen, 2010). Also seen as critical, is the teacher’s use of assessment to identify individual abilities and aptitudes to provide insight into individual learning differences, specifically here around number (Buli-Holmberg, Nilsen & Skogen, 2014). A recent study in Norway found an evident absence of systematic assessment practices in classrooms as well as limited systematic use of assessment to improve students’ learning (Hopfenbeck, Thronsen, Liw & Dale, 2012). A central finding that emerged from this study was a lack of understanding around formative assessment and how to use, embed and implement it in the Norwegian classroom.

Currently, Norway’s approach to student assessment in math is based on a mix of teacher based classroom assessment (Nusche, Ealry, Maxwell & Shewbridge, 2011). It is the purpose of this study to examine formative numeracy assessment in Norwegian first grade classrooms using Vermont, USA’s Primary Number and Operations Assessment (PNOA). The central question explored is how the PNOA is experienced in the hands of Norwegian practitioners who have chosen to adopt and implement it as a formative numeracy assessment tool. It also considers how the information garnered from using the PNOA in the beginning of first grade, may shape teachers perceptions of using a formative assessment in the classroom. The following sub-questions will guide and structure the various parts of this interpretive study:

1. How does the information garnered from the PNOA inform teacher’s expectations around individual ability with number?

2. Do learners become more visible through formative numeracy assessment?

3. Does using a formative numeracy assessment tool bring teachers closer to their learners?

In the first research question, participants are asked to reflect on learning goals around early number knowledge. The math learning goals that are embedded in the current curriculum in these four Norwegian first grade schools are also highlighted. The data derived from the PNOA in this study is discussed more in depth as far as the diversity of learners. What did the
data reflect from September to December and were there surprises? Also discussed is whether the formative assessment gave them a clearer sense of individual needs.

The second question will examine the experience of using the PNOA from the perspectives of the participants. Particular emphasis will be on how the evidence collected from the PNOA may have shaped how they approached and adapted instruction according to their learners. In addition teachers will be asked what they discovered about their learners and did they see evidence of different learning needs within their classrooms.

The final question concentrates on the experience of using a formative numeracy assessment tool and if formative assessment, specifically in the interview format offered greater insight into classroom ability? Did their learners become more visible and why? Also explored is how the experience impacted the teacher and learner relationship.

A researcher’s pre-understanding is not something that she can step outside of or put aside but instead it is already with her in the world (Laverty, 2003, pp. 8). As a teacher from the USA, living in Norway and one familiar with formative numeracy assessment, in this case the PNOA, my pre-understanding of the phenomenon will augment the analysis and interpretation of this study. The PNOA involves presenting numerical tasks that engage the learner to determine the extent of the knowledge and ability with numerical strategies upon entering first grade. Each task assesses specific developmental prerequisites of early numeracy acquisition. The assessment results in a working profile of the learner. The PNOA does involve a good deal of learning on the part of the teacher, as well as time out of the classroom to conduct the one to one assessment.

Despite ongoing dialogue around formative assessment in Norway, there is limited research on the actual experience of using a formative numeracy assessment in the classroom. Argued is that while the actual process of thinking remains invisible, the best and perhaps only way to find out how knowledge is built up, is to investigate what and how learners know (Glaserfeld, 1995, pp.13; Wright, Martland & Stafford, 2006). Therefore, by exploring the selected questions in depth, through the lens of the Norwegian teacher, the hope is to shed light on the possible role formative numeracy assessment could have in shaping more conducive math instruction to support learning differences in first grade. Also considered is if formative numeracy assessment can be a catalyst for equipping Norwegian teachers with the information needed to bring them closer to their learner.
A qualitative design using interview as a method was selected to generate an understanding of the experience of using a formative numeracy assessment in Norwegian classrooms because it hones in on the perspectives of the participants, through text and interpretation. Posed as the theory of interpretation, hermeneutics is used to provide a deeper understanding of the phenomena. It is the researcher who must consider what paradigm, quantitative or qualitative, better serves the purpose of the study and because learning and teaching involve an interchange, dependent on one interpretation and another, it seemed the appropriate approach. Unlike quantitative studies that can be statically analyzed, qualitative studies must be assessed in terms of how well they meet the explicit goal and purpose of the research. Qualitative data was collected through transcribed semi-structured interviews. The findings themselves are not designed to be generalizable to other contexts but to offer insight on using a formative numeracy assessment in first grade classrooms in Norway.

1.3 Outline

This study is organized into five chapters. Chapter 1 provides the background and context to the study; what the study is exploring and why.

Chapter 2 introduces the literature review, an anchor to the study, where selected authors and theories are woven together to provide a holistic account of what numeracy and formative assessment are. The constructivist approach specifically the social constructivist ideas of Lev Vygotsky, are highlighted, in an effort to gain greater insight on the role of formative numeracy assessment in teaching and learning. Included here is a brief review of the history of assessment in the USA where particular attention is given to Australia’s Math Recovery and the impact it has had on shaping formative assessment of number in the USA. This is followed by a review of the history of assessment in Norway, where it is today and how societal norms and values may have influenced its present state. Chapter 2 concludes with a review of the theory behind Vermont, USA’s Primary Number and Operations Assessment (PNOA).

Chapter 3 lays out the qualitative research design and methodology, illustrating how the study was conducted and why a qualitative design was selected. Also discussed are the steps taken to collect the data, the subject sampling, the research setting and the ethical considerations of the study.
Chapter 4 illustrates the results and the analysis of the data. Included is a discussion that places particular emphasis on the main themes that emerged. Chapter 5 concludes with the integration of the data in offering new insight on future implications of using early formative numeracy assessments in Norway.
2 LITERATURE REVIEW

2.1 Numeracy

We inhabit a world flooded with numbers. The concept of numeracy and the term itself were introduced in the Crowther Report published in 1959 to imply a more sophisticated level of mathematical understanding (The Cockcroft Report, 1982). To be numerate is more than being able to manipulate numbers, or even being able to “succeed” in school or university mathematics. Numeracy (Johnston, 1994) is a critical awareness that builds bridges between mathematics and the world. In other words, it is an individual’s ability to identify and understand the role mathematics plays in the world, to make well-founded judgments, and to use and engage with mathematics in ways that meet the needs of that individual’s life as a constructive, concerned and reflective citizen (OECD 2004, pp.15). This study brings attention to how understanding individual learning differences is critical prior to teaching early number. It also exposes how challenging becoming numerate is for students who are merely pushed on in school without regarding their skill/concept attainment.

2.2 Theoretical Background

Up until the 1980s, teaching and learning were seen as two separate processes with teaching based on transmission and reinforcement (Fosnot & Dolk, 2001). Early numerical instruction therefore focused on the transmission of rote information and less on constructing meaning. With the increased use of achievement testing, numeracy instruction became outcome driven. Therefore what was assessed and how it was assessed rested on what was practical and easy to measure (Fosnot & Dolk, 2001). As thinking in education progressed, a growing awareness that students move at different paces and that classroom teaching was not conducive to supporting these differences emerged. It was advocated that teaching needed to be seen as “inherently connected to learning” (Fosnot & Dolk, pp. 13) and that the teaching goal was to look at revealing the tacit knowledge hidden within the learner to make it transparent, explicit and available. As a result of this new understanding of the relationship between teaching and learning, the teaching of number began to shift, and more emphasis was placed on learning math as a constructive activity rather than a product of transmission. In the past decade or two, the most important theoretical perspective to emerge in mathematics education has been...
that of constructivism (Glasserfeld, 1995; Steffe & Thompson, 2000). Constructivism sees the learning of number as the active construction of knowledge, where learners engage with and try to understand new knowledge and incorporate it into the developing mind (National Research Council, 2000; Shepard, 1991; Wertsch, 1985).

Of particular relevance to this study is the social constructivist theory, which highlights the overarching focus on the interdependence of the social and individual process in the co-construction of knowledge (John-Steiner, 1996). Simply stated, “education, must be thought of in terms not of the transmission of knowledge but of transaction and transformation” (Chang-Wells & Wells, 1993, pp. 59). Because the process of numeracy is constructive, teachers need to facilitate at the edge between the structure of mathematics and the development of the learner (Fosnot & Dolk, 2001, pp. 13). Thus, tension serves as a motivation to learners. The social constructivist sees the learner and the social world as indissolubly interconnected, where mind, interaction, conversation, activity and social context form an interrelated whole (Ernest, 1994). Development begins with a dependency on others with more experience and then over time becomes internalized by the learner.

Today, leaders in education continue to draw support from the works of social constructivists like Lev Vygotsky, whose interest lay in assessing the ways in which learners progressed. Since the publication of Mind in Society in 1978, Lev Vygotsky’s ideas have grown substantially (John-Steiner & Mahn, 1996). His theory positioned teaching and learning as the very pathway through which human minds develop (Wells & Claxton, 2002, pp.84). A major tenant of Vygotsky’s (1978) theoretical framework is the fundamental role social interaction plays in the development of cognition. He saw social interaction as the bridge through which skills can be developed with adult guidance or peer collaboration. To Vygotsky this social exchange between the expert and the novice, exceeds what can be attained alone. This study, therefore, looks at the interaction between the teacher and the learner.

Because Vygotsky (1978, pp.64) focused not on the product of development but the very process by which higher forms are established, he criticized educational instruction that lagged behind what was already developed. Learning, according to Vygotsky was characterized as non-linear, uneven and composed of the intertwining of external and internal factors (1978, pp.73) and teaching should be focused on what was just beyond the “cutting
edge” of the student’s current knowledge. This area he referred to as the Zone of Proximal Development (ZOPD).

The distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance. (1978, pp.86)

The ZOPD highlights the pivotal role assessment can have in informing early numeracy instruction that is more conducive to these optimal zones of learning. The principle of the ZOPD is instruction that is focused not only on what is mastered but what is just about to be mastered. “What the child is able to do in collaboration today he will be able to do independently tomorrow” (Vygotsky, 1978, pp. 211). To support development in these optimal zones, it has been argued that teachers need a working profile of their learner prior to teaching number. In light of this, Vygotsky (1978) indicated that for teaching to be developmental, it has to be related to the learner’s ability and potential ability.

Learning which is oriented toward developmental levels that have already been reached is ineffective from the viewpoint of a child’s overall development. It does not aim for a new stage of the developmental process, but rather lags behind this process. The only good learning is that which is in advance of development. (pp. 82)

Contrary to many perspectives, it is believed that the ZOPD was not the main or central concept of Vygotsky’s theory. The ZOPD is believed to serve as a reference to an important place and moment in the process of development (Kozulin, 2003, pp. 46). His idea was that rather than teaching to the test one should look at assessment that facilitates the construction of meaning, used as an instructional approach to close the gap between the current level of understanding and the desired learning goal (Vygotsky, 1978). Vygotsky often used the term collaboration in his discussion about assessing the zone of proximal development because the nature of formative assessment guides an exchange that is not solely directed at the learner or the teacher but a cooperative and shared activity.

Central to the Vygotskian view of development and assessment, is the interdependence of the teacher and the learner or the novice and more experienced other. Critical to this collaboration is the face-to-face interaction, which often involves the providing of effective assistance, the exchanging of resources and the providing of feedback to improve performance. Reasoning,
the sharing of mutual goals, trustworthiness, and increased motivation are facilitated through this interaction. Pertinent to this study is the pivotal role formative numeracy assessment could have in making the learner more visible and teaching more optimal.

### 2.3 Early Numeracy Development

The underlying developmental progression of early number sense is critical to the understanding that the teaching/learning process is a joint venture. In conjunction is the role formative assessment plays in facilitating numeracy development. Early numeracy develops around the acquisition of strategies and skills that include counting, addition and subtraction, knowledge of number word sequences and numerals, and the ability to reason with tens and ones. Although the term early number sense has been defined differently, most agree that number sense involves abilities related to counting, number patterns, magnitude comparisons, estimating, and number transformation (Berch, 2005). Despite number sense being deemed sequential, certain understandings do serve as precursors to others. For instance, one to one correspondence is a precursor to cardinality (that the last counting word represents all the items in a group) and cardinality is then a precursor to unitizing. There are landmarks that are associated with early number sense that are integrated and not separate and these landmarks comprise the critical knowledge and number strategies that form the foundation of numeracy (Fosnot & Dolk, 2001).

These landmarks involve the ability to represent and process numerical magnitude information and are essential to normally developing numerical skills (Butterworth, 1999; Feigenson, Dehaene, & Spelke, 2004). An example of this is how subitizing, the fast verbal naming of small quantities without counting the items separately, precedes and supports the development of counting skill (Le Corre, Van de Walle, Brannon, & Carey, 2006). Early numeracy development is a cumulative process, where concepts and skills build on prior concepts, skills, and knowledge (Wright, Martland & Stafford, 2006). For example preverbal number sense, an approximate representation of magnitude, is already present prior to the emergence of symbolic number representations (Lipton, & Spelke, 2005) which is also suggested to be a base for later numeracy proficiency.

The learning of a conventional counting system in early childhood begins with acquiring whole-number-word sequence skills (Kyttala, Aunio, & Hautamaki, 2010, pp.1). It is
suggested that these number-word sequence skills develop over six stages and early in a child’s development: the primary understanding of amounts and acoustic, asynchronous, synchronic, resultative and shortened counting. The primary understanding of amounts emerges at around two years of age. Here children show knowledge of how the different number-words refer to different numbers of objects. At around the age of three, at the acoustic counting stage, they can say number words, but not in the correct order. Around the age of four, they enter the asynchronous stage where they are able to say number words in the correct order and to point to objects, but the words and pointing are not coherent. Six months later, at the synchronous stage, children are able to recite number words and to indicate the counted objects correctly by pointing at or moving the objects. The final early numeracy counting stage emerges around the age of five, when children are able to say number words correctly starting with one. Here they are able to demonstrate an understanding that countable objects are counted once and that the last said number word represents the total number of objects in a set. At this stage children also understand that number words form a series and grow in magnitude, the larger number the greater the amount (Kyttala, Aunio, & Hautamaki, pp.2).

To represent number, young children often initially rely on finger counting strategies. Research indicates that, “successful finger counting and finger based math serve as building blocks for later numerical development and thus should be taught in both kindergarten and primary school” (Moeller, Martignon, Wesssolowski, Engel & Nuerk, 2011, pp. 3). While there are varying theories regarding the benefits of finger counting, it is argued that fingers are the sensory-motor tools through which learners can internalize the fundamental properties of natural numbers (Di Luca & Pesenti, 2011, pp.1). Also suggested is that finger counting strategies are often the first or second most frequent strategy observed in young learners across cultures and that tactile discrimination using the fingers is strongly related to mathematical competencies (IBID, pp.2-3). More specifically, finger counting contributes to acquiring and then building and internalizing number. Given the diverse approach to learning and the vast variance in early childhood exposure with number, Stanford Professor Jo Boale reflects that,

Telling students not to use their fingers to count or represent quantities is akin to halting their mathematical development. Fingers are probably our most visual aid,
critical to mathematical understanding and brain development that endures well into adulthood.

As reflected, early numeracy depends much on the mastery of each stage encompassing consistent application of strategies, where stages sequentially build on and incorporate the previous stage and where each new stage involves a conceptual reordering. An example of this is how finger counting promotes and supports establishing 1-1 correspondence, cardinality and ordinality, all primary components of early number sense. These findings maintain that numeracy is hierarchical (i.e., new skills build on previously learned skills) and imply that moving a student through a numerical curriculum without understanding the foundation skills would contribute to a student who continues to experience failure (Miller & Mercer, 1997). Also evident is that students with a mathematics learning disability (MLD) have a poor early understanding of number concept and number system (Gilmore, McCarthy, & Spelke, 2010). These skills that the students lack unfortunately are the foundation of higher order mathematical skills (Jordan, Glutting, & Ramineni, 2010).

Despite the increased focus on math curriculum and teaching, a growing number of students continue to fail to acquire the early and essential mathematical skills. This early limitation also hinders the development of a positive disposition towards mathematics. A lack of fluency with accurate and efficient use of counting strategies, fact retrieval, and arithmetic combinations remains a critical correlate of MLD and should be a goal of early intervention (Gersten, Jordan & Flojo, 2005, pp. 302). Evidently, systematic early numeracy screening and targeted intervention can allow early identification and support at this critical and early stage for those at risk of developing math difficulties (Siegler & Ramani, 2008). Furthermore, it is recommended by many that teachers be equipped to be able to understand each student’s proficiency with number before they begin instruction in the school year. This understanding can lead to more early identification of students with MLD or with weak skills in math, while also informing and shaping more effective early intervention and instruction for all students. There are five intertwining strands that constitute mathematical proficiency (Kilpatrick, Stafford & Findell, 2001, pp. 116):

1. Conceptual understanding encompasses the comprehension of mathematical concepts, operations, and relations.
2. Procedural fluency refers to the skill in carrying out procedures flexibly, accurately, efficiently, and appropriately

3. Strategic competence is the ability to formulate, represent, and solve mathematical problems

4. Adaptive reasoning is the capacity for logical thought, reflection, explanation, and justification

5. Productive disposition entails the habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy.

Once students have acquired conceptual understanding in an area of mathematics, they see the connections among concepts and procedures and gain confidence, and build on the known so they can gain a new level of understanding (Kilpatrick, Staffrod & Findell, pp.119). This also suggests that developmentally appropriate numerical instruction is not simply about age or grade but rather largely contingent on prior opportunity to learn (Duschl, Schweingruber, & Shouse, 2007, pp,2).

### 2.4 Significance of Prior Learning

Many children come to school with number competencies that are developed through their informal experiences (Ginsburg, Lee, & Boyd, 2008). These numerical competencies acquired before first grade, can serve as a ladder for learning number in primary school (Jordan, Glutting & Ramineni, 2010). A recent study demonstrated, that the acquisition of counting and relational skills before formal schooling are predictive of the acquisition of basic arithmetical skills and overall mathematical performance in grade one (Aunio & Niemivirta, 2010). This early number sense can also be reliably measured in young children and is predictive of later mathematics achievement outcomes (Clarke & Shinn, 2004). David Ausubel (1968, pp.6) famously stated, “If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly.”

Learning for Ausubel is bringing something new into our cognitive structure and connecting it to our prior knowledge. Research shows that prior knowledge acts as a mental hook for the construction of new information and is the basic building block of content and skill
knowledge. Teachers can make informed, strategic decisions about the content to be taught by meeting students where they are (Campbell & Campbell, 2008, pp.9-12). Accessing this prior knowledge can serve as the critical first step in the learning cycle of the classroom. Studies related to math have shown that student number sense varies considerably due to their informal learning experience before entering first grade (Hotulainen, Mononen & Aunio, 2016). For this reason, it is advocated that early numeracy assessment and the necessary intervention be targeted as early as possible and closely tied to school entry (Molnar, 2011). It is suggested there is a fallacy in the belief that one method of teaching number can bring all children to the same point in understanding at the same time because according to Fosnot and Dolk, “We build new ideas on old ones, or reformulate old ideas into new ones, just as children learn to crawl, walk and talk at different ages, their mathematical development proceed differently as well” (2001, pp. 23)

### 2.5 Summative and Formative Assessment

In 1967 Michael Scriven proposed the terms summative and formative assessment to explain two distinct roles that evaluation could play in evaluating curriculum and learning. Summative assessment is a process of assessment which encapsulates all the evidence up to a given point through a test, usually given at the end of a term, chapter, semester or year (Taras, 2005). The most recognized summative test is the PISA lead by the Organization for Economic Cooperation and Development (OECD), and implemented on a three-year cycle to measure the performance of a country’s education system according to student achievement in reading, mathematical and scientific literacy (www.oecd.org). Trends in International Mathematics and Science Study (TIMSS) TIMSS is run by the International Association for the Evaluation of Educational Achievement and conducted on a four-year cycle. These large-scale assessments provide useful data for monitoring overall performance of education systems and of individual schools and groups of student but are argued as having an indirect influence on day-to-day instruction in the classroom (www.oecd.org). Formative assessments such as classroom tests, thematic assessments based on curriculum goals and classroom based observation are also used to monitor progress and development.

The distinction between the summative and formative roles of assessment proposed by Scriven were later explored by British researchers, Black and Wiliam (1998), who contended that formative assessment, properly employed in the classroom, would help students learn
what is being taught more effectively. Backed by evidence garnered from their research review, a meta-analysis, they concluded that student gains in learning prompted by formative assessment were "among the largest ever reported for educational interventions" (Black & Wiliam, 1998, pp. 61). Although their study has been criticized as too disparate in topic and the collection studied too diverse to be combined, they are still considered to be pioneers in defining formative assessment. In contrast to summative assessment, formative assessment, is when the evidence garnered is used to adapt the teaching to meet student needs and when “assessment is carried out during the instructional process for the purpose of improving teaching or learning” (Shepard, Hammernes, Darling-Hammond, Rust, Snowden, Gordon, Pacheo, et al., 2005, pp. 275). While summative and statistical reviews can provide broad and general information about differences and changes in numerical achievement, they are criticized as providing only “snapshots” of achievement at particular points in time (Pellegrino, James, Chudowsky & Glaser, 2001, pp.27). Suggested is that these summative results do not capture the learning progression of students and provide little information on precisely where the students’ strengths and weaknesses lie to help guide day to day instruction (Pelligrino, Chudowsky & Glaser, 2001).

Formative assessment methods have been important for raising overall levels of student achievement with research showing it as one of the most important interventions for promoting high-performance ever studied (www.oecd.org). Proponents of formative assessment see it as a means to equip teachers with the information needed to shape and improve the student’s competence with number while avoiding the often random and inefficient trial and error learning (Sadler, 1989, pp. 120). Renowned mathematician, Freudenthal (1986) emphasized that students are individuals, each following an individual learning path and advocated that learning be adapted to these distinctive learning processes.

Many suggest that the issues around summative and formative assessment encapsulate the tensions between learning versus performance in an increasingly standardized testing world. With the ultimate goal to improve teaching and learning, this study deliberately examines formative assessment.
2.6 The Objective of Formative Numeracy Assessment

There is a growing realization that assessment should not be an isolated process, independent from teaching and learning. Instead teaching, learning, and assessment should be inextricably interrelated (Wells & Claxton, 2002, pp. 73). The objective of formative numeracy assessment is to support the teacher in facilitating numeracy by clarifying numerical learning intentions, by providing feedback intended to move learners forward and through guiding more effective classroom discourse (Leahy & Wiliam, 2009). Teachers are the pivotal negotiators responsible for making the crucial decisions about what is appropriate numerical instruction for students on a daily basis (Smyth, Dow, Hattam, Reid & Shacklock, 2000). Studies show that while teachers recognize when numerical tasks are too difficult, they tend to overlook tasks that are too easy (Leahy & Wiliam, 2009). Also evident is that throughout primary school, curricula and teachers continue to teach learners’ concepts and skills the students already know (Sarama & Clements, 2009, pp.16). It is argued that developmentally appropriate numerical instruction is not simply about age or grade but rather largely contingent on prior opportunity to learn (Duschl, Schweingruber, & Shouse, 2007, pp.2). Proposed is that through assessing students through formative assessment teachers are better prepared to adapt teaching styles. Following assessment teachers responded by presenting more intensive and challenging numerical tasks, with more targeted and purposeful instruction and dialogue around number (Wright, Martland & Stafford, 2006, pp. 151).

With ample evidence reflecting the diverse numerical knowledge of students in the beginning of school it is also suggested that without support these differences increase over time (Wright, Martland, & Stafford, 2006). It has been documented that between 5% and 8% of school-age children have some form of memory or cognitive deficit that interferes with their ability to learn concepts or procedures in one or more mathematical domains (Geary, 2004). Moreover, research shows that targeted interventions in numeracy can have significant impact on student performance and self-confidence (Wright, Martland, & Stafford, 2006, pp.3). In light of this, students who feel they have supportive, caring teachers are more motivated to engage in academic work than students with unsupportive, uncaring teachers (Moore, 2015). Differential treatment according to teacher expectation mediates learner’s motivation and inevitably effects performance (Wentzel, Wigfield & Miele, 2009, pp.366). Thus when teacher’s expectations are high they increase motivation which improves performance and
when teacher expectations are low they generally undermine the learner’s motivation. Central to these findings are the prominent role the teacher plays in cultivating motivated learners to improve early numeracy performance.

Naturally teachers thinking changes, when they understand the reasons for the children’s mistakes (Wright, Martland & Stafford, 2006, pp.151). In The Child’s Understanding of Number (Gelman & Gallistel, 1978), the authors ask that we look for skills young children have, at least as much as we look for skills they lack. The ultimate goal is that students are challenged to stretch, to learn number and content, and to think in complex ways beyond their current numerical capacities (Wells & Claxton, 2002). Formative assessment that elicits a performance from the upper rather than the lower threshold resonates with Vygotsky’s Zone of Proximal Development (1978) because the assessment exposes both the known and the almost known to inform the teacher where to begin instruction (Wells & Claxton, 2002, pp. 75).

All teaching involves some degree of feedback between those taught and the teacher. It is the quality of these interactions, which is at the heart of pedagogy (Black & Wiliam, 1998, pp.16). Quality feedback provided in the learning process is a main pillar in formative assessment both to guide and facilitate the learner’s thinking. Indicated is that formative assessment can enhance learning when it is designed to provide students with feedback about particular qualities of their work and guidance on what they can do to improve (Pellegrino, James, Chudowsky & Glaser, 2001). Feedback in the context of formative assessment is the information shared with the learner about the gap between the actual level and the reference level (Ramaprasad, 1983, pp. 4). By making the learning goals explicit, the teacher and learner can monitor the learning progression together.

### 2.7 Numeracy Assessment in the USA

Today, early education in the United States involves about 75 million people, almost one-fourth of the US population. This number includes 40 million in grades pre-K through 8 (US Census Bureau, 2010). Public schools are operated at the state level through departments of education, and locally by school districts and publicly elected or appointed school boards. The US ranks fifth in spending per student. Only Austria, Luxembourg, Norway, and Switzerland spend more.
The roots of the standardized test movement in the US can be traced back to the 1960s. The First International Mathematics Study, spearheaded by the International Assessment for the Evaluation of Educational Achievement (www.iea.nl) assessed basic arithmetic, algebra, geometry, measurement, statistics and number systems in 13-year old students. The evidence collected from the first test reflected poor performance of the students assessed and placed the US at the bottom in almost all categories. Some questioned if the results were a reflection of the math instruction of the time, which focused little on how students actually learned math.

In 1969, further research driven by the National Association of Educational Progress (NEAP), portrayed an educational landscape in need of mandatory standardized testing in all schools at selected grade levels. Also evident was a focus on formative numeracy assessment and the effective use of data to inform instruction, evaluate student performance and progress in mathematics. In response to these findings, the Back to Basics movement of the 1970s emphasized the practice of rote memorization and repeated testing and teaching to assure competence in basic math skills (Walmsley, 2003). This helped ensure better competencies with basic numeracy skills but unfortunately hindered progress in higher-order reasoning abilities in numeracy. How students actually learned number was not a priority in the 1970’s.

Beginning in the late 1980s several documents were published expressing a concern that, given the trend toward a more technological world, the poor performance of American students in mathematics needed to be addressed in a different way (National Commission on Excellence in Education, 1983; National Research Council, 1989). With these findings came a greater demand for math instruction focused on how students understand and connect mathematical concepts with problem solving being a central theme in math instruction (Ellis & Berry, 2005). Also pivotal to this shift was the 1989 publication of “A Nation at Risk” which highlighted the inadequacy of the US math educational system. This publication exposed the need for equitable treatment of the diverse learning population and the availability of appropriate content to meet particular learning needs.

Between 1994 and 1995, the Third International Mathematics and Science Study (TIMSS), a large and comprehensive investigation of mathematics teaching and learning in different parts of the world, was also conducted. The TIMSS scored mathematics achievement in more than 40 nations. The results from 1999, 2003, and later in 2007 showed a persistent achievement gap between the U.S students and their counterparts in other industrialized nations (National Center for Education Statistics, 2010). Although this movement began to draw on teaching
and learning as interrelated, numeracy assessment continued to be designed inadequately, based on scores, providing little to no insight on the student’s ability (Fosnot & Dolk, 2001). The 1995 release of “Assessment Standards for Teaching Mathematics” proposed the development of new assessment strategies and practices to enable teachers and others to assess students’ numerical performance (NCTM, 1995).

To gather more insight on educational policies and practices internationally, the Program for International Student Assessment (PISA), conducted by the OECD was implemented. The US math results of the 2000 PISA, reflected US students had a weakness with performing mathematics tasks. Tests such as PISA also provoked debate around the way mathematics was being taught in many classrooms in the US. The concern was that these summative tests focused most on accountability, which promoted teaching to the test. The debate drew on the tension between the traditionalist approach of memorizing and practicing basic facts and skills and the constructivist approach which called on numerical instruction that supported discovery, understanding, and the integration of numerical knowledge. This period marked the beginning of a more defined distinction between roles of formative and summative assessment and how they could guide teachers’ decisions around numerical instruction. Critics saw the standardized movement as a means of imposed compliance and as harmful to teaching and learning (McNeil, 2000). While summative tests were used for quantifying and comparing achievement, many argued they failed to inform teachers of their learners.

During this time, Math Recovery (Wright, Martland & Stafford, 2006) was developed in the Australian State of New South Wales, originating from research that investigated the process of young children's arithmetical learning and based on early formative numeracy assessment and intervention. The philosophy behind Math Recovery (MR), formulated from extensive research pioneered by Steffe and Wright, theorized that the construction of numeracy skills depended on well defined “habits of mind” (US Math Recovery Council, 2014, pp.2). These habits included counting, sequencing, grouping, and patterning. The program was based on the notion that children grow in mathematical skill along a continuum similar to literacy (Wright, Martland & Stafford, 2006). Argued was that prior to teaching any topic in early number curriculum, it is critical to have a valid understanding of the students current ability (Wright, Martland & Stafford, 2006, pp.21). MR was part of a surge in other early intervention and formative assessment practices aimed at determining a student’s knowledge and level of numerical strategies (Wright, Martland & Stafford, 2006). The USA Originally
adopted MR in 1995 and by 2014 it expanded to 36 states, playing a transformative role in shaping formative numeracy assessment in many parts of the USA. Today, MR is internationally recognized as a highly successful program of assessment and intervention.

In 2009 to clarify mathematical standards nationally the US adopted the Common Core (CC) Standards for mathematics. Drawn on conclusions from the Trends in International Mathematics and Science Study (TIMSS), the standards were designed to better equip students to apply and extend from one mathematical foundation to the next and provided clarity and specificity rather than broad general statements (http://www.corestandards.org). As a result, almost every state has standards in place defining what all students should know and be able to do in math. These standards are intended to guide both practice and policy, including the development of assessments of student numeracy performance.

2.8 Numeracy Assessment in Norway

Norway is founded on the principle of a unified school system that provides equal and adapted education for all (https://www.regjeringen.no). Norway spends over 6% of its GDP on education, one of the highest across all OECD countries (www.oecd.org, 2013). Norwegian schools are highly influenced by principles of equal rights for all and historically influenced by an egalitarian ideology (Hopfenbeck, Tolo, Florez & Masri, 2013). The pedagogical rationale behind the egalitarian content in the schools’ curriculum was to ensure equal opportunities for all irrespective of abilities and conditions (Welle-Strand & Tjeldvoll, 2002, pp. 674).

Evidence, however, began to reflect inequalities in learning conditions, assessments and opportunities (Hopfenbeck, Tolo, Florez & Masri, 2013, pp.22). The standardized test movement in Norway evolved in the 1990s despite the system’s longstanding goal of educational equality. In 2001, referred to as Norway’s “PISA Shock,” Norway was ranked below the OECD average and below other Scandinavian countries, despite generous spending on education and teachers reporting high levels of satisfaction with their self-efficacy (OECD, 2009). This marked the beginning of a new focus on the monitoring of quality in education and an increased awareness of evaluation and assessment. Educational authorities showed a strong desire to raise performance and to increase equality in education. One of the main points of interest was on numeracy.
In 2004, the Ministry of Education and Research launched the National Quality Assessment System to build up national tools and procedures to monitor quality at different levels of the educational system (OECD, 2011 pp.18). This system intended to help schools, school owners, and educational authorities evaluate performance and to inform strategies for improvement (OECD, 2011 pp.24). A separate report called for a “better culture for learning”, which highlighted how important it was for Norwegian schools to be prepared for a changing society (Report no. 30 to the Storting, 2003-2004). This report pointed out that treating all pupils in the same way would only result in greater differences. Many saw this documenting the growing tension between achieving quality and equality in Norwegian schools. The Knowledge Promotion Reform of 2006, produced in conjunction with the National Agency for Quality Assessment (NQAS) was established to provide new goal defined curriculum in reading, math and science. Among other things individual assessment was core to the new framework (http://www.udir.no).

While the intention of the reform was progressive it was hindered by a lack of specific numeracy assessment and diagnostic tools. Also included in the Norwegian Government’s white paper on early intervention for lifelong learning (Report No. 16, 2006-2007, pp.6), were surveys that reflected a tendency in Norwegian schools to ‘wait and see’ instead of intervening at an earlier stage of the learners’ development and learning. Recommendations included the integration of assessment tools and the necessary follow-up to ensure that all learners were guaranteed a quality and equal education. In response to the increased attention on measuring individual learning, the study called Improving Assessment Practice was piloted in 2010 to examine the implementation of assessment in Norwegian schools in all subjects (OECD, 2011). Findings from this study indicated a lack of shared numeracy assessment practice between schools and municipalities, limited shared language of assessment and vague common learning goals (Hofenbeck, Tolo, Florez & El Masri, 2013). The OECD also asserted that teachers needed to further strengthen competencies by interpreting and following up on student assessment results obtained from national tests and mapping tests. They also advised valid and reliable assessment tools needed to be developed which would enhance formative assessment practices (Nusche, Earl, Maxwell & Shewbridge, 2011).

In an effort to pilot a numeracy assessment in the early grades, the Early Grade Mapping test was introduced in 2012. The test, named Early Intervention for Lifelong Learning, surfaced due to international surveys that reflected Norway as “one of the countries with the greatest
variation in learning outcomes among students, with a large percentage of students with weak mathematics skills” (http://www.aea-europe.net/index.php/numeracy-mapping-tests).

Mandatory mapping tests in reading skills began in 2012 in year one in Norway. The numeracy portion of this test was used primarily to assess and identify students at risk of having mathematical learning difficulties. In this test, the majority of students “passed” the numeracy mapping test because the primary use was to map the confidence of the weakest 20%. The assessment includes number identification, quantity discrimination, missing-number identification, word problem solving, addition and subtraction, shape recognition, and pattern extension. This study is still underway.

Today, in Norway, typical student assessments around numeracy are based on a mix of teacher based classroom assessments (OECD, 2013). The content is largely defined by the school and “is dependent on the teachers’ ability to interpret and execute the curriculum in a way that finds the right balance between the consideration to communality and the adaptation of the education” (Buli-Holmberg, Nilsen, & Skogen, 2014, pp.3). In the first of three reports conducted by the National Leadership Education for School from 2010-2014, asserted was that, “perhaps the biggest challenge for (Norway) was that cultural conditions for close dialogue about teaching and learning seemed quite absent in the school” (Lyso, Stensaker, Aamod & Mjoen, 2011, pp.56).

The single mandatory numeracy assessment in the first year of primary school in Norway is Kartleggingsprøven, used primarily by schools and teachers as a summative assessment to identify at risk students, to monitor learning and to adjust instruction (http://www.udir.no/Vurdering/Kartlegging-gs/). This assessment is conducted during the spring in primary school years. In Norway, comparative testing between schools begins in first grade but nationwide tests do not start until year five. Many argue that waiting until the end of fifth grade to see national results only delays the time when unresolved issues can be identified for the learner. Some believe this delay makes it more difficult to lessen the gap (Fuchs, 2004).

Historically, in education, countries lean on each other to learn from each other. In less than a decade, Norway has come far in developing systems for evaluation and assessment. The overall vision for equal and quality education continues to thrive, even as the cultural landscape is rapidly changing. There is also growing support for a more established and embedded evaluation culture, specifically, shared and coherent numeracy assessments where
data is used in a holistic way to inform strategies at the classroom level (OECD, 2011). Australia’s MR, had a defining role in developing formative numeracy assessments in the USA, specific to this study, Vermont’s Primary Number and Operation Assessment (PNOA). The PNOA has been selected for this study, as a forum to explore the use of formative and numeracy assessment from another country (USA) in first grade in Norway.

2.9 The Primary Number and Operations Assessment (PNOA)

In 2004, the Vermont Agency of Education invited classroom teachers, teacher leaders, network leaders and primary mathematics specialists to form a development team. As a result, to address the need for more applicable and formative primary level numeracy assessments, preliminary work began on the developing of the Primary Number and Operations Assessment (PNOA). In early 2009, mathematical tasks that were modeled on Australia’s Math Recovery became part of the PNOA. These tasks also adhered to the Vermont Common Core State Standards of Mathematics and were designed to identify a set of skills that are core to understanding number when assessing a student’s ability. The PNOA was created with the intention to be a resource tool and not to be used as a statewide mandated assessment. Designed to assess student’s number knowledge and to monitor it over time, the PNOA aims to understand the learner and help shape instructional decisions around teaching early number.

As a formative assessment it is used as an early screening tool for first grade students and to inform early interventions and daily instruction. Educators collectively established what they needed to know and created the PNOA as a formative tool to gather data about students’ early numerical knowledge and reasoning. The premise of the PNOA is that the data collected will inform teachers to better understand and develop students’ early numerical thinking (Wright, Martland & Stafford, 2006) by assessing some of the most critical foundational skills of early numeracy. The theory is that without the knowledge of these essential understandings more students would struggle in mathematics (S. Stanhope, personal communication, June, 2015). It carefully draws on the systematic components of numerical development and offers information across a range of numerical abilities. Currently 80% to 90% of all primary teachers in the state of Vermont are using the PNOA. These teachers are using the formative
assessment for differentiating instruction and progress monitoring (S, Stanhope, personal communication, June, 2015).

The PNOA consists of two versions, a screening version to capture a profile and a first and second grade version to go even deeper into a student’s knowledge of number. The screening version is typically administered to most first grade students to establish a baseline on entry level tasks. It is administered in an interview forum, with one teacher engaging with one student at a time. Ideally, it is conducted in early fall as a baseline, followed by the full PNOA midyear and in late spring to monitor progress. Each of the PNOA tasks is chosen because of their predictive nature in terms of early numeracy development and to determine the most advanced strategies available to the learner. Scoring is based on automaticity or the time it takes to produce an accurate answer efficiently, appropriately and with flexible application. Mathematical proficiency is dependent on automatic skills and number counting, identification, addition and subtraction and place value (Barodody, 2006). Points are accrued through check marks in the form of 2 checks, 1 check or an X. Two checks imply that the answer is given in a 2 second time frame accurately. One check reflects a correct response but with thinking time and an X reflects incorrect responses. Assessors are also asked to record observable strategies or patterns that may lead to better insight on the learner.

An important challenge for the teacher as observer and diagnostician is to attempt to elicit the child's most sophisticated strategy (Wright, Martland & Stafford, 2006, pp. 703). The PNOA stems from a constructivist perspective. Each portion of the assessment is carefully selected to be at a level that extends the child's current thinking to observe the actual level of sophistication.

### 2.9.1 PNOA Tasks

For the purpose of this study the Vermont’s Primary Number and Operation Mathematics Assessment (PNOA) was translated from English to Norwegian. The PNOA was further deconstructed into the following six areas: Forward Sequences, Backward Sequences, Symbolic Notation, Groupings and Place Value, Estimation and Magnitude, and Operations. Each of these components, were purposefully selected as the core skills and broken down as they pertain to the concept of number. Each task is introduced using clear and concise language and then modeled or demonstrated for the learner. The following is a brief breakdown of the tasks:
1. “Forward Sequences” involves rote-counting skills. It was selected because it is a prominent aspect of mental computation used by students in the primary years. It is also a prerequisite skill for the understanding of addition, subtraction, and the ten-to-one concept of place value. “Number Word After” and “Backward Sequence” tasks (number word before) follow because they are important in the assessment and facility with number words. This task provides an important basis for the development of early addition and subtraction strategies.

2. “Skip Counting” is a precursor for recognizing numeric patterns, functional relationships, and concepts underlying money, time telling, and multiplication. It increases overall math confidence and students flexibility with number.

3. “Symbolic Notation” encompasses both numerical recording and numerical identification, which are important aspects of early numeracy. Mathematical symbols are important because most of mathematics is represented using symbols. Adequate counting, comparing, and symbol knowledge skills are essential to most addition and subtraction problems presented in primary school.

4. “Groupings and Place Value” are assessed because they are fundamental concepts necessary for all higher-level mathematics. Place value, in essence, is the understanding that the same numeral represents different amounts depending on which position it is in.

5. The “Magnitude task” requires students to order a random group of numerals in counting order. This task assesses the learner’s understanding of the relationship between numbers and quantities and the ability to sequence numbers and for the understanding of greater than and less than.

6. “Operations or automaticity” is the final task of the PNOA screening assessment and looks at the student’s ability to solve simple addition and subtraction problems. Automaticity of facts forms the basis for efficient calculation (Fosnot & Dolk, 2001, pp. 113).

2.9.2 Limitations of the PNOA

While it has been adopted by most of the primary schools in Vermont, USA, it has also been criticized by some, as too sophisticated and hard to validate with a lack of the statistical measures to norm the assessment and quantify results. It is understood by the developer that there are certain limitations of the PNOA (S, Stanhope, communication in person, May,
2016). Even though most teachers are trained and calibrated in the administration of the PNOA, according to the developers, there needs to be even deeper training to effectively teach from the tool. “The PNOA is a grass roots assessment based on research, but it has not gone through psychometric nor statistical measures in order for it to be considered a norm-referenced assessment” (S, Stanhope, communication in person, May, 2016). The developers of the PNOA are in the process of finding out how to proceed with these measures. Currently, the primary use of the PNOA is to collect data routinely from teachers and schools who are using it for progress monitoring purposes and to examine how it is being used to inform instruction.

For the purpose of this study, the participants were given the proper materials to prepare in terms of the administration of the PNOA. The study, however, did not involve deep guidance in integrating findings with instruction. Also noted is that the screening version of the first grade PNOA was used to shorten the more time consuming administration of the full first grade PNOA.

Although, it has been revealed that there is a commonality in describing what being numerate is among most countries (Wright, Martland & Stafford, 2006, pp. 14), it is important to note, that age related expectations around early number may vary. The full first grade PNOA is related to the US Common Core standards and entails a longer assessment format. It provides a more robust profile of the student’s knowledge. The full PNOA is more time demanding, taking around 40 minutes to administer versus the 20-minute administration of the screening version. The screening version was selected for this study because as noted, the intention of this study was to explore the experience of the participants using a formative numeracy assessment.
3 METHOD

3.1 Philosophy of Science

Science and philosophy have always learned from each other (Spirkin, 1983). Philosophy of science is a discipline that tries to expose the underlying presuppositions that structure important practices and institutions of life. It forces researchers to think about what they are doing and why (Machamer, 1998). This study examines the role that hermeneutical philosophy can play in understanding science. It is grounded in the desire to see science as not only seeking statistical evidence but also as seeking a deeper truth by listening and searching for meaning through the voices of the informants.

3.1.1 Hermeneutics

According to Gadamer (1975), understanding is language bound. The roots of the word hermeneutics is derived from the Greek verb hermeneuein, translated as to interpret. The goal of a hermeneutic approach is to seek understanding. Gadamer (1999) writes,

> The hermeneutic approach stresses the creative interpretation of words and texts and the active role played by the knower. The goal is not objective explanation or neutral description, but rather a sympathetic engagement with the author of a text, utterance or action and the wider socio-cultural context within which these phenomena occur (pp.63)

Hermeneutics looks at our relation to the word as the medium through which we perceive our world (Gadamer, 1976, pp.29). Hermeneutics involves the merging of the pre-understanding, the framing of the phenomenon and the interpretation of the text, to unite the pieces to make a whole where the tacit becomes explicit. This approach appealed to the researcher because it invited a voice and a horizon into the study rather than imposing its absence. As Gadamer suggests, rather than closing us off, our prejudices are themselves what open us up to what is to be understood (http://plato.stanford.edu/entries/gadamer/). Within this frame, the purpose of this study is to illuminate the experience of using formative numeracy assessment in first grade classrooms in Norway.
3.2 Qualitative Method

In the Handbook of Qualitative Research (2005), Denzin and Lincoln offer the following definition:

Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that makes the world visible. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret phenomena in terms of the meanings people bring to them (pp. 3)

This study adopted a qualitative research approach to enable the researcher to collect and analyze the participant’s perspective of formative numeracy assessment. Qualitative design seeks data that is generated primarily in the form of words, not numbers. The goal is to understand and explore how meaning is constructed and how participants experience the phenomena (Merriam, 2009, pp. 13). The intention of this study is to explore and illuminate the experience of the participants and to understand the phenomena from a flexible position. “Qualitative studies can help researchers evaluate the saliency” (Curry, Nemhhard & Bradley, 2009, pp. 1444) of the phenomenon that cannot be measured quantitatively. As a result, this approach offered room for richer data collected within the natural setting. It also provided a framework for a more comprehensive understanding of the phenomenon.

In this study it is understood is that the nature of the research problem should have the most influence in guiding the choice of method. "That is, what one wants to learn determines how one should go about learning it” (Trauth, 2001, pp.4). A method is a term that suggests a carefully considered way of approaching the world so that we may understand it better (Sayer, 2010). The use of interview is considered a method of data collection. Interview methods can range in structure from unstructured, semi-structured, to highly structured. Whether they are the former or the latter depends on how direct of a role the interviewer will have in the interaction. With the intention to explore the phenomena from the participant’s perspectives, a semi-structured interview was implemented. These interviews offered a forum to establish meaning and gather perceptions, where nuances and feelings where not lost but instead seen as an essential part of the interpretation. Qualitative interview as a method aims to develop detail, to integrate perspectives, to bridge and develop a holistic description and to lay the
grounds for future more quantitative studies (Weiss, 1995). Using a semi-structured interview to guide the data collection, participant views and experiences were elicited on his or her own terms. Other qualitative data collection methods may have prohibited the density of the data by rigid or pre-established response categories. The goal of this study was to understand and search for coherence, the red thread in the data. The intention was to lay the foundation for subsequent teacher-learner based research, specifically around using formative numeracy assessment to leverage individual potential in the early years of school in Norway.

3.3 Data Collection

3.3.1 Participation Selection

Purposive sampling is the technique often used in qualitative studies and refers to sampling with a purpose. For this study, participants were deliberately selected to provide the most information-rich data possible given their expertise in the area of teaching. These were participants who could illuminate the phenomena of using a formative numeracy assessment in first grade Norwegian classrooms. Since first grade in schools, is seen as a pivotal period in early numeracy development, first grade teachers, with a minimum of 2 years teaching experience in Norway, were selected to generate insight on the experience of using the PNOA as a formative assessment. Four teachers were included in the selection to enhance the interpretive status of the evidence in providing a deeper understanding of the phenomena. The researcher initiated contact with the two schools and was then granted permission to conduct the study. The research took place in two Norwegian primary schools to also add to the variety of the sample. Both schools were fairly homogeneous with regard to demographics, specifically socioeconomic status.

3.3.2 Collection of Data

Qualitative data collection occurs most often in a natural setting and produces text-based data through open-ended discussions and observations. Central to this study was the use of semi-structured interview which consisted of a predetermined set of questions developed by the researcher prior to the interviews. The semi-structure allowed the researcher the possibility to explore particular themes or answers further without the restriction of a more structured
It also ensured a level of consistency in conducting the interviews so that the interviews could be revisited when comparing the findings later in the analysis.

Participating teachers conducted the PNOA on all first grade pupils in early September 2015, to assess each student’s school entry number sense. Each participant was provided with administration rules and a video with an example of a specific script to follow. All participants practiced administering the PNOA before actually using it with their students. The data from the PNOA was utilized only to generate conversation within the interviews and to expand on the findings.

This study utilized the PNOA only as a tool through which to observe and explore formative numeracy assessment in the context of Norway. Prior to interviewing the participants, a pilot interview was conducted to clarify aims and modify the interview guide. The time frame of the study was August 2015 to December 2015. Interviews were taped following the initial PNOA experience in September and after the final November administration. Only the researcher and the participant were present for the interviews, which took place in the respective schools of the study.

3.3.3 Transcribing of Data & Data Analysis

There are different positions the researcher can take when engaging with the relevant literature of a study. Driven by a theoretical interest in the phenomena explored, literature was intentionally utilized prior to the data collection, as well as in shaping the analysis and conclusion. Influential authors such as Catherine Fosnot, Lev Vygotsky and the work of Robert Wright, were selected to frame the background and context of the study. It has been argued that by engaging with the literature beforehand, the analysis can be enhanced by sensitizing the researcher to the more subtle features of the data (Tuckett, 2005). By leaning on the selected literature and experts, the study found the substance needed to explore the phenomena deeper.

3.3.4 Transcribing

“Researchers need to think about transcription carefully before beginning the development of a transcript” (Lapadat, 2000). Following the interviews, the recordings were transcribed verbatim. Before beginning the transcription process, the researcher chose to approach the
data by moving back and forth between the recordings and the transcriptions. The transcription process included all elements of the dialogue other than idiosyncratic elements such as stutters and pauses with a focus on addressing the research questions. This not only secured an authentic representation of the informants’ voices but ensured that when the data was later revisited it was collected in an organized format.

### 3.3.5 Coding

Using the constant comparative method (Glaser & Strauss, 1967), data was reviewed line by line in detail and when a pattern became apparent, a code was assigned. Here, the entire set of data was systematically given equal attention. When patterns were witnessed, they were coded. These codes helped organize key concepts that were theoretically driven, while honoring the original context in which they occurred. Text segments were compared to ensure that the codes were properly assigned and reflected the same concept. The computer software HyerResearch was used to maintain consistency and help refine the initial 21 codes in the data. These codes where then systematically narrowed down to four main themes that best represented the findings in light of the research question.

### 3.3.6 Thematic Analysis

The emerging themes or patterns across the data that best described the phenomenon were selected to organize the findings. Each theme was determined by its prevalence across the data and how relevant it was in relation to the overall research questions. Here, words, statements, and phrases that were felt to be of significance were set aside to revisit, question and reflect on. The extracts selected in the thematic analysis were chosen because they illustrated and highlighted important points in the data. As Willis (2007, pp. 202) stated, thematic analysis is a “nonlinear, recursive (iterative) process in which data collection, data analysis, and interpretation occur and influence each other.” This approach allowed for flexibility in accounting for the data. It also invited the researcher to engage with the findings in a way that was open to the researcher’s theoretical interest and prior-knowledge of the phenomenon.
3.3.7 Presentation of the Data

Following the thematic analysis, the selected themes were discussed with the participants and analyzed as evidence to generate the meaning of the data. Four final themes were selected. These four themes were supported in the form of quotations from the interviews and excerpts from observations on site and are included in the analysis.

3.3.8 Validity and Reliability

Traditionally, in qualitative study, it is the depth and sophistication of the analytic lens on the data that lends richness, credibility, and validity to the analyses (Luborsky & Rubenstein, 1995). Validity can be defined as how accurately the account represents participants’ realities of the social phenomena and refers to the credibility of a study or how accurately the account represents participants’ realities of the social phenomena explored (Creswell & Miller, 2000). Reliability refers to the rigor and transferability of the study. The transferability of qualitative studies is usually based not on explicit sampling of some defined population to which the results can be extended, but on the development of a theory or understanding that can be extended to other cases (Becker, 1991; Ragin, 1987 in Maxwell, pp. 246)

Qualitative researchers use a lens not based on scores, instruments, or research designs but a lens established using the views of people who conduct, participate in, or read and review a study (Creswell & Miller, 2000, pp.125). Three different lenses were used to establish validity: the lens of the researcher, the lens of the participants and the lens of the people external to the study.

3.3.9 Lens of the Researcher

The researcher is the instrument used for collecting and analyzing the data in qualitative studies. Acknowledged, therefore, is that the study is somewhat subjective and that other researchers may approach the same research differently. The difference lies in how researchers enter the collection and interpretation of the data and from which point of reference. Central to this study is the positioning of the researcher as a co-constructor of meaning and a shaping voice in the interpretation of the data. Eisner (1998) suggests that how we interpret what we see bears our own signature, a unique insight that is not a liability but a forum to bring individual insight to a situation. Researchers must remain conscious of how
their presence affects the setting and the individuals being observed, and how this could affect the research results. Given the researchers prior experience as a teacher, one familiar with the PNOA and as a parent of a child attending first grade Norwegian primary school, the study was entered with an understanding of teaching, learning and assessment as interrelated.

To protect the integrity of the findings, data was collected in a way that revealed the whole picture, in the field, using a semi-structured interview. This approach makes it more difficult for the researcher to see only what they want to see. Also included was disconfirming evidence which provides further support of the account’s credibility because reality is multiple and complex (Creswell & Miller, 2000, pp.127). Suggested is that “when data from different kinds and sources converge and are found congruent, the results have greater credibility” (Kaplan & Maxwell, pp.45). As mentioned, this study used multiple sources from two different settings to strengthen the robustness of the data which also adds to the credibility of the study.

### 3.3.10 Lens of Participants

Maxwell (1996) noted that failure to accurately collect and interpret descriptive data will lead to invalid interpretations, which will result in invalid conclusions. Member checking is also a crucial process that any qualitative researcher should undergo because it is the heart of credibility (Onwuegbuzie & Leech, 2007). The single most important way of ruling out the possibility of misinterpreting the meaning of what participants say is through member checking (Maxwell, pp.45). To focus the lens on the participants, therefore, data was available throughout the study for the participants to review and confirm the credibility of the findings. To ensure an accurate and realistic account of their experience, direct quotes and words of the informants were included and embedded in the analysis. This helps ensure authenticity. By presenting a sufficient portion of the original evidence in the written account the researcher was able to confirm the relation between the interpretation and the evidence (Greenhalgh & Taylor, 1997). “The main threat to valid interpretation is imposing one’s own framework or meaning, rather than understanding the perspective of the people studied and the meanings they attach to their words and actions” (Maxwell, 2013, pp. 89). By using semi-structured questions participants were free to elaborate so that the researcher was less likely to compromise the interpretation.
This study also involved a direct engagement in the field. The time involved included 6 days on sight for each of the four classrooms both in September and then again in late November. This allowed the building of trust and rapport with participants and ensured informants felt comfortable disclosing information. The researcher reciprocated the time involved on behalf of the teachers by helping cover the classrooms during the days the PNOA was administered. This adds to the credibility of the study because the experience offered a better understanding of the context from which participant views culminated as well as ample time to observe the process.

3.3.11 Lens of People External to the Study

According to Koch (1994), to strengthen reliability, the researcher must establish an audit trail describing and justifying all the steps undertaken in the research process. Reliability refers to whether a particular research technique will yield the same results if applied repeatedly to the same object (Babbie, 1997). Strategies used to attain reliability involved selecting an appropriate method, the collection of detailed and transparent data, immersion in the field and member checking to verify consistency of the findings. As far as external validity, this data is not generalizable, based on a sample from a single geographic location in Norway. While the study did not intend to be generalizable to the greater population, it did set out to illuminate in detail the perceptions and experience of the phenomenon.

Following the coding process of the documents, an external auditor was asked to review the analysis. “As the qualitative researcher often is perceived as the research instrument, he or she must ensure that the information he or she reports/records is accurate and not oversimplified or misinterpreted” (Lewis, 2009, pp.7). A peer-review was also conducted and by someone familiar with the phenomenon. This review both supported and challenged the researchers’ assumptions and helped ensure a collaborative forum to drive the process and analysis further.

3.4 Ethical Considerations

“Research is of great importance to individuals, to society and to global development. Research also exercises considerable power at all these levels. For both these reasons, it is essential that research is undertaken in ways that are ethically sound” (The Norwegian National Research Ethics Committee).
Ethical considerations around respect, fairness and integrity were considered at every stage of this study. Both the supervisors (the primary school principals) and the participants (the first grade classroom teachers) were informed about the research both via email and in a planned meeting with the researcher. Participation was voluntary, with informed consent collected confirming the right to withdraw from the study at any stage. Data was registered on a private computer and was only accessible using a security code. To ensure all information and findings were handled with care, all data was destroyed on completion of the study.

Participants were informed of the privacy procedures prior to agreeing to participate. Research carried out in this study was ethically sound in safeguarding the dignity, rights, safety and wellbeing of all research participants. Consent, written approval and data confidentiality were enforced. The names of the two schools as well as the four participants were not incorporated in the data, to protect and control anonymity of participants. To confirm that all perspectives were reflected accurately, member checking was included for participants to review and approve of the findings. Upon completion of the study in June of 2016, all original data was destroyed. A crucial part of the ethical issues of research is the honest and open aim to validity (Check & Schutt, 2012). Great care, therefore, was placed in reporting honestly and in detail to provide a full picture of the findings.

In preparation for the study, the Norwegian Social Science Data Services (NSD) was notified of the planned study and permission was granted in June of 2015, confirming the plan was in accordance with the Norwegian Personal Data Act. This letter can be found in the Appendices and functions as an official permission for the starting date of this study.

For both of the schools included in the study, permission was first granted by the principle or school leader and then by the four participating first grade teachers. Examples of these documents can be found in the Appendices. The forms do not include names of the participants to protect anonymity of those involved.

### 3.4.1 Limitations of the Study

Limitations that pertain to the findings of this study include the differences of teachers preknowledge around numeracy and formative numeracy assessment. Important to consider is that the researcher is from the USA and the research was conducted in Norway, therefore, language and cultural and social expectations may have played a role in data collection. Also important to note is that the first interview was conducted in English. In an effort to derive
more in depth information from the interview, the second interview was conducted in Norwegian and later translated. While it could be argued that this decreased the validity of the study, I argue that it does the opposite. The interviews were taped with only the researcher and the informant present. The translator was used only after the interview to transcribe the texts verbatim. In this approach, the possible bias that can be innate to the transcriber familiar with the study is eliminated leaving the raw text exposed for analysis. As Gadamer (1975-1996, pp.386) states, “Translation like all interpretation is a highlighting” while thematic analysis is a rigorous method if applied systematically, it does come with limitations.

More in depth interviews, from other areas and more informants could have enriched the information on the experience as well as provided comparative contexts for this analysis. A more robust sample could have also provided a deeper look at the similarities and differences among the more varied but comparable experiences. These limitations could be carefully considered in future studies.
4 DATA ANALYSIS AND DISCUSSION

4.1 Themes that Illuminated the Phenomena

The data analysis focused on identifying themes that were voiced by the four informants in this study. Each theme, voiced by the participant, was selected to capture the data most relevant to the research questions. The final themes selected were; the importance of assessment as an informant, the importance of learning differences, the importance of accessing prior knowledge and the importance of the one to one time with the learner.

The first theme was selected to explore how using a formative assessment functioned as an informant on learner’s early math knowledge. The question posed was did the formative assessment tool inform teachers of students’ early numeracy skills they would otherwise not have known. The second theme, accessing prior knowledge considers what informants saw as an appropriate place to begin early numeracy instruction from. Here, the teachers spoke of the variety of readiness around early number acquisition witnessed through the PNOA findings in their first grade classroom. These answers lent themselves to the third topic, learning differences, which highlights the vast and unequal abilities these teachers observed around early number ability and development through the formative assessment. The latter theme hones in on the inherent struggle that teachers’ face, which is how do responsible classroom teachers meet the different learning needs in their classroom. The final theme captures the consensus among the teachers as to the benefit of the one to one interview format inherent in the PNOA; specifically that the interview forum offered a chance to observe and monitor learning.

4.1.1 Theme 1: Assessment as an informant

Each participant confirmed that prior to the use of the PNOA the common assessment method used in all four classrooms was classroom observation. The four participants confirmed that they were not familiar with the purpose of formative numeracy assessment and only one of them had used a math assessment similar to the PNOA prior to the study. Upon initiating the study, there was an evident reluctance on behalf of the participants to sign on to such a time intensive exploration. Following conducting the PNOA in early September, these teachers’ initial thoughts were:
“I would not have focused in the same way without the knowledge of my learners (before using the PNOA). I wasn’t so observant about the challenge areas or the type of mathematic abilities, I didn’t have the skill.”

“To know what they are able to do and not able to do so early on in the school year rather than later. What is new (math skills) to some is old to others.”

“The very deep info on students straight away, you see how they think and how to talk to them...”

Unlike summative assessment, formative assessment is when the evidence garnered “is actually used to adapt the teaching to meet student needs” (Black & Wiliam, 1998 pp. 140). By conducting the formative numeracy assessment both in September and then again in November, teachers could reflect on their learners growth and monitor instructional approaches. It is suggested that this approach recognizes learning as socially constructed, dependent on how the teacher facilitates and tailors instruction more conducive to different learning needs. The idea is that just as learning is ongoing, assessment should be as well. Glaserfeld (1995, pp.13; Wright, 2006) observed that while the actual process of thinking remains invisible, the best and perhaps only way to find out how knowledge is built up, is to investigate what and how learners know. In regards to this, participants reflected:

“It seems obvious but if you don't know what your students can do, then you don't really know where to start.”

“Now I know there are some students that will need extra support. I may not have really understood this before the results pointed out how far behind they were from their peers. I kind of assumed but now I know.”

Although many of the students were well suited to be assessed using the first grade PNOA screening tool from the USA, some participants expressed that learners may have benefited from an easier starting point. These comments indicate how assessment can further the dialogue around early formative assessment:

“It was too hard for some. Like I got very little information on them in the beginning because the tasks were too advanced. Might be better to make it easier.”
“I would never have tested them on some of the things from the PNOA because I would have thought that it was too hard. An example of this was like counting with 10s I would never have guessed they could do it or tried it out. And the magnitude, so many could not do it and then in November so many could. How simple it was to teach but I would not have before.”

The teachers also commented on how assessment can track growth:

“How good they were, how much they could do. When I first got this I thought they were not going to be able to do anything, this is too hard. I was really surprised how much they could do.”

Interestingly, the majority of the participants did reflect that they would never have known or inquired how much their learners could do with number without using the PNOA formative assessment to guide them. Relevant to this exploration is the understanding that numeracy is constructive, comprised of critical landmarks that may not be sequential but are cumulative, where concepts and skills build on prior concepts, skills and knowledge (Wright, Martland & Stafford, 2006). Teaching number is not a “ready-made discipline to be handed down” and only transmitted (Fosnot & Dolk, 2001, pp. 3). One participant highlighted that:

“Maybe in the way that you need to recognize the starting points of individuals students in order to move forward. If all children can already master certain things there is no point starting there. I had some students who scored 5 points out of 96 and others scoring 69”.

As noted, in the past decade or two, the most important theoretical perspective to emerge in mathematics education has been that of constructivism (Glasserfeld, 1995; Steffe & Thompson, 2000). Intended as a resource tool, the PNOA helps teachers understand the constructive nature of learning, by assessing some of the critical foundational skills in early numeracy. Constructivism sees the learning of number as the active construction of knowledge where learners engage with and try to understand new knowledge and incorporate it into the developing mind (National Research Council, 2000). In essence each learner is constructing knowledge from what has been referred to as different learning landscape, unique to the learner (Fosnot & Dolk, 2001). This builds on the notion that assuming all first grade students enter school with similar pre-understandings, experience and knowledge is limiting both for the teacher and the learner.
Recent findings suggest that systematic early numeracy screening and targeted intervention can allow early identification and support at critical early stages for those at risk of developing math difficulties (Siegler & Ramani, 2009). Argued here is that by establishing an initial profile of the learner upon entering first grade, teachers can tailor numerical instruction to meet individual needs and reduce knowledge gaps. By carefully drawing on the systematic components of numerical development, the PNOA offers information across a range of numerical abilities. The theory behind the PNOA is that without the knowledge of the essential understandings captured by the assessment tool more students will struggle in mathematics (S. Stanhope, personal communication, June, 2015). In regards to this, participants conveyed that:

“What I see here is that all children have had the same type of instruction/teaching but the progression of some rather than others shows they need different things.”

“If we put resources into where they need to improve it is worthwhile as opposed to just general maths teaching.”

The problem in math instruction can be in many cases teachers do not have sufficient skills to identify student’s difficulties in early numeracy (Wright, Martland & Stafford, 2006, pp.15). Evidently, what may appear to be math learning disabilities may only be the result of weak early mathematics experience (US Math Recovery Council, 2014). Using assessments like the PNOA can alleviate this problem. Through assessing using PNOA both in early September and again in late November, participants were also able to follow student’s growth and development over time. The participants in this study responded to their increased knowledge with the following:

“To get to know them like this in such a short period of time. I got much more knowledge of my students much earlier, and systematically so I could see it.”

“Some of my weakest students are now right in the middle, I guess I am surprised by how much growth some of them have made. I would not have been able to see this without knowing where they started.”

Also referred to, was how easy it was to overlook “certain learners” and that some students just “blend” in. These comments infer that without using a formative numeracy assessment some learners may be assumed to be more competent than they actually are with number.
There was also an expressed surprise of how strong some of the learners were in their math understanding and a clear range of ability as noted by the following excerpts:

“I was so surprised by how far some could count and that they know like the transition from 29-30 and 39-40, and here we are working on just 1-10.”

“Sometimes you assume what you don't know…. it became obvious for me that I thought I knew more than really did.”

Evidently, these participants expressed the benefit of having tools to provide them with a clearer profile of each learner. The impression from the four participants was that the PNOA data changed expectations of their learners because they could see what learners could not do but also what they could do. This was especially evident in the November interviews after participants had seen the growth reflected in the second results. Many students had mastered portions of the assessment that the teachers expressed they would not have expected. Others made gains that the teachers expressed they would not have thought possible. Interestingly, participants suggested that the growth occurred primarily on tasks they focused most of their instruction on, such as operations and automaticity and place value. The following was reflected by two participants:

“I worked based on the results and see that where I did focus was where we got the greatest improvements.”

“I wonder, why the strongest students, gained the least in my November results. Maybe I am spending too much time building up the weaker ones and not enough time challenging them. I now know I have to work on this.”

The results were useful to observe learning progressions but also offered a chance for teachers to observe how their instruction impacted their learners. There was an evident sense of ownership on behalf of the participants when they visually could recognize the growth of their learners. One participant expressed that she shared specific learning goals with her learners after conducting the assessment and each of the participants used the findings to provide positive feedback to their learners. This builds on the shared learning and teaching interplay, which is central to the social constructivist theory.
4.1.2 Theme 2: Learning Differences

With each participant conveying similar discrepancies in their classroom PNOA findings, it was evident that there were obvious gaps in the abilities and knowledge of these students upon entering first grade. Looking closely, teachers confirmed that not one student scored the same. These are comments by the teachers regarding learning differences:

“It seems obvious but if you don't know what your students can do, then you don't really know where to start.”

“Now I know there are some students that will need extra support. I may not have really understood this before the results pointed out how far behind they were from their peers. I kind of assumed but now I know.”

The following conjecture is consistent with this study’s findings, that learning is individual and should be honored as such. As stated, “the objective of formative numeracy assessment is to support the teacher in facilitating numeracy by clarifying numerical learning intentions, by providing feedback intended to move learners forward and through guiding more effective classroom discourse” (Leahy & William, 2009). Participants reported:

“The assessment provided me with a visual of learning. I actually could see where they are weak and what they don’t know. Like none of them could do magnitude, I now know I need to focus more on that.”

“I saw that all children don’t learn the same method, really……how different the learners are.”

“The weakest students became very clear when they became ranged and also the strongest……I could see the difference between them through the results.”

A report in 2006-2007 in the Norwegian Government’s white paper referred to earlier in the study called on a stronger correlation between assessment tests that inform and ensure the necessary follow up to ensure equal and quality education for all. This supports the notion that developmentally appropriate numerical instruction is not simply about age or grade but instead contingent on prior opportunity to learn (Duschl, Schweingruber & Shouse, 2007, pp.2). This also highlights the limitations of the “wait and see approach” on early intervention. When asked what kind of intervention might be provided for those students who
were really struggling in these four classrooms, the consensus among the participants was that it was up to the teacher. One participant reflected:

“There is no one but me. I am in charge of each of these students. The only thing I can really do is to connect with the parents. As I said, I also used the PNOA results to give more direct information to the parents. I hope they will work with their child but it doesn’t always happen. We don’t have a special educator available to us for support around this.”

One participant expressed that it was not until third grade that any kind of intervention or diagnosis would be made. The following was stated:

“I have expressed concern for students in the past, the answer is always that it is too early, we need to wait or to try a different approach. There is very little support to really give some of these kids what they need. Then it is up to you, that is a lot of pressure. I use parents as a resource when I can, writing them helpful notes in hope that they will work with their child.”

Trajectories are ways of characterizing what happens in between any given set of beginning and endpoints and what kinds of instruction are needed for the student to be supported in moving from where his or her thinking now stands to levels that would be closer to matching the learning goal (Daro, Mosher & Corcoran, 2011, pp.26). A common thread through the various narratives of the participants was their implicit and explicit references to the vast difference of their learners:

“How to make it all happen in the classroom with 5-7 strong students with so much knowledge and then the very weak? How to meet them all and especially the lowest ones?”

“How am I going to be able to teach all these students, they are all so different, I have 4 who know only how to count to 5 and some that can count by 5s?”

“All the different needs, for me is the biggest challenge. I knew there would be differences but look at my graph they are all at different places.”

“Some learn just by hearing it once and others I can review it every day and they still don’t know.”

“I knew many of them would be high but not so high and so many.”
“Also that my graph looked so different, no kids at exactly the same level. The spread in level was very surprising.”

These answers demonstrate the challenge with a one size fits all approach to teaching number.

### 4.1.3 Theme 3: Prior Knowledge

The theme of the importance of prior knowledge was referred to often throughout the interviews. These teachers understood that when a learner reveals their prior knowledge it can assist the teacher in the appropriate selection of future instruction. When the learner is monitored through continuous formative assessment, the teacher is able to examine individual development and measure what is working or not working. They then learn to increase tension or decrease tension when it is needed. Argued here is that prior to teaching any topic in early number curriculum, it is critical to have a valid understanding of the student’s current ability (Wright, Martland & Stafford, 2006, pp.21). Assessment needs to foresee where and how one can anticipate that which is just coming into view in the distance (Fosnot & Dolk, 2001).

Early number sense can serve as a ladder for learning number in primary school (Jordan, Glutting & Ramineni, 2010). Studies related to math have shown that student number sense varies considerably due to their informal learning experience before entering first grade (Hotulainen, Mononen & Aunio, 2016). As revealed by research and these four participants’ input, there is a lack of systematic tools to assess first grade Norwegian students’ knowledge and competence around early number in the beginning of first grade. This is of relevance because “of all the learning differences, prior knowledge, is recognized as one of the most powerful resources on which to build learning” (Dumont, Instance & Benavides, 2010, pp.16). Included here are further teacher comments:

“The results showed me who needed extra support and in which areas.”

“I used the data to shape my instruction. Now I know where we can start.”

“I now know that students A B & C, need more challenge for me to be doing my job and I also know that certain students will need extra attention to get them where they need to be.”
“They are all around the same age, but they all have such different experience and knowledge with math.”

Suggested from these comments is that when a teacher knows the learner, strategies such as slower pace of delivery, more feedback or adaptive instruction, can be implemented to better serve the learner. Teachers are the pivotal negotiators responsible for making the crucial decisions about what is appropriate numerical instruction on a day-to-day basis. Also interesting to consider is the potential impact teacher expectations can have on the learner’s motivation as well as how important these expectations comply with the individual’s ability. The following quotations embellish on this:

“During group teaching, I know who should be pushed and who needs more practice.”

“I also know who needs a different level of support and one who just always needs my feedback. She knows it but needs me to encourage her when it comes to math.”

“Without this insight, I would be teaching many things they already know. Like these four students are way beyond what we are teaching. Now I know where to push and where to pull back.”

According to Fosnot (Fosnot & Dolk, pp.162) and as captured by Vygotsky’s theory of ZOPD, what is just coming into view for one learner may be in the far distance for another. Inferred here is that by assessing how a learner mathematizes, through their prior knowledge, teachers can acquire information that enables them to determine how to proceed. For the first grade student with weak numeracy skills this early systematic numeracy assessment can serve as a screening tool and guide for targeted intervention during this critical early stage for those at risk of developing math difficulties (Siegler & Ramani, 2008).

### 4.1.4 Theme 4: One to One with the Learner

All four participants reiterated the value of the one to one time with their learners, as well as the chance to give them individualized feedback. In this study, the information gained by the teacher through the formative assessment, was used to tailor instructional approaches, to share feedback and to monitor learning progression. Participants reflected that:
“For certain children, I stepped back and realized that I had to slow down with my approach and for others, I used the information to push them harder.”

“It is so easy to see them as a group until you are alone with them. Then you really see what is going on inside their minds.”

“The benefit of getting time alone with my students, when you sit 1x1, you see where they stop. You don’t see this when they are all sitting together.”

“My expectations for my students are more according to where they are at. Like my weakest student went from a 9 to a 60. Clearly she needed exposure. But I would never had seen this without knowing first.”

“And I saw that all of my students improved in the second results but I can see there is 1 learner who clearly needs more than what I can give him alone.”

Evidently, teacher’s thinking changes when they understand the reasons for the children’s mistakes and progress (Wright, Martland & Stafford, 2006, pp.151). Optimal teacher learner relationships involve teachers’ confidence in students’ underlying abilities as well the facilitation of how to reach high levels of understanding and performance (Stipek, 2002). Differential treatment according to teacher expectations mediates learner’s motivation and inevitably effects performance (Wentzel, Wigfield & Miele, 2009, pp.366). Thus when teacher expectations are high they increase motivation, which improves performance and when teacher expectations are low they generally undermine the learner’s motivation.

Participants also expressed becoming more sympathetic to their learners. One participant used the initial findings to connect with the parents of struggling students. In addition, she used examples from the PNOA findings to describe to the parents how they could support learners at home. When reflecting on one student, a participant said:

“He is so busy, hardly sitting still and his behavior gets in the way of teaching. Then I see that he can hardly count and recognizes only 2 numbers during the assessment. I guess it changed how I saw him.”

And another participant expressed:
“Through the assessment, I feel I know my students better now. Especially after the second results- all of them grew but some I would never have expected to grow so much. Like this one, she was at the bottom and now she is in the middle.”

Evidence suggests that teachers’ instructional interactions with children have the greatest value for students’ performance when they are focused, direct, intentional and characterized by feedback loops involving student performance (Hamre & Pianta, 2005). Participants reflected that the formative assessment helped promote the exchange of feedback, stating:

“I was able to give them time, to watch them and recognize their growth.”

“To be able to praise their growth, give them real feedback, like wow, look at how far you have come, for them to see it too.”

“You could also see how excited the children were (to be alone with us) they would say, “Is it my turn yet?”

The four teachers in this study volunteered that almost all instruction was whole group. With one teacher and 16-22 students, the classroom culture was most conducive to either independent deskwork or floor time with the teacher leading. The teachers corroborated that the whole class teaching may be an inappropriate time to assess individual learner’s prior knowledge. Others commented on how challenging is to tailor instruction in a whole group setting to meet the individual needs of the learners. Noted here is the inevitable impact this can have on the motivation to learn (Myhill & Brackley, 2004, pp.273). All participants confirmed that the one to one interview format offered a chance to see and recognize each learner as an individual.

4.2 Additional Themes

Along with the selected themes in the data, the study also revealed additional themes worth noting around using a formative numeracy assessment like the PNOA. The four additional topics were: the importance of learning goals, the importance of using the PNOA results to organize small learning groups, the importance of teacher empowerment and the importance of effective feedback and classroom support.
4.2.1 Learning Goals

To understand the context around numeracy expectations, the researcher inquired about established goals around number for first grade Norwegian students. Also probed was how and when these teachers would typically measure individual competencies. All four participants confirmed that the single goal around number in first grade was to count from 1-10 by December and up to 20 by May. In response to this goal, one participant expressed that it is the responsibility of the teacher to define and guide what students must know, stating:

“There are goals that they have to hit, quite easy numbers up to 10 before Christmas and up to 20 by Easter. “

As examined earlier in the study, math is highly proceduralized, continually builds on previous knowledge and is dependent on early instruction and approach. It is common knowledge that there is a difference in the numerical knowledge of students when they begin first grade and ample evidence that reflects that students who begin as low numerical attainers tend to remain there without targeted intervention (Wright, Martland & Stafford, 2006). The social constructivist theory argues that with the guidance of a teacher or more experienced other, the novice learner can master numerical concepts and ideas that they cannot understand on their own. Information gained from this formative assessment provided these teachers with a clearer sense of how to approach students to maximize learning. Reflected by one participant was:

“Also the growth, I would never have expected to see some of these students come so far. If I had not have known where they were in September I also would not be able to measure it now.”

Evidently, these participants attributed the lack of more in depth numeracy goals as hindering their ability to tailor their teaching to stretch learning. With all four participants confirming that the single goal around number in first grade was to count from 1-10 by December and up to 20 by May, one could question how this serves the learner. As stated, number acquisition is the accumulation of many landmarks, and far more complex and interrelated than simply counting from 1-10. In response to this limitation one teacher reflected:
“It is not actually specified what to master with regards to numbers up to 10. It’s the teacher that works out what they must do. The only tests we have are designed to catch the REALLY, REALLY weak students (in the Spring).”

These participants also revealed how much rests on the classroom teacher in these Norwegian classrooms.

4.2.2 Teacher Empowerment and Confidence

In contrast to formative assessments, like the PNOA, many assessment scores are not readily available to the teacher until days or weeks after administering. Formative assessment can reveal not just what learners know but how they think in the moment. Huffman and Kalnin (2003) highlight the influencing factor of ownership experienced when teachers can collect their own data as in formative assessment versus having it collected by someone else. Throughout the feedback, the word empowerment was used, teachers felt especially empowered by the November results. They expressed how proud they were of their students’ progression with number and also with their own teaching. One teacher expressed:

“The results gave me feedback, direct feedback on my teaching. This I never had before to this degree. I am really proud.”

4.2.3 Need for Effective Feedback and Classroom Support

Participants’ accounts also revealed a concern and uncertainty of what to actually do with the findings from the formative assessment. Upon reflection, participants suggested a need for role models, mentors, and peers to enhance their teaching abilities, stating:

“So, now I have all this information, I will use it to group my students and I know even more who is strong and who is struggling but I want to know what it means, like a teaching direction. Like why magnitude is important.”

“I see my graphs, my classroom results. This is great, but what to actually do with this information so I become better?”

Research suggests that today’s classroom and the individual needs of pupils are considerably more complex. Suggested is that “students with diverse learning needs around number are
not the problem but instead it is the barriers in the curriculum and the approach that are the root of the difficulty” (Hitchcock, Meyer, Rose & Jackson, 2002, pp.9). The PNOA assessment provided these participants with insight regarding each of their numerical learners, information they would otherwise not have known. The participants, however, expressed uncertainty with how to use the PNOA findings to accommodate the different needs and abilities in their classrooms. One participant requested, “simple teaching tips” that related to the assessment findings while others suggested teaching mentors who could model more tailored instruction to cater to the learning differences both in whole class and small group instruction. Another participant voiced how isolated teaching can be and referred to the value of having another adult (the researcher) in the classroom saying:

“How wonderful it was to have you, another teacher in the class, an assistant to support me. I know how to teach the different learners but how to handle it and where is the time? To have someone to discuss it with is so helpful.”

The main challenge seen by all participants as far as future use of a formative numeracy assessment was the time involved specifically the necessary classroom coverage and support that would be needed to make it possible. One participant confirmed:

“I would definitely like to have the ability to use this assessment throughout the year. But, who will watch my classroom when I am one on one with each student? I question if the administration would help me with this.”

This is a common argument and researchers have suggested that formative assessment is too labor intensive and time consuming. However, with one teacher and 16-22 different learning landscapes it could be argued that to adequately assess and then tailor numerical instruction to meet individual needs, Norwegian teachers could benefit from mentoring and support from specialized educators and school leaders. Upon reflection, all participants suggested a need for mentors, institutional support, professional development opportunities and peer collaboration to enhance their teaching abilities.

4.2.4 Use of Peer Collaboration

As mentioned, Lev Vygotsky indicated that for teaching to be developmental, it has to be related to the learner’s ability and potential ability. Chaiklin argues that Vygotsky formulated
the ZOPD out of his interest in appropriate pedagogical interventions, including principles for possible instructional grouping of children, and identification of specific interventions for individual children (as cited in Kosulin, Gindis, Ageyev & Miller, 2003). In this study all participants used the PNOA findings to organize learning groups for their students. These groups varied between peer master and peer novice, to blended ability and most commonly according to ability. The following are some accounts of how the PNOA findings were used to shape group learning:

“I was able to see how big the gap is between a lot of students and this we need to take into consideration when we instruct and group our students.”

“I used the findings from Sept to divide up the class into ability levels and the content informed what I did.”

“With the groups, I was better able to stretch tasks to challenge the different abilities. Like, for the 5 students struggling they played the same game but just used lower numbers”

“I also used my stronger math students to work with some of my weaker, which is also a great way to get the class to work together I think.”

“By grouping my pupils according to ability, I was able to monitor learning better and to select partners that could support each other best. I would have probably grouped differently without the findings.”

This also correlates with the central role the teacher plays in organizing and managing meaningful learning communities. By using the PNOA results to understand where their learners were, teachers were able to provide more effective scaffolding in small group contexts.

4.3 Disconfirming Evidence

Disconfirming evidence consists of searching for potentially disconfirming data in the analysis or setting. This aids the researcher in understanding and exposing the complexities of the phenomenon.

4.3.1 Regrets
Regarding the final interview, when asked if there was anything they would have done differently looking back on the formative assessment experience, all four participants were reluctant to express their thoughts on this. One participant reflected:

“I don’t know completely (what I would have done differently), it is better to test early but I don’t know if looking back I would change anything.”

The researcher contemplated the following questions due to this answer: Was the question posed wrong or did participants feel exposed in critiquing their experience? Culturally, was this question too intimate? Perhaps a survey questionnaire may have provided a more anonymous setting? With the open-ended interview forum, participants were not able to hide and may have felt reluctant to share these more intimate details especially given the researcher/participant dynamic. Interestingly, none of the four participants wanted or had reason to disclose their own doubts or regrets.

4.3.2 Finger Counting

As noted in the literature, fingers are considered by some to be one of our most useful visual aids when learning math. Brian Butterworth (1999, pp. 249), a leading neurocognitive researcher, implies that if students aren’t free to learn about number through thinking through their fingers, numbers “will never have a normal representation in the brain.” Also suggested is that the better students’ knowledge of their fingers is in the first grade, the higher they scored on number comparison and estimation in the second grade. Interestingly, however, each of the participants in this study expressed hesitation around encouraging finger patterns or the use of fingers as a counting strategy for their learners prior to administering the PNOA (which encourages the learner to use finger counting). The participants implied that they had been taught to avoid the use of fingers in first grade. This could be an interesting topic to explore further.
5 CONCLUSION

“How one searches determines what one finds; and what one finds is the basis of the conclusions of one’s integration” (Glass, 1976, pp. 6). Methodological congruence is when the purpose, the questions, and the methods of the study are interconnected resulting in a cohesive whole rather than fragmented and isolated parts (Creswell, 2004, pp.50). The structure of these five chapters was organized to build from one section to the next. In this chapter implications of the analysis are discussed. Key aspects of the data that are particularly relevant to the future of exploring the use of formative numeracy assessments in Norwegian classrooms are also highlighted.

5.1 Future Implications

The information from this study explored the possible added value of repeatedly assessing both pre-grade and grade level skills for identifying students who follow different learning trajectories. As noted, many children come to school with number competencies that are developed through their informal experiences (Ginsburg, Lee, & Boyd, 2008) and these numerical competencies acquired before first grade, can serve as a ladder for learning number in primary school (Jordan, Glutting & Ramineni, 2010). Participants used the information gained from the formative assessment in early September to adjust and plan instruction, in grouping their students and in measuring numerical growth. There was evident growth reflected from the November results according to the teachers, specifically in the lower performing students. This increase in growth could be due to maturation or it could also correlate with the direct influence the formative assessment findings had on the instructional approach and exposure that followed. This leads the study back to the central role of the learners pre-understanding of number. The documented growth found in the follow up assessment conducted in November, suggested that for some learners simple lack of early exposure to number could have altered early performance. All the teachers involved confirmed that by using the early formative assessment, they recognized their learners’ differences. This could imply that the formative assessment process did bring these teachers closer to their learners.

5.1.1 Curriculum Development
Curriculum encompasses the content and methods that guide students learning and development and is intended to answer the “what to teach” and “how to teach” (OCED, 2013). Research suggests that pivotal to formative numeracy assessment, teachers need a working understanding of number and the aligned pedagogical goals. As discussed, formative numeracy assessment is contingent on adequate teacher training, proper support and a certain level of involvement in the learning and teaching process (Ruthven, 1994). It is also important to consider that a primary learning barrier for students is when learning styles are not well matched to the way the information is presented (Frederickson & Cline, 2009, pp. 339).

As found in this study and confirmed in the literature, learners have diverse routes of mathematical development. Recommended is the consideration of learning goals that are innovative, with different levels of mastery that are easily adaptable to changing exceptions and appropriate for different learning needs. “School mathematics; in curriculum, in pedagogy and in assessment should reflect a commitment to equity that simultaneously fosters excellence” (Steen, 1990, pp. 228). Findings from this study suggest that by expecting the same from all 16+ learners in a classroom, without accessing their mathematical pre-understanding or background, meant teachers approached their classes as a group instead of as individuals. Expecting the same from all students releases the teacher from creating a diversified curriculum. While this approach may serve as a shield from early bias or students’ from judgment, it could be argued that it also inhibits the teacher’s ability to provide the equal and quality education that Norwegian learners are entitled to. Steen (1990) writes,

Equity requires mathematic expectations for all. Although the goals of equity and excellence sometimes appear to clash, in mathematics education they converge on a single issue: heightened expectations. Equity for all requires appropriate challenge for all both for those who learn mathematics slowly as well as for those who show special talent for mathematics (pp. 227).

5.1.2 Learning Expectations

Because of the sequential nature of mathematical knowledge, innumeracy inherited from early years becomes an insurmountable obstacle to subsequent study of any mathematics-related field (Steen, 1990). Teachers tend to focus, lead or ask questions in relation to their own agenda (Fosnot & Dolk, 2001, pp.9). This also lends itself to how teaching agendas can be
more intuitively shaped when teachers understand where learners are in the process. This hones in on the role formative assessment could have in framing where learners are in the process; that by recognizing a ZOPD teachers have a reference point to begin appropriate instruction from. Studies also reflect that while teachers recognize when numerical tasks are too difficult, they tend to overlook tasks that are too easy (Sarama & Clements, 2009).

Written curriculum alone does not determine students’ success nor does prior knowledge. Instead, much rests in the experiences in the classroom shaped by the teacher’s expectations.

Suggested is a need for future studies in Norway focused on the process of learning that provide ways of documenting change and transformation in the classroom around numeracy. The primary aim of this small study was to explore the experience of using a formative numeracy assessment from the USA with first grade teachers in Norway. Future studies could involve the obtaining of sufficient data from enough Norwegian contexts using a formative numeracy assessment that caters to Norwegian math curriculum, to make the validity and efficacy arguments more credible. These findings could generate results with more ample evidence of the effectiveness of using a formative numeracy assessment for learning and teaching of number.

5.1.3 School Learning Culture

Formative assessment exists within a bigger system, a larger educational cultural context. Evidently, a major influence on the teacher and the learner today is the school learning culture. A report conducted in cooperation between the NIFU and NTNUE Social research, as a follow up evaluation concerning national leadership education for school principals in Norway, emphasized the “principle’s influence on the school learning environment, especially the teachers motivations and working conditions which in return is believed to influence the outcome of the student’s learning” (Hybertsen, Stensaker, Aamodt & Mjoen., 2011, pp. 9). To ensure effective utilization of formative assessments such as the PNOA, it seems that much would rely on coherence between the school leadership system and the teaching staff.

Successful integration of a formative numeracy assessment in Norway would require a change not just in how formative assessment is perceived and embedded in the classroom but ultimately a change in the traditional educational and testing system (Bennet, 2011). Considering that the classroom teachers in this study were solely responsible for student numerical progress and assessment, a lot relies on the implicit trust of their ability to assess
student work (Hertzberg, 2008). There also may be little oversight on how or if teachers use information gleamed from formative numeracy assessments to implement measures and expectations to improve student achievement.

With the more recent focus on developing both teacher and leadership competencies in Norway, it seems that implementing shared and formative assessment tools could contribute to developing the quality of the school learning culture. The four participants in this study implied that the leadership culture in their respective schools may not support or recognize the process of formative numeracy assessment, conducted one to one like the PNOA, as adding value to the teaching/learning process.

5.1.4 Teacher Judgment

As mentioned, what to teach, when to teach it and how to adapt instruction to reach each learner requires information that is dependent on the teachers’ judgment of the learner. This can place great responsibility in the hands of insufficiently equipped or novice teachers. While using ongoing formative numeracy assessment does reveal more about the learner it does not guarantee effective instruction. It is understood there will be a variation in how teachers will implement the findings in their instructional approach to teaching and learning. As teachers have found through hard experience, the scores and associated inferences of tests and assessment are not always helpful in designing instructional interventions that support students in continuous progression (Daro, Mosher & Corcoran, 2011, pp.30). For numeracy assessment to function formatively, the results have to be used to adjust teaching and learning and continuously revisited and ongoing. Much, therefore, depends on the ability to infer adequately about what a student knows and can do with number. The success of the learning outcome is inevitably closely connected to how teachers differentiate instruction to accommodate individual zones of development, according to the assessment findings. Crucial to the formative assessment process is the ability to infer adequately about what a student knows and can do with number, and then to adapt the instruction accordingly. Bennet (2001) states,

The distinction is crucial because a failure in either step can reduce the effectiveness of formative assessment. If the inferences about students resulting from formative assessment are wrong, the basis for adjusting instruction is weakened. Similarly, if th
the inferences are correct but instruction is adjusted inappropriately, learning is also less likely to occur. (pp.14)

It is important to note that improvement in learning is contingent on the alignment of assessment, curriculum and instruction, which emphasizes common learning goals (Pellegrino, James, Chudowsky & Glaser, 2001). More specifically, it is about how the teaching approach responds to the information gleaned from the assessment to better tailor and align instruction. Many educators often have limited background and capacity to develop or engage in quality assessment practices (Herman & Gribbons, 2001; Shepard, 2001). Thus there are many perceptions of how assessment should impact learning, along with different frames of reference.

Informal debriefing sessions with participating teachers at the completion of the study indicated that the formative assessment process provided them with information they would otherwise not have known. The common answer among these participants was that it would not have been until mid-year that they would have had such a clear picture of where their students were numerically. Teachers reported feeling empowered by knowing so much so early in the teaching year. There was an evident shared value of the early insight on the students and the advantage with using the assessment twice over a span of 2.5 months, with the initial administration upon school entry. All four participants agreed that the formative assessment brought them closer to their learners. However, while learners did become more visible, there was a lack of cohesion between what was being assessed by the PNOA and what was being taught in the classroom curriculum.

A future recommendation would be that of a whole school, domain specific formative assessment tool would be implemented. This could eliminate the often, complex challenges of multiple assessments being used versus one shared process. This approach could promote a more coherent dialogue around numeracy assessment and findings for teachers to collaborate with and utilize in the teaching of early number. This collaboration is suggested as important for reducing the isolation of the teaching profession, as witnessed in this study, and key to enhancing individual teachers’ professional growth, to improve their teaching, and increase connections with other educators (Huffman & Kalnin, 2003).
5.1.5 Early Exposure

Most children who start behind in mathematics stay behind throughout schooling (Duncan, 2007). This is often due to a lack of home support, a lack of early numerical exposure and or a poor understanding of student’s numerical ability in the early grades. These limitations are felt from the primary school through higher education (John-Steiner & Mahn, 1996). Weaknesses in key number competencies underlie mathematics difficulties and these competencies can be developed early through targeted instruction. While this study did not look at early numeracy curriculum in Norwegian Barnehage (Norwegian preschool) it might be worth considering for future studies. Evidence reflects that early exposure to number is critical for later academic success. Norway has an ideal forum to introduce an early math curriculum with 95% of all Norwegian 3 year olds attending preschool (www.udir.no). Through a government endorsed early math curriculum, young learners could potentially get the exposure they need to decrease learning gaps that follow them to first grade. If properly implemented, this early curriculum could also provide first grade teachers with a more concise learning reference to assess and teach from.

We know that inadequate informal knowledge in the early years, due to lack of exposure often produces a gap. This gap follows the learner into first grade and can greatly delay or hamper the learning of school mathematics in at least two ways (a) If a teacher attempts to relate formal instruction to common everyday experiences, a child without such experiences will not have a basis for meaningfully assimilating the school instruction. (b) Inadequate informal knowledge can also prevent children from inventing informal problem-solving strategies or interfere with their efficient execution or effective application (Barody, Lai & Mix, 2005, pp. 198). In addition, numerical competencies acquired before first grade, can serve as a ladder for learning number in primary school (Jordan, Glutting & Ramineni, 2010). This early number sense can be reliably measured in young children and is predictive of later mathematics achievement outcomes (Clarke & Shinn, 2004). Research shows that targeted interventions in numeracy can have significant impact on a learner’s performance (Wright, Martland & Stafford, 2006).

5.1.6 Early Intervention, Early Motivation

Targeted interventions in numeracy can have significant impact on children’s performance and self-confidence (Wright, Martland & Stafford, 2006, pp.3). Student motivation and
confidence are critical components of the first years of school. This is evidently influenced by the teacher’s approach to the learner. By administering a numeracy assessment in the beginning of first grade in Norway, targeted intervention could be provided early for those at risk of falling behind. While summative testing and assessment have been well researched both to evaluate and measure educational programs, they do less to serve the individual learner. When teachers rely *only* on summative results to raise performance for high stakes purposes, they teach to the test, accountable for results and not for effective teaching (Pollard, Triggs, Broadfoot, McNess & Osborn, 2000). This inevitably shapes the teaching and learning dynamic. As Wells and Claxton (2002) write,

> The informal language that teachers use to comment on success, failure and difficulty embodies and conveys a view of learning and knowing which takes up residence in the learners’ minds, channeling development of their learning dispositions and influencing how their learning capabilities are expressed and developed. (pp.29)

While motivation is innate to the learner it is also shaped by the expectations of the teacher and school culture. As reflected in this small study, teacher expectations changed through the one to one exchange with the learner. The formative assessment process was witnessed to be a positive experience for the students who were eager to participate. Also confirmed was that the teachers valued the chance to be one on one with their learners.

This highlights the mutual nature of the teacher learner relationship as well as the role ongoing formative assessment could play in cultivating it. While standardized tests provide information to evaluate, they are less authentic than formative assessments and risk underestimating the pupil’s knowledge. This is because leaning on only summative assessments and results often encourages classroom cultures in which transmission teaching and highly structured approaches predominate, favoring only certain learning dispositions (Harlen & Crick, 2002, pp. 4). Steen (1990) captures this interaction by writing,

> Mathematical learning progresses in proportion to what one already knows. Hence the range of student learning grows exponentially. The further one moves up the educational ladder, the farther apart students become. In no other discipline is the range of achievement as large as it is in mathematics. (pp. 226)
Early math intervention is especially applicable to the educationally disadvantaged student because it provides the early support and adapted instructional opportunities early before the learning ‘gap’ between their peers is too wide. Mathematical difficulties are “highly susceptible to intervention” (Wright, Martland & Stafford, 2006, pp.3) and in many cases, the time dedicated to the interventions does not have to be extensive to be effective (Dowker, 2004). Given that early number competencies mediate success in school mathematics and beyond, it would be relevant to study how these competencies can be developed through early formative assessment and targeted interventions and if they change learning outcomes. Further studies could explore whether explicit and differentiated instruction in number sense can compensate for early shortcomings and if this approach increases math achievement for all in Norwegian first grade classrooms.

5.2 Conclusion

Mathematical learning progresses in proportion to what one already knows and because students who know more learn faster, investing effort and time on school mathematics often can increase the gap between the strongest and the weakest (Steen, 1990, pp.226).

Interestingly, all four classrooms in this study had a similar and diverse spread in pupil ability. This could be a reflection of the common demographics or just a coincidence. It could also reflect a typical pattern that occurs in many classrooms around the country. This pattern depicts a diverse learning landscape and may highlight the importance of recognizing learners as individuals with unique learning paths around number upon entering first grade.

The Norwegian principle of a school for all recognizes the plurality of individual differences. “When teachers are only judged in terms of their ability to get all students to jump through the same hoops they are naturally unwilling to encourage diverse individual developmental trajectories” (Wells & Claxton, 2002, pp. 207). Quality teaching of number involves the ongoing collection, synthesis, and interpretation of information about each learner.

Vygotsky’s theory advocated that learning is socially mediated first between the caregiver and the child and then between the teacher and the learner. Teachers, therefore, play a pivotal role in the trajectory of their learners throughout their formal schooling experience (Baker, Grant, & Morlock, 2008). Pertinent to this study is that what students already know, through their “prior experience” with content around number, is a strong indicator of how they will learn new information. This acquired background knowledge, is unique to each learner.
Central to this study is that learning and teaching are inseparable (Fosnot & Dolk, 2001, pp.1). In essence the entire teaching and learning experience is altered when teachers know what their learners know and don't know. The social process of formative assessment offered one to one, opens an active discourse between the learner and the teacher. The evidence garnered from the assessment can then provide a forum for more tailored expectations, clearer interpretations of the learner and a more collaborative teaching/learning enterprise (Wells & Claxton, 2002).


Greenstein, L. (2010). What Teachers Really Need to Know About Formative Assessment. ASCD.


**REPORTS:**

A Nation at Risk: The Imperative for Educational Reform. National Commission on Excellence in Education. 1983

Balancing Trust and Accountability? The Assessment for Learning Programme in Norway. A Governing Complex Education Systems Case Study


The Norwegian National Research Ethics Committee (https://www.etikkom.no/en/)


SITES:

Common Core Standards retrieved at http://www.corestandards.org


Developing Numeracy Mapping Tests for Primary Years retrieved at http://www.aea-europe.net/index.php/numeracy-mapping-tests

International Association for the Evaluation of Educational Achievement retrieved at [www.iea.nl](http://www.iea.nl)


Norwegian Early Intervention for Lifelong Learning retrieved at [https://www.regjeringen.no/contentassets](https://www.regjeringen.no/contentassets)

Vedlegg

INTERVIEW GUIDE/ SEPTEMBER 2015

Prior to interview, participants are provided with the definitions for summative and formative assessment as well as the terms differentiated instruction and numeracy.

Guidelines:

The interviewer will inform participants of the purpose of the study and how the data will be integrated into the study. The interviewee will be provided the expected length of the interview, use of recorder, transcription and confidentiality as well as offered ample time to reiterate questions or answers.

Start with a general question to orientate interview to the topic by reviewing the definitions of summative and formative assessment and the word numeracy.

I have 2 or more years of teaching experience.
YES/NO
The PNOA is my first experience using a formative numeracy assessment.
YES/NO
My main hesitation going into this study was the time the PNOA would take.
YES/NO
A big challenge in teaching is the diverse developmental needs of my students.
YES/NO
Did the PNOA data provide insight on your learners that you would otherwise not have known? How?
Did the findings of the PNOA drive your numeracy instruction? How?
Given the data garnered how will you differentiate numerical instruction?
Did the PNOA help generate a numeracy assessment culture? How?
Do you think using the PNOA has changed you as a teacher? How?
What was the most surprising finding of your experience with the PNOA?
Will you continue using the PNOA?
If you could start the process all over what would you do differently?

What do you think is the intention of the PNOA now that you are more familiar with it?

Did your findings inform your instruction?

Did you use the information to group your students?

If so how? Was this different?

How did the data from the PNOA help you identify where your students were numerically? How? Specifically gaps in their numerical knowledge?

Does the PNOA data better equip you in identifying where your students are going? How?

Do you feel empowered or more confident in identifying what steps you need to take to get your students numerically where they need to be?

Do you intend to share some of the PNOA findings with the parents of your students? Prior to the data collected from the PNOA, what information would you have on your students in a parent meeting regarding number?

With the mandate of inclusion in Norwegian schools do you feel the PNOA will assist you in differentiating your numerical instruction to meet your student’s needs?

How will you use this data to plan and shape your numerical instruction?

How might you use the PNOA data to help organize your classroom for small numeracy groups and peer mentoring?

Given the data, were there surprises in the PNOA results? Where?

How do you forecast your students performing on the PNOA in December?
How did you use the evidence garnered from the PNOA to adapt your instruction?

Did your forecast compliment the December findings?
What were the surprises in the PNOA data from September to December?

What was most useful about using a formative assessment like the PNOA?

How did using the PNOA assessment effect learning outcomes?

Is formative assessment more applicable for guiding instruction in the classroom than summative? Why?

Would you use the PNOA again to gain insight on your numerical students? What would you do differently?
Request to participate in a research project

Background and target

My name is Elizabeth Hansen. I am a Master Student in Special Needs Education at the University of Oslo. My master’s thesis will examine the experience of using the early numeracy assessment called the Primary Number and Operations Assessment (PNOA) from the USA, in first grade Norwegian classrooms. The supervisor of this study is Mia Cecilie Heller.

Participation in the research

Your teachers will be asked to administer the PNOA on all of their students within the first three weeks of school. When the assessments are complete, teachers will take part in an informal interview. This will be recorded and transcribed. This process will be repeated in late November or early December.

What will happen to the information collected?

All the data collected in this study will be confidential.

To motivate the schools to participate in this study, I will make myself available to provide support whenever necessary in the classroom. Information garnered from the PNOA can be used to guide the grouping of students, ground instruction and measure numerical growth and as a forum to provide more detailed information to parents and administration.

The names of the participating class teachers and the participating schools will not be identified in any phase of this study. Participants will not be recognized from the publications.

This project will end 30.06.16 and all the original data will then be destroyed.

Voluntary participation

Participation in this research project is voluntary. You give your consent for the participation by signing this document and have the right to withdraw from the research at any time.
This study is, according to the Norwegian practices, reported to the Data Protection Official for Research at the Norwegian Social Science Data Services and the project number is 43773. In addition, Sandi Stanhope, one of the leading founders of the Primary Number and Operations Assessment (PNOA), has provided her support, insight and the necessary materials to supplement this exploration.

Thank you again for your time and willingness to participate in this study.

With kind regards,

Liz Hansen

Master Student in Special Needs Education

Faculty of Educational Sciences, Department of Special Needs Education, University of Oslo

Email: lizhansen8@gmail.com

Mobile 97709494

Mia Heller

Supervisor of this study

Faculty of Educational Sciences, Department of Special Needs Education, University of Oslo

Email: m.c.heller@isp.uio.no

Principle Signature:

Date:
Mia Heller  
Institutt for spesialpedagogikk Universitetet i Oslo  
Postboks 1140 Blindern  
0318 OSLO

Vår dato: 14.07.2015  
Vår ref: 43773/ISRHT  
IRH  
Deres dato:  
Deres ref:

AVSLUTTER SAKSBEHANDLING

Vi viser til innsendet meldeskjema for prosjektet:

43773  
Numeracy Assessment and the Zone of Proximal Development (ZOPD)

Det fremgår av epost fra Elizabeth Hansen, datert 09.07.2013, at prosjektet er meldt to ganger. Siden prosjektet også er meldt inn under prosjektnummer 43724, avslutter vi med dette saksbehandling av prosjektnummer 43773.

Ta gjerne kontakt dersom noe er uklart.

Vennlig hilsen

Katrine Utaker Segdal

Hildur Thorarensen

Kopi:  
Elizabeth Hansen, Oscars Gate 79, 0256 OSLO