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Conveying Mathematical Experiences: The Voice of a Child with Nonverbal Learning Disability

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## **Abstract**

This qualitative research study examines a student-participant's perceptions about mathematics. Within this case study, one child with a nonverbal disability, NLD shares his experiences in a mathematics setting. The child with NLD's voice is not often reflected in the literature, as clinical research traditionally characterizes the core deficits of this learning disability. Three main questions guided this research: What does a child with NLD experience in a mathematics classroom, how does he or she conceptualize mathematics, and what are some of the strategies he or she employs in a mathematics setting?

The thematic analysis of the qualitative data gathered from observations in a classroom, interviews with the student-participant, as well as mathematics interactions advanced the generation of salient themes. The role of family, school, attitude and conversations about learning, attention and persistence, and the study of error patterns emerged as the main factors influencing the way in which a child with NLD experiences mathematics. I provide a model for conceptualizing the data collected and suggest that a child's affect around mathematics may provide considerable influence in the development of mathematics skill development. The model is supported by the behaviours exhibited by the child with NLD in an in vivo mathematics setting.

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## **Introduction:**

Children with a Nonverbal Learning Disability (NLD) are unique individuals whose experiences in the school system are as varied as is this LD subtype. NLD has received more attention in the past decade, inspiring several theoretical viewpoints that aim to explain the traits of NLD and the ensuing assets and deficits. Academic difficulties, especially in mathematics, have been documented as constituting one of the basic characteristics of this LD subtype. While many studies acknowledge the scope of the mathematics disability for children with NLD and while there are numerous pedagogical proposals as to how it might be treated, few focus on the individual child's experience in the mathematics classroom. Given that children with NLD have significant verbal strengths, this asset could be called upon to explore the mathematics learning experience. The student's voice needs to be heard by educators. In order to implement appropriate interventions in an educational environment, educators need to know the child, his/her abilities and challenges, and to attend to the unique experience of the child with NLD.

The present case study follows the path of a child in a mathematics classroom and documents his experience as he encounters his educational challenges. In a naturalistic environment, this qualitative research design aims to gain an in-depth understanding of the essence of how a child with NLD experiences mathematics. From the insights gleaned from this case study, a more thorough and perhaps intimate perspective on learning mathematics may develop. Bekerman and Tater (2005) argue that phenomenological analysis explores in detail how we make sense of our personal and social world, and consequently, the meanings attributed to the experiences affect professional attitudes. It is my hope that the solicited student-participant's experience will help

direct a more creative teaching practice, harmonize the interactions in learning centres, inspire ongoing conversations about learning, and inform future research in the area of mathematics and the NLD population. Choosing a case study design represents my philosophical view of qualitative research and will inform my research practices (Perselli, 2005).

This thesis first describes the features of the NLD syndrome and its impact on children, particularly in an educational setting. The research on NLD is evolving, as is our understanding of mathematics disabilities. The study I conducted attempts to highlight the most recent scientific views of the challenges children with NLD experience. Capturing the voice of a child with NLD in a mathematics setting is the focus of this case study. Through the analysis of the data collected, I learned more about the patterns of a child with NLD in a mathematics setting. The findings helped me to develop insights into the child with NLD's experiences and these help bring to light some of the best practices for instruction of students with NLD.

## **Statement of Problem**

For the past forty years researchers have actively pursued an accurate description of nonverbal learning disability and its subsequent etiology. While researchers have attempted to delineate the characteristics of the disability, the way in which a child with NLD processes information continues to be explored. This paper will highlight the more prominent research about NLD, particularly the core assets and deficits of the NLD syndrome. Nonverbal learning disability remains a challenge for educators as little is known about how the child with NLD experiences the educational setting. Specifically, this chapter focuses on the criteria for the diagnosis of NLD and the questions that have arisen about how a child with NLD conceptualizes mathematics.

NLD was first identified by Johnson and Myklebust in 1967 and the conception of a NLD syndrome was further developed by Rourke and associates in 1987 (Forrest, 2004). A number of hypotheses about the disability have emerged in recent years. This paper outlines the contributions of researchers in terms of their descriptions of the NLD phenotype and offers a delineated understanding of the NLD symptoms. Controversy and disagreement about NLD diagnosis continues to influence the research without a clear direction of how to treat children with NLD. A more precise view of the learning difficulty is required with research that focuses on the child's experience with this learning disability subtype. Questions remain about the essence or experience of the child with NLD and this thesis attempts to advance this inquiry.

A nonverbal learning disability (NLD) is described as a neuropsychological disability that impacts cognitive processes and, more specifically, manifests itself as a central processing deficiency (Rourke, 1989). Galway, 2004, Rourke, 1995, and Saerlier-van den Bergh, 2002)

indicate that while there is some debate about the presenting characteristics of NLD, specific expressions of the disorder have been highlighted in the current research:

- impairments in tactile-perception (i.e., poor coordination in gross and fine motor skills) which may result in delays of such skills as those of tying shoes, of holding a pencil, of catching a ball, of riding a bike, or of assembling puzzles;
- visual-spatial organizational impairments (eye-hand coordination) such as difficulties with handwriting, drawing, and copying from the blackboard;
- difficulty with psychomotor coordination (i.e., coordination of actions using sensory cues to guide motor activity) such as catching a ball or reproducing patterns in sport, dance, or art work.

Children with NLD often exhibit academic difficulties in arithmetic, written language, and reading comprehension. In particular, the student with NLD may have mathematical difficulties such as those of: aligning numbers, confusing mathematical symbols, struggling with geometric shapes, and exhibiting deficits in number sequencing and problem solving (Rourke, 1995). Written language may be a significant difficulty for some children with NLD. Gross-Tsur et al., (1995) demonstrated that in a study in which the subjects were examined using the Rey-Osterrieth complex figure test (a timed recall test that asks the subjects to replicate a complex geographic figure), the subjects exhibited graphomotor impairment in writing, specifically atypical coping strategies. While reading, spelling, phonological skills, and rote memory are strengths, reading comprehension may be compromised (Rourke, 1989). Typically, difficulties with comprehension are more apparent as the child with NLD gets older, as figurative language

and inferences can become more challenging. The contextual cues that are developed in literature may be missed as a child with NLD advances in age (Volden, 2004).

In addition to the academic difficulties, the child with NLD's socioemotional interpretations may be problematic. The socioemotional problems related to NLD are associated with the child's inability to decode nonverbal cues such as facial expression and body language. According to Telzrow and Bonar (2002), social functioning deficits often described as misinterpreting social cues, pedantic and unusual speech prosody, are also typical characteristics of the child with NLD. The child with NLD may display problems understanding jokes and sarcasm, the motives of others, and exhibit deficits in social competencies. Children with NLD may lack insight into others' nonverbal responses, and they may experience such social problems as: an inability to take the perspective of others, a misinterpretation of body language, impulsivity, or an inability to inhibit verbal responses.

While research in the area of NLD is forthcoming, it has traditionally focused on the deficits of the child with NLD rather than on his or her assets. For example, rote memory is usually superior for children with NLD, and therefore, the child is reliant on automatic verbal responses in novel situations (Telzrow & Bonar, 2002). The NLD syndrome is typically characterized by well-developed auditory perception, rote memory, verbal expression, and phonological skills (Galway, (2004), Rourke, (1995), Saerlier-van den Bergh, (2002).

Current research clarifies the rules for classifying children with NLD and assists in diagnosing the disability (Pelletier et al., 2001). Rourke (1989) estimates that only 0.1% of the population is

liable to present the NLD syndrome, with an equal ratio of males to females. The criterion most often used by psychologists to diagnose NLD was set forth by Rourke (1989): a 10-point difference between the Verbal Intelligence Quotient (VIQ) and the Performance Intelligence Quotient (PIQ) scores on the Wechsler Intelligence Scale for Children (WISC-III). However, Pelletier et al. (2001) propose more refined rules for the classification of NLD. These rules for classification may closely reflect the actual incidence of NLD as the study showcased that the criterion of a 10 point discrepancy between WISC/WISC-R VIQ>PIQ only represented 27.3 % of the subjects tested in the study (See Table 1). Their research suggests that other neurological diagnostic criteria ought to be utilized in the diagnosis of NLD. According to Pelletier et al. (2001), the rules in Table 1 would appear to be useful for clinical purposes and require further validation in a broader age range for clinical and research purposes. Nevertheless, Pelletier et al. (2001) caution that no matter how precise the criteria for classification, a comprehensive neurological assessment is the best method to understand the complex interactions of neurological assets and deficits in an individual child with NLD.

Rourke's (1989) description of NLD includes a profile of neuropsychological assets and deficits that interact with one another and influence the expression of the disorder. Rourke's (1989) NLD model (Table 2) describes the developmental stages of NLD; he postulates that primary neuropsychological assets and deficits determine the level of secondary and, subsequently, tertiary neuropsychological functions and dysfunctions. For example, if a child with NLD has tactile perceptual and visual-perceptual deficits, which he describes as essential for early learning, Rourke (1995) reasons that the child will be less likely to investigate and adjust to novel stimuli, and hence, the child's flexible thinking and problem solving abilities could be

negatively impacted. In a mathematics setting, children with a compromised visuospatial ability are more likely to experience difficulty with spatially represented information, impacting on their conceptualization of mathematics (Geary, 2004). Intervention programs tailored to the specific needs of arithmetic disability subtypes ought to be developed to meet the needs of the different neuropsychological assets and deficits of this learning disability (Rourke & Conway, 1997). Indeed, Venneri et al. (2003) concluded from their visual spatial learning disability (VSLD) study that participants with visuospatial learning disability (VLD) did not have a problem with calculation per se or number manipulation; rather, they experienced difficulty with some processes that govern calculation especially those loading on visuospatial abilities. Therefore, developing strategies to assist a child with visuospatial difficulties would require consideration of the types of on-line strategies a child is capable of employing.

According to Torgesen (2000), Rourke's NLD model has shortcomings in that the evidence for causal relationships between the specific neuropsychological problems identified in the NLD syndrome and the academic outcomes are relatively weak. Torgesen (2000) asserts that one of the limitations of Rourke's model is that it does not clearly specify how the cognitive limitations of children with NLD actually produce the primary academic symptoms. Proponents of the information-processing model believe that more efficient interventions might be employed if researchers were more aware of how the brain navigates the neural pathway to conceptualize information. A reconceptualization of learning disabilities using a self-organizing system (SOS) paradigm may help to interpret specific brain dysfunctions, and therefore, acknowledge the plasticity of the neurological system as it reorganizes to amend the dysfunction (Zera, 2001). The

theories surrounding the NLD syndrome suggest that attention to the NLD subtype and the distinctiveness of the child is paramount to the interventions employed.

Forrest's (2004) research also questions the criteria currently employed to identify NLD and asserts that Rourke's NLD Model describes a broader constellation of assets and deficits that span across disease types. Forrest (2004) suggests that only through careful psychological screening will clinicians be able to differentiate between the identifying characteristics of the NLD syndrome, the Asperger Syndrome, and high-functioning Autism. Forrest's (2004) research findings reveal that there needs to be greater specificity and differentiation among the subgroups of NLD children, as this would assist educators in better understanding the nature of the deficit and the purpose of treatment and interventions.

Questions continue to be raised about the merit of the criteria currently used to diagnose a nonverbal learning disability. In particular, delineating NLD's symptomology may be helpful in determining the impact specific deficits and assets have on reading comprehension, mathematics learning, and social learning. Cornoldi et al. (2003) believe that nonverbal difficulties are often brought to the attention of clinicians much too late for effective rehabilitation. In addition, they argue that utilizing criteria for identifying children with a specific visuospatial learning disorder (VSLD) in the absence of verbal deficits may be helpful in developing academic interventions at an early point. However, early and reliable detection of children with nonverbal learning disabilities in a classroom can be complicated as there are broad developmental outcomes at each grade, and there can be variance from child to child (Cornoldi et al., 2003).

Within the school system, children with NLD may need varied interventions in accordance with the asset and deficit complement manifested. The distinctive patterns of strengths and challenges that characterize children with NLD have inspired the compilation of interventions. Telzrow and Bonar (2002) propose that a child with NLD's primary deficits may mask the secondary and tertiary deficits. Therefore, finding effective interventions to support a student with NLD's academic performance may be challenging. Selecting an intervention based on the individual child's age, severity of deficits, degree of functional impairment, and evidence of embedded abilities may begin to address the child with NLD. In Figure 1, Telzrow and Bonar (2002) provide a list of interventions that incorporate the "deficit" track of a child with NLD. While these interventions are practical, the unique gifts and experience of the child with NLD are often not included. Learning disability research continues to psychopathologize a child with LD and consequently, assets get overlooked.

van Garderen and Montague (2003)

Little (1993) suggests that while researchers agree on core deficits that define a nonverbal learning disability subtype, they differ on the coexisting symptoms such as spelling ability, reading comprehension level, socio-emotional characteristics, and ability to solve verbal problems. A mathematics disability is often described as a hallmark of this disorder. While Forrest (2004) claims that research to date doesn't offer a coherent account of the prevalence of mathematics difficulties in the NLD profile, Rourke et al. (2000) state that 72% of children with NLD have difficulties with arithmetic, as measured by the Wide Range Achievement Test (WRAT). While clarification of the type of mathematics disability is ongoing, limited research exists that inform us on the appropriate interventions that need to be employed to assist the child with NLD in the mathematics classroom.

Despite the hypothesized link made between mathematics ability and NLD, few studies have examined the experience of the child with NLD in the mathematics classroom. To date, studies have only begun to investigate the function of visuospatial ability (Cornoldi et al., 1999), calculation abilities (Rourke, 1989), conceptualization abilities (Geary, 1993) as they relate to how a child organizes and performs tasks using mathematics. While the results imply that a disability in mathematics may develop for children with NLD, few studies document the experience of the child with NLD in mathematics settings outside the research realm. In vivo research, outside of the laboratory, may provide holistic data that could be translated into a clearer view of the child with NLD.

The case study I conducted was guided by one main objective: to examine what children with NLD may teach us about their learning experience in mathematics. Specifically, this study seeks to answer the following questions:

1. What does a child with NLD experience in a mathematics classroom?
2. How does the child with NLD conceptualize mathematics?
3. What are some of the strategies employed by a child with NLD in a mathematics setting?

Children with NLD are expected to perform poorly in a mathematics environment due to their difficulties with visuospatial representation, visual memory, and problem-solving skills (van Garderen and Montague, 2003). In this study, I observed and subsequently analyzed how an individual child with NLD conceptualizes mathematics and how strategies are extended and employed to solve problems. While it is assumed that children with LD would generally have a more negative self-concept than normally achieving children, due to academic difficulties and

even failures, the research remains inconclusive (Zelege, 2004). Studying a child with NLD in his or her natural learning setting should give voice to the child's affect. The literature review brings to light the research on NLD syndrome and how over the past thirty years delineated rules for classification of the LD subtype have evolved. As well, mathematics disabilities have received more attention in past decades, revealing a growing understanding of the mathematics learning disability subtypes. The NLD research and mathematics LD research together is beginning to expose the variability that may exist in describing a child with NLD syndrome. How a child with NLD functions in the mathematics classroom given the complex sets of assets and limitations possessed is not well known.

Researchers on NLD advocate that interventions cannot be employed unless there is a clear assessment of the child's strengths and weaknesses (Volden, 2004). More recently, attempts have been made by researchers to operationally describe the varied aspects of NLD, specifically visual imagery (Cornoldi, 2003 and van Garderen and Montague, 2003), mathematics problems solving (Owen and Fuchs, 2002) and even calculation errors (Rourke, 1987). However, little is known about the child's experience in a mathematics setting. Children with NLD cannot receive a comprehensive educational program plan if we do not understand how they experience mathematics. This study aimed to articulate the experiences of the child with NLD in a mathematics setting and, thus, amplify the voice of the learner with NLD in the mathematics setting. This is important because the assets and strengths of the child with NLD may help us learn something about the child's resiliency and his ability to execute tasks in a school setting.

The next chapter reviews the literature on NLD syndrome with a particular emphasis on the mathematics difficulties experienced by children with a nonverbal learning disability. As research emerges about mathematics disabilities, many questions remain regarding the experience of the child with NLD. This thesis explores several aspects of mathematics difficulties as they pertain to the child with NLD. Specifically, the current research on visuospatial difficulties, memory issues, over reliance on rote procedural mathematics is addressed in the next chapter. The gap in the literature on how the child with NLD learns has inspired further inquiry into the experience of a child with NLD in a mathematics setting.

## **Literature Review**

### **Introduction**

The NLD phenotype is explored in this chapter with particular emphasis on Rourke's theory on right hemisphere white matter demyelination. While research varies about the expressions of the NLD syndrome, researchers agree that the neuropathology of the brain may lead to difficulties with visuospatial abilities, that in turn may impair mathematical functions and abilities. The research on mathematics disabilities is in its infancy, with an emphasis on theory rather than on empirical evidence (Gersten et al. 2005). The emerging mathematics learning disability (MLD) subtypes are beginning to launch the kinds of mathematics interventions now being employed. There is a noticeable absence in the literature documenting what it is like for the child with NLD to navigate in a school setting when experiencing mathematics difficulties. This chapter explores in more detail NLD and its relationship to mathematics learning disability (MLD).

As discussed previously, nonverbal learning disability (NLD) is described as a neuropsychological disability that impacts cognitive processes and, more specifically, manifests itself as a central processing deficiency (Rourke, 1989). Galway (2004), Rourke, (1995), and Saerlier-van den Bergh, (2002) indicate that while there is some debate over the presenting characteristics of NLD, specific expressions of the disorder have been highlighted in the current research. NLD is characterized by impairments in tactile-perception (i.e., poor coordination in gross and fine motor skills) which may result in delays of such skills as those of tying shoes, of holding a pencil, of catching a ball, of riding a bike, or of assembling puzzles. Visual-spatial organizational impairments (eye-hand coordination) such as difficulties with handwriting, drawing, and copying from the blackboard are also characteristic of the NLD syndrome.

Difficulty with psychomotor coordination (i.e., coordination of actions using sensory cues to guide motor activity) such as catching a ball or reproducing patterns in sport, dance, or art work may be a distinguishing feature observed by the teacher of a child with NLD. Telzrow and Bonar (2002) provide a snapshot of the characteristics and indicators of NLD syndrome (See Figure 2).

Research suggests that disruptions of right-hemispheric functioning, caused by early damage to the white matter connections in the right-hemisphere, form the neurological basis of Non-Verbal Learning Disorder (Badian, 1983, Denckla, 1978, Rourke, 1995, Voeller, 1994. Rourke's (1989) proposed comprehensive etiological model for NLD is based on discrepancies between right and left hemisphere systems. The left hemisphere is postulated to be superior in analyzing and classifying cognitions into existing schemas while the right hemisphere is considered more adept at processing novel information and construction of schemas that are shared between the hemispheres (Semrud-Clikeman and Hynd, 1990). Rourke (1995) asserts that the NLD syndrome develops in circumstances that interfere with the functioning of the right hemisphere systems. Rourke (1989) suggests that the phenomenon of children with NLD may be dependent on: the amount of white matter dysfunction, the developmental age of dysfunction (stage of development could influence manifestations of NLD syndrome), and the ability of the right hemisphere to develop and maintain specific functions such as intermodal integration (how the brain receives or acquires information from a sensory mode).

### **NLD and Mathematics**

While poor mathematics ability has become a defining feature of the NLD syndrome, the specific nature of the mathematics difficulties is not well understood (Forrest, 2004). For

example, Mc Closkey and Carmazza (1987) suggest that a child may have difficulties interpreting symbols such as those found on the WRAT but still have intact mathematics processing abilities. In her study, Forrest (2004) found that mathematics abilities of children with NLD were not uniform, and the mean performance of children with NLD on KeyMath concepts (a diagnostic inventory of essential mathematics) was better than the one for children with VLD. He reasoned that these results might indicate that a child with NLD may rely on rote verbal abilities to work through mathematics problems, or that children with NLD may understand mathematics concepts but make visual perceptual errors in reading mathematics signs. To that end, Cornoldi et al. (2003) devised a shortened visuospatial questionnaire (SVS) that might prove useful to teachers in the early identification of visuospatial learning disabilities in children in primary school. However, Forrest (2004) claims that there are a number of children who meet the criteria for NLD and do not exhibit the same mathematics difficulties as children with VLD. Semrud-Clikeman and Hynd (1990) conclude that given the complex and interactive cognitive and perceptual processes involved in arithmetic, right hemisphere learning disabilities may have specific deficits associated with it. The literature in the field of mathematics is emerging, and questions remain about the screening tools that are used to identify mathematics disabilities. Mazzocco (2005) evokes some fundamental questions about recognizing mathematic disability; what is a mathematics disability, what inherent difficulties, deficits, or variations manifest van Garderen and Montague (2003) a mathematics disability, and how does it change over time? The research on valid screening is in its infancy (Mazzocco, 2005 and Gersten et al. 2005). As research on NLD develops, a qualitative review of mathematics errors made by NLD children may reveal more about this disability.

## **Mathematics Learning Disability**

In determining how one might assist a child with NLD having mathematics difficulties is no simple task, as the range of theories suggesting the root cause of the mathematics difficulties vary with each researcher. Cornoldi et al. (2003) observed that children with VLD do not have a generalized problem with calculation or number manipulation, but present specific difficulties with aspects of calculation requiring visuospatial processing. He and her colleagues argue that young adolescents with high verbal intelligence and low visuospatial intelligence presented marked deficits in a series of visuospatial working memory tasks that impact mathematics learning (Cornoldi et al. 1999). According to van Garderen and Montague (2003) pattern imagery is considered essential in mathematics problem solving (abstraction and generalization). As well, the authors report that schematic imagery was found to be related to success in mathematical problem solving (van Garderen and Montague (2003). Looking at visual-spatial ability alone, an educator may wrongfully conclude that a child with NLD may require significant interventions in this area.

Other theories about mathematics learning require some consideration when reviewing how a child with NLD performs in a mathematics environment. It has been argued that faulty conceptual knowledge could impede successful acquisition of calculation skills (Kaufman et al., 2003). While children may be able to demonstrate rote procedural knowledge, they may lack further understanding of the underlying arithmetic problem. Mazzocco and Myers (2003) judge that it is unclear to characterize NLD, as not all children with NLD reveal poor arithmetic skills, and certainly not all children with poor arithmetic have a profile consistent with NLD. Further investigation into how children with NLD call upon their rote procedural knowledge to solve

mathematical problems may reveal more about the mathematics difficulties experienced by some children with NLD.

The NCTM (1989) recognizes mathematics anxiety as a problem and has made recommendations for teachers to assess a students' mathematics disposition. The child with NLD's affect, specifically, mathematics anxiety, is another factor that should be considered in depicting the experience of a child with NLD in a mathematics setting. Furner and Duffy (2002) suggest that only 7 percent of Americans have had positive experiences with mathematics from kindergarten to college. In particular, linkages between affect or mathematics disposition and the subsequent negative impact on a child with NLD have not been explored in the literature. Research has not discussed the ways mathematics learning and testing would require strong support in order to reduce dread and stress for all children who have difficulties learning mathematics.

To understand better the role an educator may play in planning interventions for a child with NLD, more information is required about how the child with NLD learns mathematics. Forrest (2004) suggests that a review of the neuropsychological processes that underpin mathematics skill is needed to understand the incidence of mathematic difficulties. Geary (2004) asserts that the following neuropsychological abilities contribute to the development of mathematics skills: visuoperceptual, visuomotor, visualsequential memory, verbal association of sequential information, and abstract concept formation. In particular, Keller and Sutton (1991) specify that:

“Deficits in these abilities may lead to problems with decoding symbols; writing and copying numbers; appropriate sequencing and alignment of numbers; fact mastery; acquisition of the semantics of mathematics; memory; conveyance of multi-step; sequenced cognitive operations;

monitoring performance; linguistic competencies; applied reasoning; and abstract conceptual abilities” (page 9).

Rourke (1989) states that the quality of an arithmetic error may be a function of numerous variables and that we need to be mindful of such things as the presentation of a lesson, the testing environment, the type and quality of the lesson, and the developmental age of the child. Rourke et al.’s (2000) qualitative analysis of mathematics errors on the WRAT arithmetic subtest revealed that one group of students labeled HV-LP (whose verbal IQ was at least 10 points higher than their PIQ) tended to make numerous and wide ranging errors. Rourke (1989) reports that the most prevailing types are:

- spatial organization errors, visual detail errors (misreading signs)
- procedural errors, failure to shift psychological set (when two or more operations are required)
- deficiencies in graphomotor skills (crowding, illegibility of numbers)
- possibly poor memory of number facts, and judgment and reasoning errors (attempted work that is not within their expertise which leads to unreasonable solutions).

Rourke’s analysis of these kinds of errors is reflective of the child with NLD’s difficulties with visual-spatial organization, psychomotor skills, concept formation, and hypothesis testing abilities. His studies reveal that the child with NLD will have limitations in his capacity to employ pieces of warehoused information that is needed for calculations (Rourke, 1989).

The literature suggests that there are numerous considerations in reviewing the mathematics difficulties of children with NLD. Visuospatial difficulties, memory issues, and over reliance on

rote procedural mathematics are some of the areas that have fueled researchers' inquiry into children with NLD. A question that emerges from the literature is: what is a mathematics learning disability, how is it operationally defined? Dyscalculia, mathematics disability, mathematics difficulties, and poor mathematics achievement are terms that refer to extreme difficulty in learning mathematics and are the focus of many studies. Mazzocco (2005) suggests that these terms are not mutually exclusive and the literature's use of the terms is often reliant on standardized score criteria which can be limiting. While learning disabilities in mathematics have received less attention than those pertaining to reading; longitudinal studies have begun to discuss the developmental course of difficulties in arithmetic learning (Jordan and Hanich, 2003 and Montis, 2000).

Fleischner and Manheimer's (1997) research reveals that mathematics learning problems are as prevalent as reading disabilities. In fact, it is suggested that between 5 and 6 percent of school-aged students have significant difficulty with learning mathematics (Fleischner and Manheimer, 1997; Mazzocco and Myers, 2003; Geary, 1993). In reviewing the extensive research on reading disabilities, Mazzocco and Myers (2003), states that it is not surprising that reading disabilities are better understood than mathematics disabilities. Fleischner and Manheimer (1997) disclose that most school-identified students with learning disabilities have academic achievement deficits in both mathematics and reading. Geary (2004) asserts that recent studies using experimental measures, other than standardized tests to determine deficits associated with dyscalculia found that 5% to 8% of the sample exhibited some form of mathematical learning disability (MLD) with a comorbid disorder such as reading disability (RD) and attention-deficit hyperactivity disorder (ADHD). Recent literature examines the role reading level has on

mathematics achievement. Jordan and Hanich (2003) suggest that differentiating between mathematics difficulties with normal reading and mathematics difficulties with comorbid reading difficulties is necessary, as children with mathematics difficulties-only tend to use their strengths in reading to compensate for weaknesses in mathematics. Mathematics learning disability (MLD) refers to children with low achievement scores relative to IQ and children with low achievement in both mathematics and reading are children identified as MLD/RD (Geary, 2004). Mazzocco (2005) cautions that while standard scores are currently used in the field of mathematics study, children with sufficient compensatory skills may perform average on achievement tests despite underlying MLD. Geary (2004) actually suggests that low mathematics achievement scores, used as a screener to identify children with mathematics disability (MD), should not be used as a diagnostic marker. His research reports that the 25<sup>th</sup> percentile cutoff on a mathematics achievement test, the typical criterion for diagnosing MLD, does not reflect the actual number of MLD. In fact, Mazzocco (2005) discusses the use of varied measures to tap both formal and informal mathematics ability as a complement to standardized achievement tests. More recently, Fuchs et al., (2005) posit a model for realigning the measures for identifying learning disabilities which involves documenting the child's inadequate response to intervention.

Because students with various learning disabilities are integrated into the regular classroom, the types of cognitive strengths and weaknesses that children possess will impact the learning process in the mathematics classroom. An emergent body of research on the characteristics of students with mathematics disability (MD) has contributed to the understanding of the struggles students have with mathematics (Bryant, Bryant, & Hammill, 2000). Geary (1993) postulates

that core components of cognitive and neuropsychological research may explain the deficits in mathematical disabilities.

Geary (2004) posited an organizational framework for research that may assist with the understanding of MLD (See Figure 3).

**Figure 3 - Framework for the identification and study of potential learning disabilities in mathematics (Geary, 2003)**

<b>Mathematical Domain</b> (e.g., Base-10 Arithmetic)			
<b>Supporting Competencies</b>			
<b>Conceptual</b> (e.g., base-10 knowledge)		<b>Procedural</b> (e.g., columnar trading)	
<b>Underlying Cognitive Systems</b>			
<b>Central Executive</b> <b>Attentional and Inhibitory Control of Information Processing</b>			
<b>Language System</b>		<b>Visuospatial System</b>	
<b>Information Representation</b>	<b>Information Manipulation</b>	<b>Information Representation</b>	<b>Information Manipulation</b>

This framework has led to a preliminary taxonomy of three MLD subtypes (See Table 3). The MLD subtypes are: procedural, semantic memory, and visuospatial. These MLD subtypes may help explain the delays or the deficits exhibited in children with NLD. Geary (2004) reports that procedural errors committed by children with MLD may be due to the use of developmentally immature strategies (e.g. finger counting) and primitive problem solving procedures (e.g.,

counting all). Working memory has also been implied in poor execution of mathematics procedures as well as poor conceptual knowledge (understanding of the concepts underlying a procedure). Studies have shown that intact working memory function can predict solution accuracy of mathematics word problems independent of other measures of fluid intelligence, reading skill, knowledge of algorithms, phonological processing and others (Swanson and Beebe-Frankenberger, 2004). Visuospatial subtype is described as having difficulties in spatially denoting numerical and other forms of mathematical information and relationships. Geary (2004) suggests that the relationship between visuospatial competencies and MLD require further exploration.

Geary and Hamson (2000) found that many children experiencing mathematics difficulties are not stable over time; in fact, some difficulties are not evident from grade to grade and others are simply misdiagnosed. Gersten et al. (2005) suggest some goals for mathematics intervention:

- increased fluency and accuracy with basic arithmetic combinations;
- development of mature counting strategies (magnitude comparison and number line use);
- integration of procedural and conceptual knowledge in mathematics (embedding teaching of concepts in procedural work);
- using structured peer work centres;
- problem solving instruction using schema-based strategy instruction.

To date, the evidence doesn't suggest one best way to develop proficiency in mathematics. Differentiated approaches to teaching mathematics may work best with each MLD subtype. Research into the role of the teacher in the creation of effective and strategic mathematics

learning environments is necessary (Butler et al., 2005). Clearly, researchers are on the cusp of understanding the MLD subtypes, and therefore, the development of specific interventions for MLD is evolving. Presently, learning more about how a child with mathematics difficulties applies strategies may help in the development of mathematics interventions specific to the NLD subtype. This case study anticipates learning more about the successful and unsuccessful mathematics strategies employed by a child with NLD.

Much of the research has relied on adult interpretations of student reasoning and test performance, resulting in new and innovative ways to conceptualize mathematics learning. Simons (1996) believes that experience is the basis on which we construct meaning and this is contingent on our ability to negotiate the qualitative world we live in. In order to learn more about how children and adolescents negotiate the world of mathematics, researchers need to ask the question, how do they know when they know (Garii, 2002)? A description of a child with NLD's experiences about his own learning may be a noteworthy piece of the puzzle that could move us toward understanding how a child with NLD interacts in a mathematics environment.

This study explores the experience of the child with NLD beyond the assessment results found in a laboratory. The emerging research on mathematics disability reveals that mathematics disabilities are just beginning to be comprehended. The following chapter describes a case study design that permitted me to learn more about the child with NLD who experiences difficulty with mathematics. The research methodology and rationale for using qualitative research will be described. I present the value of representing the voice of the child with NLD and illustrate how I plan to convey the child with NLD's experiences in a mathematics setting.

## **Methodology**

### **Introduction**

Distilling the research on NLD has produced numerous arguments about the characteristics of the child with NLD. These characteristics have led many researchers to hypothesize about the child as a learner and his functional abilities in a mathematics setting. The voice of the child with NLD has rarely been audible in the research findings. Gleaning a clearer view of the child with NLD in a mathematics setting is the purpose of this research. A case study design was chosen as field research captures the more contextual interaction between the student-participant and his situation and surroundings. The following research questions direct the goal of this study:

1. What does a child with NLD experience in a mathematics classroom?
2. How does the child with NLD conceptualize mathematics?
3. What are some of the strategies employed by a child with NLD in a mathematics setting?

I attempt to unravel the experiences of a child with NLD in a mathematics classroom as I look for acceptable answers to these questions. This case study explores the child with NLD in typical learning environments: the mathematics classroom and the mathematics resource setting. In presenting a rationalization for the case study research, I outline in detail the research design plan and provide justification for the instruments, treatments, sample size, and data collected and analyses. It is hoped that this case study design provides a rich and contextual account of the phenomenon being studied, the experience of a child with NLD in a mathematics setting.

Smith (1999) asks the question: “what constitutes good research?” According to Smith (1999), this is an important question to consider because often research has informed policy, and historically, policy has marginalized minority populations. Choosing a research method that

helps us to learn more about a child's view of his experience within a school setting is essential, since, historically, a child with a learning disability has experienced disparity in the educational system. Gordon et al. (1999) acknowledges the disparity that exists for students based on the definition and diagnostic criteria of LD. Roer-Strier (2002) suggests that Western psychology has conceptualized LD in terms of persons with "deficits" and "social emotional issues" and refers to this population as the "excluded population". Smith (1999) contends that "Western research has not been neutral in its objectification of other". For example, historically, cultural research about indigenous people, such as the Maori, resulted in problematic relationships since Western researchers often interpret language and culture from a Western, English view point. Today the Maori people articulate a clearer view of themselves, and, inevitably, this leads to activism and self-determination (Smith, 1999), which in turn contributes to the Maori's quality of life. Similarly, researchers treat children with disabilities as "others", and they are often compared to "normally achieving" children. Consequently, the deficit model of viewing children with disabilities biases the interactions and expectations educators have with the so-called, "learning disabled child". Children with disabilities are injured by the LD labels and the expectations that develop from the branding of LD. In fact, Valas (2001) reports that empirical evidence suggests that inferior social skills of adults with learning disabilities was more likely to be due to poor self-concept caused by social alienation and exclusion resulting from LD labels than due to deficits in cognitive processing resulting from the disability itself.

According to Smith (1999), quantitative research tends to distance itself from the reader and perhaps lead the reader to hold myopic views. Because children with disabilities have often been researched and defined outside of their lived reality, this case study approach enables me to represent the day-to-day educational processes for a child with NLD and the influences

institutional structures have on the child (Bromely, 1986). As a school psychology student, I am cognizant of the values and belief systems embedded in the helping profession and recognize how the psychopathology of a disability may lead to biases about the child's performance. Acknowledging the differences between social injustice and individual psychopathology assists me in better understanding the distinction between the perceived psychopathology of a person from the disorder (Sanchez and Fried, 1997). This qualitative research design gives voice to the child with a nonverbal learning disability with the purpose of contributing to a broader way to conceptualize the learner with a nonverbal learning disability.

Qualitative research has several philosophical roots that guide the data collection and analysis (Yin, 1994). Within an individualist theoretical orientation, interpretive research in education is a process that highlights the lived experience of an individual in a school setting (Merriam, 1998). A case study is neither a data collection mechanism (e.g. survey) nor simply a research design (e.g. statistical results); it is a comprehensive research strategy that incorporates the person being studied (Yin, 1994). Case studies rely on several sources of evidence to cross-reference the emerging data. The case study has been popularized as an acceptable form of educational evaluation and educational research as it offers many opportunities for the discovery of unknowns (Simons, 1996). While educational policy makers tend to respond to scientific data that is quantifiable, case studies may highlight the differences between quantifiable and qualitative and are more likely to discover new patterns on which to base educational change (Simons, 1996). Understanding the individual characteristics a child with LD exhibits is as important as knowing the number of children with LD, as both will specifically influence classroom planning.

The case study design is prevalent in the field of education and is used to achieve an understanding of a single entity and to create meaning from it (Merriam, 1998). Bromley (1986) suggests that a case study's function is to gain an in-depth understanding of an individual's experience with the goal to reveal important contextual factors and unintended consequences that might not be noticed in a more quantifiable research design. Critics of positivism suggest that Western research often only values categorizing, comparing, and evaluating through the eyes of a Western system of representation (Smith, 1999). Therefore, within this case study, the child's differences were honoured; his voice provided an account of how a child with NLD conceptualizes numbers, space, and time.

The case study can reveal a singular, naturally occurring event in the real world (Bromely, 1986). Studying a child in a classroom setting over a relatively short period of time as he engages in learning mathematics is worthwhile as it provides an understanding from the perspective of the insider. With a case study research design, I was interested in learning about how the NLD child learns mathematics in a classroom. With the help of the child's narrative, the student becomes the teacher in that the student's voice becomes a powerful instrument that informs interventions. Recent educational research has investigated the notion that mathematics learning may be associated with "situated learning"; that is, that mathematics problem solving is frequently linked to a situation or context in which it takes place (Boaler, 1998). Studies have focused on showing that school-learned methods of mathematics computation is often not transferable to non-school situations, and that indeed, the incorporation of mathematical skills is more dependent on the context or situation in which mathematics is used (Boaler, 1998). If personal experience, enjoyment, and even motivation to use mathematics promote the use of procedural mathematics,

then a case study research plan helps to reveal the “situated learning” phenomenon. Padilla and Martinez (2005) explore the beliefs that personal experience is a legitimate source of data and insight into the social world. They explain that a personal story may have significant heuristic value in that it stimulates reflective dialogue. Losh and Capps (2003) suggest that narrative not only represents a communication tool but also represents a necessary mechanism for making sense of experiences and relationships. Narratives can shape people’s social action. Because there is no existing theory extensively quantifying how a student with NLD learns mathematical concepts in the classroom, a case study design helps to scaffold the present interpretation of this phenomenon.

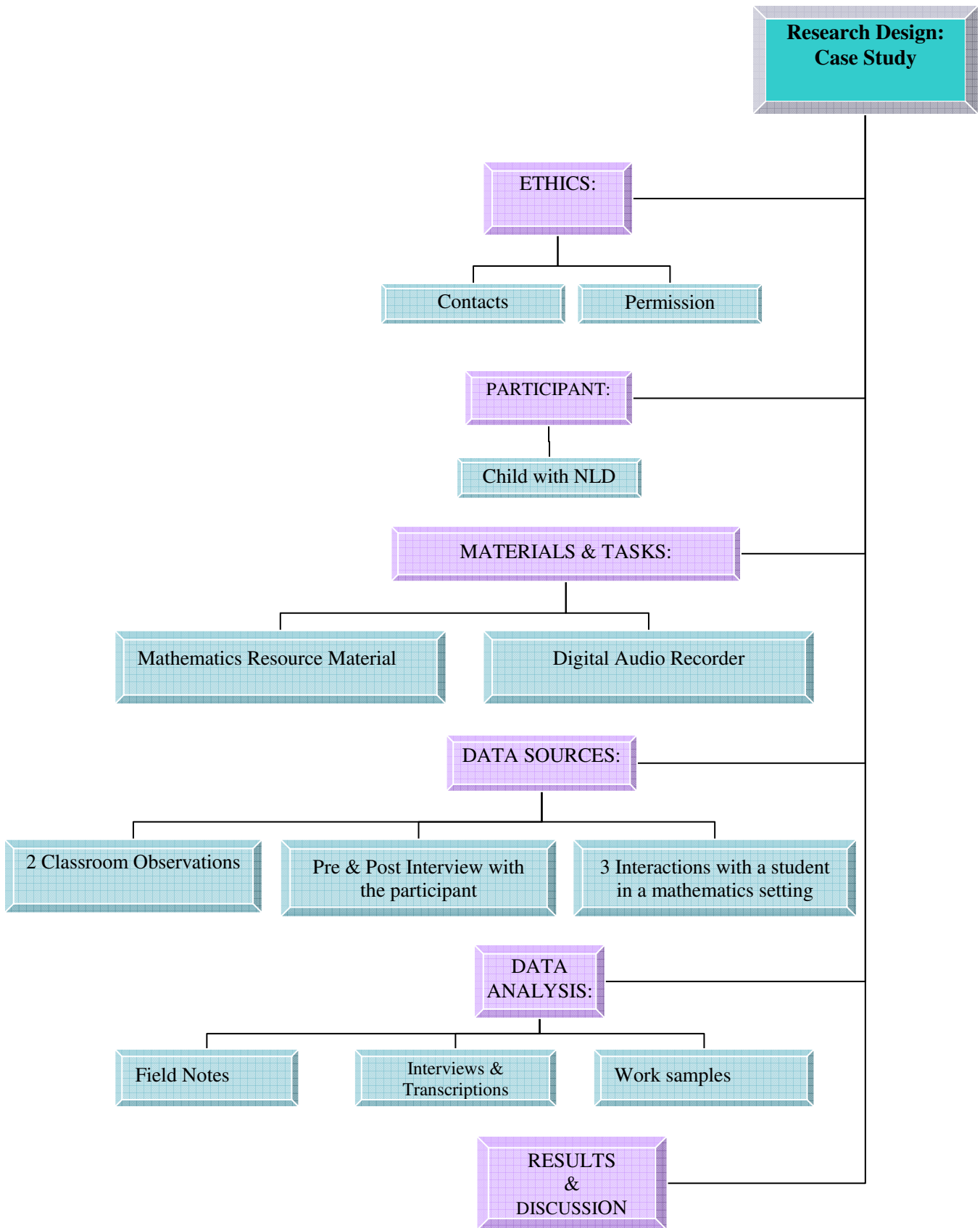
The literature on mathematics learning disabilities reveals that many processes are involved in the learning and utilization of mathematics facts. Research on the relationships between visualization, memory, calculation, decoding, and problem solving varies. Understanding the individual learner and the range of skills the student brings to a mathematics classroom is essential in facilitating a positive learning experience. Through a case study research, I explored the experience of a child with NLD in two mathematics settings and transcribed the data so that a broader appreciation of the child’s ability in a mathematics classroom was documented.

### **Research Design**

A case study of an individual student with NLD in the mathematics classroom was used in order to gain insights into the child’s experience. The data collected helped to formulate interpretations about the child with NLD. The case study focused on a single phenomenon and uncovered the interactions and features of the phenomenon. Within this case study, I planned to interact with a

child with NLD in his classroom and within a mathematics resource setting. Spending time observing and interacting with a single child in a mathematics setting is a bounded study which helps to solidify the interpretations of the study. The study of a child with NLD facilitates and documents the non-obvious and counter-intuitive occurrences that may be missed by an empirical research approach, and this unique approach is essential for understanding the human experience (Merriam, 1998). The phenomenon under consideration included the child's experience conceptualizing mathematics, how the child problem solved, and his sense of his power within a challenging educational setting. In this study, I collected purposeful qualitative data that concentrated on discerning what occurred and the implications of what occurred for this child with NLD in the mathematics setting.

To elicit a significant understanding about what a child with NLD teaches us about the learning experience in mathematics, the research questions stated in this chapter are explored. This case study focused on the learning process of the child with NLD. It was the intention of the study to work with one child with NLD in his natural mathematics setting: the classroom and the mathematics resource setting. Through observations, interviews, and interactions with the child with NLD, I gathered qualitative data about the child's experiences with mathematics. The analysis of the data provided a broader framework in which to view the child with NLD. Included is a flow chart (Figure 1) of the steps involved in the data collection.



**Diagram 1 - Schematic Representation of Research Design**

## **Selection of the Student-Participant**

Purposeful sampling helps to gain insight into the phenomenon and, therefore, the participant selection is a sample from which the most can be learned (Merriam, 1998). Conducting an information-rich case study such as this provides the basis from which I learn what a child with NLD can teach us about the learning experience in mathematics setting. Based on the time and geographic restraints and the potential challenges in finding documented samples of a child with NLD, a network strategy was employed to identify potential student-participants. In accordance with a Nova Scotia school board's protocol for research, principals in a Nova Scotia school board district were invited to assist in the identification of potential student-participants for this case study. In keeping with the Mount Saint Vincent University (MSVU) policies and procedures for ethical research involving humans, every effort was made to grant respect for the youth participant by ensuring that informed consent was acquired, that the student-participant was guaranteed privacy and confidentiality, and that the benefits of this research project were maximized.

The criteria used for the selection of the student-participant are shaped by the nonverbal learning disability syndrome and the associated difficulties with mathematics. The student-participant in the case study was a child diagnosed with NLD. Because children with NLD often experience difficulty in mathematics, the student-participant is a child with NLD who receives school-based mathematics support in and out of the classroom. During a three-week period, the student-participant in this study was interviewed, observed, and participated in mathematics interactions within a designated mathematics resource setting. This structured time with the student-participant provided the opportunity to collect the data of the child's experiences with

mathematics. Fuchs et al.'s (2005) research findings support the efficacy of preventative tutoring as a supplement to regular classroom instruction on computation, concepts/applications and on story problems. According to the NCTM Principles and Standards for School Mathematics, the concept of equivalence is one of the key ideas in the grades 3–6 mathematics curriculum. Specifically, equivalence is a central theme for students studying rational number concepts as they relate fractions, decimals, and percents (NCTM, 1999). Butler et al., (2003) states that according to the NCTM Standards, in grades 3-5 all students should develop an understanding that fractions are parts of unit wholes, incorporate models to judge size of fractions and generate equivalent forms of commonly used fractions, decimals, and percents. Because equivalence is often a challenging concept for children with mathematics difficulties, exercises on equivalence were used as a medium to encourage interactions with the child with NLD. The student-participant for this study was in Grades 5, at which time the concept of equivalence is central to mathematics learning.

Permission to conduct the study was obtained from a Nova Scotia School Board (See Appendix B). A Nova Scotia School Board was asked to support a network strategy which petitioned principals from a geographic area to contribute to the selection of a student-participant. Letters requesting principals' permission to conduct this study were sent to a specific geographic area within a Nova Scotia School Board (See Appendix B). The letter to the principals included a flyer (See Appendix D) that was distributed to parents of possible qualifying student-participants who have a NLD diagnosis. Once a student-participant who met the criteria was identified by the network strategy, a letter requesting parental and participant consent to participate in the case study was issued (See Appendix B). If more than one student-participant was willing to take part

in this study, the child who most closely met the criteria (a NLD diagnosis, receiving mathematics resource assistance in or out of the classroom, in Grade 4-6, and a school location that is readily accessible to the researcher) was to be chosen.

The participant and parents in the study were assured of confidentiality and anonymity for their involvement in the case study. All personal identifiers to the person and identifiers of the School Board were omitted from the text of the thesis. The student-participant had the right to refuse to answer questions at any time and to terminate involvement in the research at anytime. The research case study design took place in a school setting where minimal risk to the student-participant was the foremost goal.

Upon receipt of permission from a Nova Scotia School Board, a school, and subsequently, the consent of the participant and his parents, the study was conducted on the school site, over a three-week period. The study took place in a mathematics resource setting and in the classroom of the Grade 5 student who had been diagnosed with NLD by a registered Nova Scotia school psychologist. Adhering to the school schedule ensured continuity for the child, with little interruption to the child's educational schedule or risk to his learning process. The data collection occurred during 40-minute periods, so as to be consistent with the student's scheduled timetable. Being consistent with the student-participant's experience in school legitimized the rhythm and flow of the phenomenon I aimed to comprehend. Merriam (1998) suggests that aligning the case study research with the student-participant's school routine helps to build a rapport with the student-participant. By preserving the school routine of the child with NLD, the child's sense of privacy is maintained and any undue stress is prevented.

## **Materials**

In reviewing the Atlantic Provinces Education Foundation (APEF) curriculum documents, grade primary is the level at which fractions are normally introduced to children and are then developed across the elementary grades. The learning material that was used for the three one-on-one mathematics resource sessions focused on the concept of equivalence and, therefore, influenced the rationale for the selection of a student-participant in this case study. For these reasons, a Grade 5 student with NLD was considered an ideal student-participant, as the concept of equivalence had been previously introduced and reinforced in the curriculum (i.e., before Grade 4).

The Nova Scotia Primary-3 and 4-6 Mathematics Curriculum Guides provide a progressive map of the mathematics outcomes. Because the Nova Scotia mathematics curriculum outcomes are hierarchical, it is important for students to meet the outcomes at one grade level before they proceed to the next grade level. I relied on the mathematics teacher's direction to choose specific mathematics equivalence outcomes for the student-participant. Specifically, in collaboration with the mathematics teacher, I reviewed and validated the appropriate match of the student-participants' mathematics learning needs with the appropriate learning resource materials. The Nova Scotia curriculum guides suggest that by using multiple representations of the mathematics concepts (e.g., symbolic, concrete, diagrams, written) a student may avail himself of opportunities to meet outcomes. With this in mind, mathematical manipulative devices such as: Cuisenaire rods, cubes, graph paper, and pie charts were made available as supportive material that were incorporated into the mathematics resource interactions. Butler et al., (2003) cautions that there are a number of challenges associated with using manipulatives e.g., managing the dissemination and collection of the devices, providing adequate workspace, ensuring appropriate

number of devices, monitoring the accuracy of student's performance and managing students' behaviour within the classroom.

As there is no specific "grade level resource product" for students who are struggling with mathematics, I incorporated mathematics exercises that are in keeping with the philosophy that in order for students to be successful in mathematics, they must be working at their cognitive level. I drew from John Van de Walle's book, *Elementary and Middle School Mathematics: Teaching Developmentally*, to provide learning opportunities for the student-participant. Van de Walle's teacher resources (TR) match the new mathematics books presently used in Nova Scotia schools. The Van de Walle teacher resources provide teachers with insights and strategies to overcome common misconceptions about mathematics, with extra support, and with extra practice and extension. Because Van de Walle's teacher resources correspond to the Nova Scotia mathematics outcomes, the integrity of the student-participant's mathematics resource setting was maintained.

### **Instruments**

In keeping with the goals of qualitative research to gather data about the experiences of a child with NLD, two semi-structured interviews (See Appendix C) were developed by me and are an amalgamation of structured and semi-structured questions which permitted me to respond to the student-participant in the moment. The emerging ideas and experiences expressed by the student-participant during the interviews directed the interview process. In order to glean as much about the learning process as possible and to capture the student's voice, both the pre and post interviews included open-ended and semi-structured questions. The familiar language

incorporated into the questions ensured that the Grade 5 child understood the questions and was able to respond by reflecting on his experiences. The interviews helped me to grasp the child's feelings, thoughts, and ideas about learning and to appreciate his experiences in a mathematics learning setting. Both the pre and post interview questions consisted of a small number of structured questions and several semi-structured questions which aided me to assemble information about the mathematics experience (See Appendix C). During the interview, I was guided by the response of the child with NLD and the rapport that developed between the child and me. The questions were reviewed and validated by the Grade 5 teacher of the student-participant.

The interviews were free of judgment, encouraged the student-participant to respond to open-ended questions, and promoted trust building. The types of questions I had formulated were: hypothetical, ideal position, and interpretive. Hypothetical questions ask the student-participant to speculate and help the researcher to obtain descriptions of the student-participant's actual experience. Garnering an opinion is an example of an ideal position question. Eliciting the student-participant's opinion yielded both positive and negative evaluations of the mathematics program. Interpretive questions were used as they advance more tentative interpretations of what the respondent is saying. Interpretive questions helped me to verify my understanding of what was shared in the interviews. According to Merriam (1998), hypothetical and interpretive questions reveal more information, opinions, and feelings. While the sketch of questions enclosed outlined the kinds of questions I asked, being flexible with my questioning was important. Any additional questions that resulted from the interaction with the student-participant were recorded and enclosed in the field notes. Leading questions or closed questions were

avoided as they reveal a researcher's assumptions. The integrity of qualitative research is established by understanding and appreciating one's own experience as a researcher. As a MSVU researcher, my experience directed the data collected, and therefore, the choices I made about question selection. The data analysis section below addresses this in more detail.

### **Data Collection**

Data was collected over a three-week period. The child was observed in two mathematics settings: the classroom and the mathematics resource setting. The case study began with two observations in the classroom during mathematics instruction. This helped me to learn more about how the student interacted, solved problems, and performed mathematical skills in the larger setting with his peers. Following the observations, the child was asked to participate in a semi-structured interview at the beginning of the first mathematics interaction to learn more about him and to build trust and a rapport. The two successive interactions around mathematics were planned in a mathematics resource setting, where I observed and assisted the student in learning the concept of equivalence. The three interactions were an opportunity to learn more about how the student-participant conceptualized mathematics, solved problems, and utilized strategies to complete tasks associated with equivalence. At the end of the third interaction session, a post interview was conducted to gather additional information from the student-participant and to reflect on the time spent between the student-participant and this researcher. The final session was a time to bring closure to the interaction and to terminate the relationship between student-participant and this researcher. Because this case study was a time-limited resource interaction, a ritual goodbye was planned to explore feelings and to terminate the relationship. A ritual goodbye, as outlined in the parental consent form, was given to the student-

participant in the form of a children's book, *Dogs Don't Tell Jokes*. This story describes a young boy's accomplishments and his sense of humour. A note of thanks from the researcher was placed on the inside cover of the book (See Letter of Consent, Appendix B).

Data was collected in the classroom and in the mathematics resource setting. The three interactions undertaken in the mathematics resource setting were recorded using a digital audio recorder. This data collection practice ensured that the salient pieces of information with verbatim transcriptions were readily accessible for analysis. The classroom observations helped to provide context of the experience of the learner with NLD. As a researcher-observer in the classroom, I minimized my intrusion by being introduced to the Grade 5 class as a MSVU student studying the learning of mathematics. Within this stance, I had better access to a wider range of information about the student-participant's experience in the mathematics classroom. According to Merriam (1998) this stance establishes an insider's view as it is a way to observe the members of the classroom without becoming a member of the group.

In the role of researcher-observer, I collected data in the mathematics classroom. I interacted so as to establish an insider's identity without becoming an active group member. Systematic observations produced field notes and sketches. The systematic observations were used in conjunction with interviews, mathematics interactions, and document analysis. Systematic observations were conducted to triangulate the emerging research findings so that findings were substantiated (Merriam, 1998). Classroom field notes with factual observations recorded the interactions, activities, and conversations of the student-participant. I also recorded the interaction in the classroom between the teacher and the student with NLD and between the

student with NLD and other students. The classroom field notes helped to reformulate the composition of the child's mathematics classroom for data analysis. The factual observations also helped to develop an initial interpretation of how the child with NLD functions in the classroom setting. The field notes contained a sketch of the classroom and the seating arrangement. Descriptions of the setting, the number of students, and the classroom activities, as well as any actual discourse between the student-participant and members of the class were recorded.

A field work journal is often a product of qualitative study. My field work journal contained: a sketch of the classroom observations, field notes, samples of mathematical assignments, schedules of resource interactions and any other observation comments (OC). As well, the field work journal contained memos of questions that may pertain to data analysis.

Within the mathematics resource setting, I also played the role of researcher-participant. Through the mathematics resource setting interactions I examined how the child conceptualized mathematics, utilized intervention models, and operationally defined mathematics problems. The data contained conversations about mathematics problem solving and actual samples of the student-participant's mathematics work sheets. The field notes from each session helped to shift my lens as an observer to the more salient notions about the learner with NLD. The data that emerged through the mathematics interactions generated interpretations and confirmed insights about the way the child with NLD learns. Collecting samples of the student-participant's work during the mathematics resource sessions provided the documentation necessary to perform an

error analysis that further supported understanding of how the child with NLD conceptualized mathematics and solved problems.

As a researcher-participant and a researcher-observer, I became familiar with the phenomenon being studied. The digital audio recordings of each session are an analogue of the exchanges and may inform the degree of objectivity from which the interactions occur. Merriam (1998) suggests that the interdependency between the observer and the participant brings about changes in both parties' behaviours and that it is important to be able to identify that effect. To account for how the researcher-observer impacts what is being observed, it is important to document and integrate interpretations into the data.

During the mathematics resource setting, documents and samples of the student-participant's work in mathematics were collected and used to supplement the information gathered from the interviews and classroom observations.

### **Data Analysis**

Data analysis is a process of making sense of the data collected. The data derived from the interviews, field observations, reflective memos, report card, and documents about the student-participant's experience in a mathematics setting may present similar, disparate and even incongruent information. The data needs to be organized into a case record or data base. The case record includes sorted information, with segments of data organized thematically or chronologically. Once the information is organized into a case record or data base, the researcher may use this structure to draw from when beginning intensive analysis of the data.

In this case study, a phenomenological analysis of the data involved ferreting out the essence of the examination of the child with NLD. By using a constant comparative model of analysis, segments of data (e.g., a comment about mathematics) were compared with other similar incidents, forming a tentative category, which was then compared with other data. The categories reflect the research purpose and provide the answers to the research questions. Working with the data elicited the development of a hypothesis about the experiences of a child with NLD in a mathematics classroom.

The process of validly exploring and evaluating the data collected occurs when a researcher begins to put aside his or her biases and the assumptions that have been made through the literature about a learner with NLD. Sketching the child's experiences in a mathematics environment occurs by viewing the phenomenon from different angles. Documenting the perspective of the child in the classroom, in the mathematics resource setting, with his peers, through his actions, words and work, outlines how the child with NLD conceptualizes mathematics, utilizes mathematics strategies and feels about the process. Through documentation of the student-participant's interactions, I learned about the child's view of learning mathematics. By reviewing the content of the interviews, field notes, and other documents, I looked for patterns of meaning that helped me capture relevant characteristics of the learner with NLD.

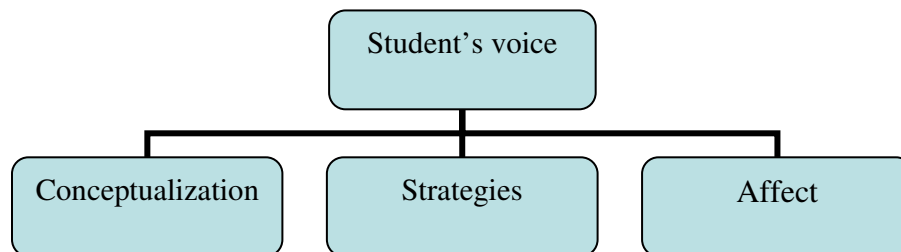
Through triangulation, multiple sources of data confirmed emerging findings about the phenomenon and assisted me in generating plausible explanations about the phenomenon. During the mathematics resource session, analyses of the errors resulting from the mathematics exercises assisted me in learning more about how the child with NLD draws on mathematics

strategies. At the end of the mathematics resource sessions, member verification occurred, where I brought some of the tentative interpretations back to the child to check for plausibility. For example, if the child reflected an attitude or feeling about mathematics, I reflected the feeling back to the child to validate any inferences I might have made. By meticulously documenting the case study process and the consistency of findings about the phenomenon, I am able to offer reliable inferences about the phenomenon.

Insights revealed from the data helped to amplify the child's voice; that is, I was able to respond to the research questions: What does a child with NLD experience in a mathematics classroom? How does the child with NLD conceptualize mathematics? And, what are some of the strategies employed by a child with NLD in a mathematics setting?

The data collected showcases how he abstracted meaning from mathematics and how his experience in a mathematics setting impacted his emotional responses. (See Figure 4).

**Figure 4** – What Data Analysis Revealed



## **Results and Discussion – Making Meaning from the Narrative**

### **Introduction**

The student's voice is the entity that is featured in this chapter. This chapter contains the outcome of the study and provides an account of the analysis and interpretations of the data. Methodically organizing the results helped to convey what was learned through the engagement with the child with NLD in a mathematics setting.

Case studies permit a researcher to cast a broad net for data collection that may yield an intimate view of the student-participant. A study of a child with NLD was conducted to provide contextual knowledge of the phenomenon being studied: the examination of a child with NLD in a mathematics setting. The purpose of the case study was to discover how a child with NLD navigates in a mathematics setting, and more specifically, how he conceptualizes mathematics, employs mathematics strategies and how the mathematical experiences impact him. Within an educational setting and through mathematics interactions, I observed the student-participant solve problems, recorded his views about mathematics, and summarize the findings in this chapter.

A case study was chosen because it allows the researcher to uncover information about the phenomenon that might not otherwise be accessed. Merriam (1998) suggests that there is no one guideline as to how to report the basic findings of what was learned about a phenomenon. Observations, impressions, interactions have influenced the choices of what I report on here. This report emerges out of the data collected from my daily interactions with a child with NLD and, therefore, planned and unplanned data are included. I supply a descriptive context of where

the study was conducted as well as a general description of the student-participant. I enclose an overview of the findings in this chapter. Chronologically organizing the qualitative report is purposeful as each mathematics interaction shaped the student-participant and observer-participant response and the subsequent themes that emerged. Other relevant themes are included. By presenting the categories in a narrative format, I supply particular descriptions, general descriptions, and interpretive commentaries. Particular descriptions consist of quotes found in notes and interviews. I include general descriptions to tell the reader whether the quotes or narratives are typical of the data. I also present an interpretive commentary to supply a framework to the reader for the general descriptions. To demonstrate reliability, transcripts and samples of work of the most pertinent interactions are included. Erickson (1986) suggests that maintaining a balance between particular and general descriptions might be achieved if interpretive commentary is supplied to indicate the salient points of the data analysis and the interpretation of these themes.

This case study used more than one method of data collection; interviews, interactions in a mathematics setting, and observations were used to facilitate the triangulation of the emerging findings. A single official document was reviewed: the student-participant's psycho-educational assessment. Report cards and teacher comments about the student-participant were not solicited as the information could have biased this researcher's views about the student-participant's conceptualization about mathematics before undertaking the study.

Four sources of data were relevant to this case study. First, the confidential file that contained the psycho-educational report and a letter from a psychiatrist were documents that supplied proof of a NLD diagnosis. Second, the observations in the mathematics classroom helped to bring

context to how the child with NLD learns in a mathematics environment. The observations also helped to demonstrate how a child with NLD navigates in a mathematics setting with a dozen or more children all around. Specific attention was paid to the level of distraction in the classroom and the interactions between the child and the other students. Third, the interviews with the student-participant helped to make audible the voice of the child with NLD. Structured and semi-structured questions permitted me to respond to the student-participant in the moment. The interviews helped to extract some of the child's feelings, thoughts, and ideas about learning and his experiences in a mathematics learning setting. A fourth source of data was the recordings of the mathematics interactions between this researcher and the child with NLD. This data provided insights into the child's learning processes and the strategies he employed to solve problems.

Permission to conduct a case study was obtained from a Nova Scotia School Board. A Nova Scotia School Board supported a network strategy to petition principals from within a geographic area to contribute to the selection of a student-participant. The first letter requesting principals' permission to conduct the case study was sent to a specific geographic area within a NS School Board. The letter to the principal included a flyer for parents in order to assist with the networking strategy. Upon checking a specific school's confidential files, the vice principal confirmed that a Grade 5 student may meet the criteria for the study. The vice principal distributed the flyer to the parents of the child in the school who had been given a NLD diagnosis. The vice principal followed up with a phone call to this researcher confirming there was a child in the school who met the criteria for the study (a NLD diagnosis, in receipt of in-class resource assistance, in Grade 4-6, and in a school location that was accessible to the researcher) and that contact had been made with the parents of this child. I agreed with the vice principal that it appeared that the child met the criteria for the study. Due to the lateness in the

school year and time constraints, I immediately asked the vice principal to contact the parents of the potential participant of the study to ask them if they would be interested in discussing the details of the study. The parents of the child with NLD agreed to schedule a meeting in their home where I explained the role of the child in the study. Informed consent was obtained from both the parents and the child after a thorough discussion about the purpose of the study and the specific role of the child in the study. In addition, assurances were made that any identifying information would be kept strictly confidential and that the parents and the child with NLD could withdraw from the study at any time without penalty.

### **Profile of the Student-Participant**

The student-participant in Grade 5 was diagnosed with “nonverbal learning problems” in April 2002 when the student-participant was 6 years, 8 months. According to a 2002 psychoeducational report, the student-participant’s general cognitive ability, as estimated by the Wechsler Intelligence Scale for Children-Third Edition (WISC-III), was found to be within the low end of the average range. The report also stated that there was a significant difference between verbal and nonverbal abilities, with verbal abilities found to be within the average range and the nonverbal abilities within the low average range. While the assessment was conducted when the student-participant was in Grade One, a follow-up assessment in October 2002 supported the Grade One findings. The school psychologist’s summary report stated, “*The results of the assessment shows T had significant strengths and weaknesses, as well as potential areas of weakness, especially on nonverbal tasks.*” In addition, within the student-participant’s confidential file, a letter from the regional psychiatrist describes the 2002 assessment as showing that “*T has a non-verbal learning disability*”. These two sources of data substantiated that the

student-participant had received a NLD diagnosis. This diagnosis is in keeping with the former criterion used to diagnose NLD. According to Rourke (1989), the criterion that historically has been used by psychologists to diagnose NLD is a 10-point difference between the Verbal Intelligence Quotient (VIQ) and the Performance Intelligence Quotient (PIQ) scores on the Wechsler Intelligence Scale for Children (WISC-III). The student-participant was found to have a 21 point difference between Verbal Intelligence Quotient (VIQ) and the Performance Intelligence Quotient (PIQ) scores.

I met the student-participant in his home. The student-participant is of average size and wears prescription glasses. Although the student-participant appeared well groomed, his long shoelaces were often undone, and they presented a hazard to the student-participant and any other student walking in close proximity. In meeting the student-participant, he demonstrated appropriate communication skills and readily engaged in a conversation with me. The student-participant openly discussed his computer games and automatically responded to my questions about the study. The student-participant agreed to participate in the study and willingly signed the consent form in the presence of his parents.

### **Role of Teacher**

Upon receiving permission from a NS School Board, a NS school, the participant, and his parents, the study was conducted on the school site, over a three week period. The Grade 5 teacher of the student-participant was contacted and the purpose of the single subject case study was discussed. The Grade 5 teacher understood that the study required: observations in the classroom, two interviews, and three interactions with the student-participant in the mathematics

setting. The teacher in the study was assured of confidentiality and that all personal identifiers of the student and the identifiers of the school would be omitted from the text of the thesis. The teacher also understood that her contribution to the study was voluntary. The teacher agreed to provide input in the study and readily consulted with me regarding the appropriateness of the interview questions and the classroom mathematics curriculum used in the study.

In consultation with the teacher of the child with NLD, I was able to establish appropriate times in the class schedule to conduct the classroom observations and to interact with the child in a mathematics setting. Adhering to the classroom schedule of forty-minute periods diminished unnecessary interruptions to the child's regular educational schedule (See Appendix E). The data collection took place at different times during the day to ensure that a broader understanding of the child's daily routine would be considered. It was my belief that being consistent with the student-participant's experience in school helped to legitimize the rhythm and flow of the phenomenon I intended to comprehend.

To ensure that the mathematics sessions were supportive, complemented the current year's mathematics curriculum, and were grade appropriate for the child participant, I sought the student-participant's teacher's advice. The teacher read the interview questions and did not suggest any changes. The teacher and I discussed the rationale of using the concept of fraction equivalence as a medium to engage a student so that I could learn more about how the student-participant interacts in a mathematics setting. According to Butler et al., (2003), fraction equivalence is a fundamental concept underlying the study of ratio, proportion, probability, rates, and functions. The teacher explained that fractions had been studied earlier in the year and that

the class was presently learning about volume. In view of the teacher's expertise with the Grade 5 class, I invited the teacher to suggest resources that I might use to review equivalency concepts with the student-participant. The teacher suggested the new Grade 5 mathematics text book; *Math Makes Sense (Atlantic Edition)* that had been distributed to Grade 5 classes within a NS School Board midway in the school year. The fraction material had not been previously reviewed by the class. The new Grade 5 mathematics book was designed to support a Grade 5 students' classroom learning. According to a NS School Board's Mathematics Consultant, the text, *Math Makes Sense (Atlantic Edition)* is used in the Nova Scotia schools.

### **Mathematics Settings**

The Grade 5 classroom was located on the bottom floor of a school. The classroom was approximately 14 by 14 feet. The outdated design of the school appeared to present the classroom with ventilation challenges. The classroom was warm and humid and the noise level was elevated as there were three large fans circulating air. The teacher's desk and white board were at the front of the class and texts and manipulatives were arranged at the back and the sides of the classroom. The class had limited storage space with supplies and audio-visual materials stored against the walls. The left side of the class contained an independent computer station. The students were seated in individual desks and were placed in irregular rows. The student-participant sat to the left of the class near the door and the computer station. The student-participant's desk was located in such a way that no other students were seated immediately behind or beside the participant, as indicated in the classroom sketch (See Appendix F).

A work station for independent work had been set up immediately outside the classroom under a stairwell. Nineteen children were assigned to this Grade 5 class and it appeared that the class demographic was varied with a balanced number of males and females and with ethnic communities represented. The Grade 5 class also appeared to have various learning abilities. While in the classroom, I observed children working on individualized program plans (IPPs) as a Student Personal Assistant (SPA) had been assigned to the class. During the two observations, 3 students attended the independent work station outside the classroom.

As a researcher-observer in the classroom, I wanted to minimize my intrusion into the classroom and asked the teacher to introduce me as a MSVU student studying the learning of mathematics. Within this stance, I had access to the dynamics in the classroom and gained more information about the student-participant's experience in the mathematics classroom. Providing concise examples of how the child navigates in a mathematics setting was challenging as one has to look for patterns of behaviour that may be relevant to the research questions. The data analysis consists of a chronological account of the sessions I spent observing, interviewing, and interacting with the student-participant. The descriptions incorporated in this report may facilitate a more holistic understanding of how a child with NLD functions in a mathematics setting.

During the observations, I sat to the left and back one seat from the student so that I could get a clear view of the classroom interaction. Once the lesson began, the students did not appear to notice me in the class as they did not initiate any direct conversations with me during the one hour lessons. It was obvious that the teacher made good eye contact with students as he asked

many questions and identified a range of students to supply answers throughout the lesson. He often used the white board to illustrate and explain volume. In addition, the teacher solicited various students to explain the concept of volume using manipulatives. It was observed that the teacher incorporated in-class assignments for her students and drew upon both their individual and group efforts. The teacher circulated around the classroom offering students one-on-one instruction and redirecting others.

The three mathematical interactions I had with the student-participant took place in a quiet room on the upper floor of the school in late June. This was referred to as the multipurpose classroom and therefore did not have the appearance of the traditional classroom. The room was chosen by the administration as it facilitated the best acoustics for recording and provided an open, clutter-free space. While the room had a door with a window for viewing in or out, it was private. The room had been used for assessments, and it supplied space that was free of interruptions. Each day the student-participant and I sat near the computers in order to access an electrical outlet. The student-participant and I did not experience any interruptions during these sessions.

### **Interpretations of the Student-Participant's Voice**

The data collection took place over a three week period in June when the student-participant had the least amount of interruption in his schedule. The study included two observations in the classroom, and three mathematics interactions in a separate classroom setting. Conducting the two classroom observations during mathematics classes allowed me to observe the student-participant interacting with his peers and the teacher. During the mathematics interactions, I

administered a pre and post interview. The three interactive sessions with the student-participant involved working on grade appropriate mathematics problems relating to fraction equivalence.

Chronologically organizing the results help to convey what I learned through my engagement with a child with NLD in a mathematics classroom. The following section incorporates detailed descriptions and excerpts from the transcriptions of the student-participant's experience in a mathematics setting.

### **Day 1 – Observation #1 (Teacher's interaction with the class and student-participant)**

As the teacher presented the concept of volume, he drew upon the knowledge of the class. The teacher asked direct and indirect questions to both individuals and the whole class. On two occasions, the teacher asked the student-participant direct questions, "*What is a word that describes the amount of space for holding?*" The student-participant readily offered an answer, "*grams*" (the answer was capacity). On a second occasion, the teacher asked the student-participant how he would find the volume, to which he responded, "*One way is to put cubes in a box*". During the introduction of the lesson on volume, the teacher asked an indirect question. He held up a large cube in front of the class and asked the class to show him the length, width, and height of the cube. The student-participant put up his hand and said, "*It's 3-D*". These examples suggest that the student-participant was paying attention and attempting to make sense of the concept of volume.

During this class, the teacher asked the student-participant, "*How many cubes are in the bottom row of the diagram here?*" While the diagram had been drawn on the white board, the student-

participant did not supply an answer. The student-participant was not visually paying attention to the teacher as the student had placed his head on the desk at that time. In order to redirect the student-participant, the teacher used a positive demeanour and asked the class, “*Does someone want to help T?*” The teacher entertained answers from the class and followed with an explanation as to how to arrive at the answer. Finally, the teacher conducted a final check with the student-participant, “*Any questions, T*”, to which he responded with a “*No*”. This is one of the two times during the initial observation where the student-participant put his head on the desk when the teacher was providing an explanation to the class.

When the teacher was ready to assign in-class mathematics work, he set a timer for 15 minutes to indicate to the whole class the allocation of time for independent work. The timer was randomly placed on the student-participant’s desk. Initially, the students worked quietly on the in-class assignment and the teacher circulated around the room providing one-on-one assistance to several students. Three minutes into the assigned work, the student-participant became distracted and played with a pencil on his desk and looked around the class. As well, the Student Program Assistant (SPA) entered the room to collect papers and gave the student-participant a ‘thumbs up’. The student-participant smiled and then began to join the whispering in the class. He then took out a book (Outrageous Guinness’ Book of Records) from his desk and began to read. The pencil and book are examples of how items on and in his desk distract him from in-class assigned work. At 1:47pm, the teacher checked the student-participant’s work, and said, “*T, you missed something here, 15 times 4 equals... 60*”. When the teacher leaves the student-participant’s desk to help another student, the student-participant begins to talk about his book.

This is an example of how the student-participant believes he has completed the assigned work, and he does not appear to be in the habit of checking his work for accuracy.

The timer rang at 1:52 p.m.; the students appeared elated and the level of the students' voices escalated. The teacher reviewed the individual in-class assignment by utilizing the white board and asking the class direct questions. He drew on various students' responses to explain the answers. At this time the student-participant was not visually attending to the teacher's explanations of how to determine the answers. The student-participant had placed his head on the desk for approximately 3 to 4 minutes during the explanations. This behaviour illustrates that the student-participant appeared to tire of the lesson and was disconnected from it.

### **Day 2 – Observation #2 (Student-participant's interaction with the class and lesson)**

During the second observation, the teacher explained to the class that they were reviewing mathematics concepts. The teacher wanted to know what amount of change from a fifty dollar bill is required if an item cost \$29.14. The student-participant spontaneously says, "*Nearly \$30*". While this is an example of the student attending to the lesson, it is the first indication the student-participant may be guessing at mathematics questions. On another occasion, a chart was required to determine an answer, and when the teacher challenged the student-participant's incorrect answer, he explained, "*I guessed*" and then proceeded to begin to erase the answer. Closer attention to the errors made by the student-participant provides valuable insights into the way he conceptualizes mathematics. Rourke (1989) suggests that by analyzing the mathematical errors, some prevailing errors are notable. He suggests that a child with NLD may demonstrate some judgment or reasoning errors, and, in turn, attempt work that is not within the child's skill

set. This may explain the student-participant's generation of an incorrect and even unreasonable solution. This sort of error may be typical of the NLD profile, as this student-participant often generated guesses or disconnected responses.

The student-participant showed evidence of a head cold or allergy as he sniffed and coughed throughout the class. He had a water bottle on his desk, and on five occasions he chewed and drank from the water bottle. On one occasion, the teacher placed the water bottle out of his reach (on the floor beside him). It is difficult to say whether his need for water was a response to his cough or whether he was distracted. However, on two separate occasions the teacher cued the student-participant to engage in the assigned seat work. On the second prompt, the student said, "*I'm stuck*". This is an example of how the student-participant openly revealed his difficulties when prompted. It was also evident that the student-participant did engage in the lesson as he responded best to the teacher's direct one-on-one assistance. The student-participant was observed to acknowledge the teacher's help by saying, "*Oh, I got it now*" or "*oh.*"

The student-participant did not show any emotion concerning the prompts or the one-on-one help he received. It appeared that when he knew what to do, he engaged in the lesson and became distracted when he did not. This was evident as he seemed to stay on task when the teacher provided explicit prompting or sat at his desk and provided one-on-one support. There was no evidence of any specific or even problematic conversations that were taking place between the student-participant and other members of the class. In fact, it was observed that in the classroom setting, the student-participant worked primarily on his own.

At the end of this lesson, the student-participant, in isolation of the others in his class, closed his text and scribbler and removed his eye glasses and looked around the class. The lesson continued for several minutes before the teacher manually opened the student-participant's text and scribbler to assist him to search for an answer. In this instance, the student-participant was able to supply a correct answer as the information was extracted from a chart that the teacher had helped with earlier. As an observer, it was evident that the student-participant could be both distracted and attentive to the lesson. Like other students in the class, the student-participant provided unsolicited accurate responses to the teacher as mathematical concepts were explained.

Evidence that mathematical strategies were employed by the student-participant during the observation were: the use of his fingers to count up when asked to count by twenty's, quietly repeating the teacher's comments while writing correct answers, and keeping an organized binder. The student-participant was able to take out loose leaf readily when asked. This was not expected given that the literature often characterizes a child with NLD as having organizational challenges.

## **Day 2 - Interview # 1**

A semi-structured interview (See Appendix C) was employed to permit this researcher to develop a rapport with the student-participant and to gather the emerging insights into the student-participant's experience. The interview disclosed aspects of the student-participant's feelings, thoughts, and ideas about learning in general and about mathematics in particular. During the interview, I was guided by the responses of the child and the rapport that developed between us as we talked.

Eliciting the student-participant's opinion yielded both positive and negative evaluations of mathematics learning. As researcher-observer, I attempted to be flexible, on occasion prompting the student-participant for more information by asking leading questions. While I tried to avoid closed questions, at times I became very involved in the questioning in order to learn more about the student-participant's ideas or feelings.

The first question I asked the student-participant was: "*Tell me about your favorite subject. Why do you enjoy it?*" Initially, the student-participant shared that gym was his favourite subject. When I asked him to rank his subjects from 1 to 10, with 10 being the favourite and 1 the least favourite, he scored gym 10. As I continued to probe, the student-participant ranked art 9 and language arts, social studies, science, and music between 3 and 4. The student-participant considered French his least favourite with a score of zero. The student explained that gym was his favourite as he received good grades in the subject. The student-participant didn't elaborate further concerning the other subjects.

When I asked the student-participant, "*How do you feel as a student in mathematics?*" he replied, "*Bored, you just sit in your chair with a pencil and your math binder and you're just like uuhhhhh*". The student-participant also described homework as "*annoying*" and studying for a test as "*boring*". The student-participant described other recreational activities he would rather do such as playing computer games. While it appeared that mathematics wasn't an interest of his, throughout the mathematics interactions and the mathematics class observations, the student-

participant was able to maintain a moderate degree of interest. At no time did the student-participant refuse to work or reject a prompt to reengage in the mathematics assignment.

Asking the student-participant about what tricks or shortcuts he might use when completing a mathematics problem generated an array of strategies. The student-participant readily explained how he had learned to estimate, memorized songs to assist with the multiplication table, and utilized a finger activity to recall the nine times table. He openly sang and displayed the tricks and encouraged me to quiz him. The student-participant also openly shared that in some circumstances, but unknown to his teacher and parents, he had used a day planner (which contained a multiplication table) during class and used a calculator at home to generate answers to the multiplication questions. The student-participant was not inhibited in sharing how he had deceived his teacher during a multiplication test. This is in keeping with Telzrow and Bonar's (2002) description of a child with NLD, as they suggest that a child with NLD may demonstrate an inability to inhibit verbal responses. The student-participant did not seem to consider what I might do with the information.

Studying for tests has been supported by the parents of the student-participant. The student-participant described instances of how he practiced mathematics with both his mother and father. In session #2, the student-participant describes an incident of how he studied intensely for a test with his father during a weekend which resulted in a positive outcome.

During the interview, the student-participant responded jokingly to my questions. When I asked the question, "*Suppose you had to teach mathematics, what would you like to teach?*" he

responded with, *“Easy adding, easy subtracting, and throwing paper airplanes around.”* The final question was, *“If you could change one thing about learning mathematics, what would it be?”* The last question also elicited some humorous yet age appropriate comments, *“No more math. I could give them questions and get them to draw pictures.”* The student-participant explained, *“Like if I said draw a skull that had the area of 1.26 or draw a spider that has a perimeter of 18.62”*. This is an example of how the student-participant was able to take a mathematics concept and connect it to a real world object. When I sought more information about what could be changed, the student-participant said, *“I’d take out everything that has to do with subtracting, multiplying, dividing, or adding.”* Rourke (1995) suggests that arithmetic difficulties may be due to difficulties with number alignment, mathematical symbol confusion, number sequencing deficits, and geometric shape misinterpretation.

At the end of the session, we confirmed the next meeting time. It was evident that the student-participant tells time as he used his watch and the clock on the wall to determine whether we would meet before or after lunch.

## **Day 2 - Session 1 - Mathematics Interaction**

During the mathematics interactions, I assumed the role of researcher-participant and worked one-on-one with the student-participant. Within this stance, I demonstrated mathematics concepts and used guided practice to assist in the completion of the exercises on equivalent fractions. Throughout the mathematics interactions, I examined how the student-participant conceptualized mathematics, utilized intervention models, and in what way the student operationally defined mathematics problems. Incorporating data that contains conversations

about mathematics problem solving and the actual samples of the participant's mathematics work sheets helped to support my emerging assumptions. The field notes from each session have also helped me to point my lens as observer-participant to the relevant notions about the learner with NLD. For example, in reviewing the transcript of Session 1, it was evident that the student-participant could easily count by twos and fives. This skill may have illustrated the student-participant's ability to sequence numbers or it may have showcased the child with NLD's rote memory skills.

During this first one-on-one mathematics session, I guided the student-participant through exercises on equivalent fractions. Believing this was a review for the student, I followed the textbook's format and illustrations for teaching equivalent fractions (See Appendix G). I initially played the role of a researcher-participant asking closed questions and teaching the student-participant. In this role, the student-participant's voice was muted. Knowing that the dialogue was being recorded, I pursued this role for a short time and deliberately commented in my field notes that a variation in the interaction with the student-participant was necessary in order to draw out the student-participants ideas. An example of this is highlighted below. As I explained the equivalence of two fractions, the student-participant often answered my questions with a simple "yeah".

B OK, so let's look at this one. There are 24 tiles in the rectangle. You already figured that out, didn't you?  
T **Yeah**  
B 12 tiles are green. So 12 of the 24 rectangles are.....  
T Green  
B There are 12 groups of 2 tiles, 6 groups are green ...  
T Three here and 3 here.  
B So you could say another fraction would be six out of 12 group. Does that make sense?  
T **Yeah**  
B Look down below. They'll explain there are 8 groups of 3 tiles. Can you see?  
T **Yeah**  
B This is a great way of seeing it. Look at this one. There are 6 groups of 4 tiles. Can you see them? Three groups are green, are 3 groups green?  
T **Yeah**

B And finally there are 4 groups of 6 tiles, 6 and 6, right, and 2 groups of the 6 are green. So, we figured out all that, didn't we?

T **Yeah**

B So you're ready for a question?

T **Yeah**

In retrospect, as an observer-participant, I realize that I became caught up in the moment of explaining the equivalence concept. As I made inferences about my stance as a researcher embedded in the study, I began to shift my questions to “*Show me how*”, thereby asking the student-participant to explain the textbook diagrams of equivalent fractions. As the student-participant worked through the exercises, it became apparent that the he was able to see patterns in equivalent fractions, and he articulated this by saying, “*I got it.*” The following conversation showcases how the student-participant illustrated three fractions that were equivalent to  $2/5$ . Through the use of diagrams, he was able to see a number pattern and number sequence within context cues from me.

B Keep going, alright? Good job. Let's look at this question here. Write 3 fractions that are equivalent to  $2/5$ . Explain.

T  $10/20$ ?

B Show me how.

T It's easy. You just  $1/2$  what's on the bottom? That's it. That's all you basically do.

B Show me.

T Like this. 3 fractions are  $2/5$ .  $5/10$ ,  $10/20$ , or  $20/20$ .

B So you're saying they're all equal, right?

T Basically yes.

B And they're all equal to what? What's the question?

T  $2/5$ .

B  $2/5$ . They're all equal? So can you actually show me that, right here? Show me how, on here (point to paper). This is  $2/5$ . So show me. Shade in  $2/5$  for me. So how would  $5/10$  be the same? Shade in  $5/10$ . Good. Now let's look below.

T (he counts)

B So we didn't do a 15. So do you think if this is  $2/5$  and you have shaded in  $5/10$ , are they the same size?

T No.

B Would that be the right answer? Let's try again.

T OK.

B So how do we get...look at your picture there? What would be the same as  $2/5$ ?

T There's nothing on that.

B The other didn't show us. Look here. This is  $2/5$ , so you shaded in  $1/5$  here below the same bar. You shaded in...how many there? (Counting together) You shaded in 1, 2, 3, 4, you shaded in 5. How many might you have shaded in?

T Might I have shaded in?

B What might have been right? Count.

T 4/10?  
 B Right. So that  $\frac{2}{5}$  is the same thing as ....look below... that was out of 15.  
 T 6/15.  
 B OK. Write it down. Did you say 6/15?  
 T Whoops (he writes 16 instead of 6, but self corrects the writing error).  
 B And what would be another one you know now, even if you weren't looking. **See a pattern? What do you see? See any other numbers?**  
 T **2, 4, 6, 8, and 10 would be next.**  
 B **10 out of...?**  
 T **Out of 25... 5, 10, 15, 20 and the next...**  
 B **So you saw a pattern there. Good job. So now I want you to draw a picture for me**  
 T **I love drawing pictures. Are we going to use these? (Points to cubes)**

As the session progressed, I attempted to draw from the student-participant his knowledge of fractions. Learning tools such as diagrams and cubes seemed to facilitate the student-participant's engagement in the problem solving process. In exercise 4a on page 247 of the text (See Appendix G), I attempted to illustrate how  $\frac{1}{4}$  and  $\frac{3}{12}$  are the same. The student-participant was puzzled. The student-participant conceptualized  $\frac{1}{4}$  by arranging 1 yellow cube and 3 red cubes together. However, conceptualizing  $\frac{3}{12}$  was more difficult for him. It appeared that he began by visualizing  $\frac{1}{4}$  and  $\frac{3}{12}$  as being in the same picture, "*Oh, how would I show them being the exact same? I thought I'd have to draw them both in the same picture.*" However, aligning the cubes so that both concepts could be demonstrated in one picture was a demanding task. As he worked through the problem and arranged cubes, he was challenged as he attempted to arrange the cubes. It was apparent that he was only able to see  $\frac{1}{4}$  and  $\frac{3}{12}$  as separate fractions. Once  $\frac{1}{4}$  was arranged with the cubes, he began to add on cubes. With repetitive cueing, he eventually established an arrangement of cubes that depicted  $\frac{3}{12}$ .

During this exercise, a number of errors were noted. The student-participant arranged 13 cubes instead of 12, he counted 35 cubes instead of 36, and he gave me an answer in decimals instead of in fractions. This is noteworthy, as the errors are examples of the student-participant supplying impulsive responses, as if guessing or estimating a mathematics answers. In another instance, the

student-participant had difficulty constructing diagrams of equivalent fractions; often he drew extra rows of cubes. It appeared as though he focused in on one piece of information and lost track of other relevant information, like the number of cubes he was to draw. This spatial organizational error is also noteworthy as this kind of error has been reported previously (Rourke, 1989). Interestingly, each time I redirected the student-participant to consider the answer he had generated, he acquiesced and openly collaborated and received input from me. The student-participant's positive demeanour was consistent, and he generally exhibited good work ethic and concentration. When the student-participant was unsure about a concept, he frankly disclosed his confusion, "*I still don't get this*" or "*It's kind of weird*".

In attempting exercise 4c on page 247 of the text (See Appendix G), the third item in a series of exercises on equivalent fractions, the student-participant was able to work quickly through the questions. It appeared that the previous exercises had facilitated a broader understanding of equivalent fractions. At this time it was not clear whether the student-participant learned through procedural practice or whether he understood the conceptual framework behind the equivalence.

### **Day 3 - Session 2 - Mathematics Interaction**

At the beginning of this session, I inquired about the student-participant's feelings about the earlier session. The student's response was consistent with the previous manner in which he had disclosed his feelings about mathematics. As noted below, it appears that he does not consider mathematics fun, nor does he look forward to the class.

- B      So how did you feel yesterday when we were doing that math.?  
T      Pretty good I guess  
B      Was it good, bad, fun...?  
T      Kind of in between all those.

B What was it?  
T Kind of in between all those.  
B Which would be what? How would you describe it? I need a word.  
T **Like... kind of good, kind of bad.**  
B You know what? That's going to pick up that noise there. We'll put that over there in case you need a drink for later. Kind of-good, kind of-bad. What was good about it?  
T We could use the cubes.  
B And that was kind of good? And what was kind of bad?  
T Having to do it.  
B Having to do it just wasn't what?  
T **It isn't fun.**  
B It isn't fun. Math isn't fun?  
T No.  
B We'll have to figure out a way to make this fun. How could we make this fun today?  
T I don't know.  
B Do you have any ideas?  
T No.  
B Is it ever fun when you do it?  
T No, kind of.  
B. Kind of... just work you got to do. So, how do you get yourself sort of motivated? What do you do to get yourself interested and started?  
T Nothing.  
B If you know it's not going to be fun, so what do you do you just have to get through it?  
T **I just say ah crap. I don't like math.**  
B Do you say that in your head?  
T Yeah. I say it every math class.

We moved to the next exercise dealing with equivalence on page 247 of the text (See Appendix G). This question connected equivalent fractions with a real-life experience and the student-participant was able to interpret the word problem and integrate his knowledge of fractions. Upon reading the mathematics question that asked who ate the most pieces of pizza, the student-participant seemed certain of the answer. He quickly said, "*Oh, I get this already*", and shortly after that, he said, "*I already know it's her*". To provide support for his answer, the student-participant drew 4 pizza pies to represent the amount of pizza pie that each person ate. He then wrote the correct answer, "*Rhonda was rite because they all ate half.*" (See sample 1, Appendix H). Once again, I observed that the student-participant experienced difficulty sketching a diagram. During this exercise, he drew 9 pizza pieces instead of the 10 mentioned in the problem, illustrating that he didn't consistently check his work and may have some spatial organizational difficulties. As noted in my field notes, he committed several errors; an error

writing the date, spelling errors, and errors drawing replicas of Cuisenaire rods. Repeatedly, the student-participant appeared to have visual-spatial organizational challenges (eye-hand coordination) which manifested itself in difficulties with handwriting, drawing, and copying from the text. This is in keeping with the current research by Galway (2004), Rourke, (1995), and Saerlier-van den Bergh, (2002) as one of a number of presenting characteristics of NLD.

The theme of equivalent fractions was further developed by reviewing the way different units are used to measure proper and improper fractions. Using the Cuisenaire rods, the student-participant appeared to grasp the concept with ease. However, when the units were changed to cups, specifically  $\frac{1}{3}$  cup units, it was more difficult for the student-participant to comprehend. In comparison with the common  $\frac{1}{4}$  and  $\frac{1}{2}$  cup units, the student-participant appeared to not be as familiar with the  $\frac{1}{3}$  units and could not see that three  $\frac{1}{3}$  units make a whole. It appeared that the student-participant used  $\frac{1}{2}$  and  $\frac{1}{4}$  units with fluency.

On an exercise on page 249 of the text (See Appendix G), I asked the student-participant to solve equivalent fractions problems in which he was asked to discern the size of a scoop (cup) that would be used to measure specific amounts. Once again, the student-participant appeared confident and answered the questions without hesitation. He had two of the four answers correct. The student-participant demonstrated uninhibited thinking and this seemed to result from guessing and not from deliberate calculations.

When the student-participant struggled to determine the scoop size required for 1 and  $\frac{2}{3}$  cups, he clearly articulated it, "*I don't know, I really don't know.*" In fact, he described his thinking

brain as having a lazy part. When I asked what he does to reengage with mathematics when his “curtain goes down”, he explained that he relies on the teacher to cue him. This seems to be a significant strategy that the student-participant relies on as he mentioned several times that he waits for his teacher to provide hints when he gets “stuck”.

- B OK. So you put one cup of sugar and third and a third. How much does that make altogether?  
T  $\frac{2}{3}$ . I thought it was going to be  $\frac{2}{6}$ .  
B. This would be similar though.  $\frac{2}{6}$  is an equivalent fraction of  $\frac{1}{3}$ . Awesome thinking!  
T I just thought when we were working ... (Gestures not to be concentrating)  
B So then what happened? A big curtain came over you. So what happens then when a big curtain comes down?  
T **I become lazy.**  
B You become lazy?  
T Yeah.  
B. Does that happen very often? And do you ever get the curtain to go back up?  
T. Sometimes.  
B How do you get it back up?  
T **By making the teacher annoy me to do my work.**  
B. By making the teacher what? Annoy you? Or you annoy the teacher?  
T No. He annoys me then I have to do my work.  
B So he comes over to your desk?  
T He asks what are you doing and then the curtain comes up (gestures the curtain going up) and then I have to do my work.  
B OK. So a curtain comes up just like (gestures the curtain going up) this, right? And what do you do to get the teacher annoyed or to annoy you?  
T **Actually I don't do anything.**  
B. How does he know that your curtain's down?  
T. I don't even know...  
B He just figures it out.  
T You could say that.

The student-participant shared that studying with his parent had led to success with mathematics. In fact, he had commented that, “parents help the most”. The student-participant described a test for which his father had helped him study which resulted in a mark of 79. The student-participant appeared satisfied with this mark and indicated that, “*I brung (sic) it to my dad's, and he looked at it, and said, “Hmm”...he came back downstairs... when he was upstairs... and he said, ‘Most of things you got wrong were actually, kind of, pretty close’*”. Enlisting the help of a parent or guardian at home is common practice in the school system. It appeared that the student-participant was aware that this was a positive strategy for meeting with success in mathematics

and that his parents' acceptance of the kind of errors he made also contributed to his personal sense of satisfaction. Such an example demonstrates the value of taking the time to perform an error analysis and to comment on the degree of correctness of a mathematics solution in the teaching of mathematics.

As the third meeting drew to an end, I noted that the student-participant often spontaneously expressed himself in a positive manner and used humour, "*I'm like a monkey man, you should never doubt my monkey powers*". In one instance where he was colouring a rod, he began to sing a Sesame Street song about colour, "*So why you are like Harry and his eyebrows are light grey, so pink and dark and fuzzy and the eyebrows seem the same (singing)*". In a third instance, he pretended to wake up when I asked him a question and said, "*What, what, what, what...*" to which I replied, "*Bring your curtain back up, I know you are going to get this.*" As the observer-participant, I acknowledged his humorous comments and then promptly redirected the student-participant. Acknowledging that children with learning difficulties may become fatigued and even inattentive during a lesson, I chose to intervene promptly by redirecting the student's attention to the task at hand whenever he became distracted.

#### **Day 4 - Session 3 - Mathematics Interaction**

Within the lesson on page 252 of the text (See Figure G), we looked at two concepts, ordering fractions from smallest to largest and applying the concept of equivalence by solving a word problem. Initially, the student-participant was asked to order  $\frac{3}{4}$ ,  $\frac{3}{5}$ , and  $\frac{5}{8}$  from least to greatest. The student-participant suggested the answer was  $\frac{3}{4} < \frac{3}{5} < \frac{5}{8}$ , and then explained that " *$\frac{5}{8}$  was the highest one on the chart, like it has 5 on the top*". This example is significant, as

given the time that had been spent working with fractions, it appeared that the student-participant had not developed a sense of the size of fractions, and that visual aids were needed to be to help him understand the size of fractions. Questions that might be pursued are: has the student-participant developed a visual spatial representation of fractions, has he automatically learned the general size of  $\frac{1}{2}$ ,  $\frac{1}{4}$ ,  $\frac{1}{3}$ , or does he need explanations each time?

Once the student illustrated the rods (rather than use the Cuisenaire rods) and coloured them in to match the fraction (See sample 2, Appendix H), it appeared this strategy assisted him to order the fractions.

- B Let's go back to the drawing board, that didn't help us at all. Let's draw them. OK those {Cuisenaire} rods didn't help us. We're drawing a rod.... Here it is in half... here it is in quarters... and you said shade in how much? You show me how to shade in? What's  $\frac{3}{4}$ ?
- T (He shades in  $\frac{3}{4}$ 's)
- B Underneath that the same rod....
- T But only split the rod in half...
- B Ok...split it in pieces...
- T .But then go like this...
- B **So you know. How would you shade in  $\frac{5}{8}$ s?**
- T **(He shades in and I count)**
- B **Ok, which is greater  $\frac{3}{4}$  or  $\frac{5}{8}$ s?**
- T **Hmmm..I'd say  $\frac{3}{4}$ .**
- B **Why do you say that?**
- T **Because  $\frac{3}{4}$  is actually bigger than  $\frac{5}{8}$ s.**
- B **Right, you weren't seeing that before.**
- T **Just by looking at it.**
- B **Yeah, it seemed liked it helped when you drew it out by hand. There's one quarter, and another quarter and another quarter (I colour in  $\frac{3}{4}$  of rod) and that makes how much? You write it, the fraction?**
- T (He writes  $\frac{3}{4}$ ).
- B. This was... this was?
- T  $\frac{1}{5}$  ,  $\frac{2}{5}$ ,  $\frac{3}{5}$ ,  $\frac{4}{5}$   $\frac{5}{5}$ 's
- B Uh uh.. Listen. Were they fifths?
- T Eighths.
- B  $\frac{1}{8}$ , what's this?  $\frac{2}{8}$ ths?
- T Actually  $\frac{3}{8}$ 's,  $\frac{4}{8}$ 's and  $\frac{5}{8}$ 's (shading)
- B If this is all shaded in, let's do something to even more, similar, to help you understand even more. We're going to divide the same rod into eights. And what happens if we divide it again into sixths. 1, 2, 3, 4, 5, 6.
- T 2, wait  $\frac{6}{8}$ 's.
- B What's  $\frac{6}{8}$  the same as?
- T  $\frac{5}{8}$ 's.
- B  $\frac{6}{8}$  and  $\frac{5}{8}$  are the same? Do they look the same?
- T No.

B What is it the same as?  
T That. (Points correctly to  $\frac{3}{4}$ 's)  
B Ahum. It gets tricky, doesn't it?  
T Yeah.

Repeatedly, the student-participant had difficulty constructing legible letters and numbers and drawing accurate pie diagrams. Cueing him to look carefully, count the cubes, and check his work appeared to benefit him. These findings allow me to conclude that the student-participant requires constant cueing and redirection in order to respond successfully to a mathematics question.

As we worked through the ordering of fractions, the student-participant became more aware of his successes. On the third item involving the ordering of fractions, he began to express confidence and noted, "*I'm working hard*". With positive prompts from me like, "*right on, awesome, you worked it out*", the student-participant worked through it.

Employing manipulatives, such as cubes, was a positive experience for the student-participant. As he worked with the cubes to support the exploration of a word problem found on page 252 of the text, he played with the cubes. While he was pleased to play with the cubes, he became distracted from the mathematics task. The mathematics question asked the student-participant to determine the number of coloured blocks required for the construction of a quilt that had 20 pieces in total. During this session, continual prompts were required to encourage him to stay on task. It was observed that the student-participant struggled with his concentration on the word problem, especially when the cubes were in his hands. While the cubes were helpful, they were also a source of distraction for the student-participant. Consideration needs to be given to

effective use of manipulatives. Butler et al., (2003) suggest that monitoring the accuracy of student performance and managing student behaviour are two areas that may present challenges.

- B So should we try this one?  
T I guess. Urrrr.... That is, if I can get up (picks something up).  
B We have some cubes here. (Place them in front of her)  
T **Oh, I love these sort of cubes (Enthusiastic).**  
B Do you? This is the cubes we need for the quilt.  
T I love stacking them on top of each other  
B We have red cubes, yellow cubes and green cubes.  
T **(He plays with the cubes for 2-3 minutes, stacking them on top each other).**  
B **Oh, you made a big tower.**  
T **(Still playing and sings out “And a pencil”).**  
B Lets have a look....  
T It the leaning tower of pencil.  
B Instead of the leaning Tower of?  
T Pizza.  
B Right?  
T Pizza  
B Pisa?  
T That’s what I said.  
B Is it Pizza?  
T No, Leaning Tower of Pisa.

Again during this session, the student-participant became distracted by the cubes as demonstrated in the following narrative.

- T **This looks like a telescope (He pretends to peer through the cubes).**  
B It does? Do you like having manipulatives in your class when you’re doing math?  
T We don’t have any. We had these last year in the grade 4 class., **they are fun.**  
B They are fun. Why do you love them?  
T Last year we’d stack a bunch of different colours on top of each other **(He sweeps the stack of cubes around like a sword and made sound affects).**  
B What were they then, they look like star wars? You made kind of a wand.  
T We’d have another bunch and then we’d have a double light saber **(He continues to sweep the stack of cubes around like a sword and make sound affects).**  
B So my question would be, when you have all these to play with, when do you get your math done?  
T That’s a good question.  
B And the answer is?  
T Never.  
B You prefer not to?  
T **When I have these things around, all I prefer to do is build.**  
B Build. Excellent, I heard that you were very good at that.

As noted in earlier sessions, the student-participant was eventually able to demonstrate the concept of  $\frac{1}{4}$  through diagrams and the use of manipulatives. He demonstrated that 3 cubes of

one colour with a fourth cube of another colour was equivalent to  $\frac{1}{4}$ . However, when I asked the student-participant to transfer that knowledge and demonstrate  $\frac{1}{4}$  of 20 cubes, he was not able to perform spontaneously this task. It had become evident that working independently and applying his knowledge of fractions was challenging for the student-participant. Interestingly, within a one-on-one environment, the student-participant didn't show frustration, didn't give up, and openly articulated his confusion and asked me for assistance. In contrast to his observed classroom behaviour, he exerted an effort to attend for longer periods of time and to vocalize his need for assistance.

T     **Because  $\frac{1}{4}$  is 4 pieces.** (cubes are now arranged in 5 rows of 4)  
 B     **So  $\frac{1}{4}$  of her whole quilt, what is  $\frac{1}{4}$  of this quilt, can you show me?**  
 T     I'll do an example of these.  
 B     No, use a different colour.  
 T     OK.  
 B     Show me.  
 T     Where's my other stackage.... There four there, take on and that's  $\frac{1}{4}$ <sup>th</sup>.  
 B     Exactly, I understand that. How about with this quilt, **there are 20 pieces there, what would be  $\frac{1}{4}$  of 20?**  
 T     **Hhmmm, 10**  
 B     10 of 20? Show me 10.  
 T     Split  
 B     Split it in half?  
 T     Yeah.  
 B.    Is that  $\frac{1}{4}$  now?  
 T     2, 4, 6, 8, 10 ...Yep  
 B     And that's 10, and 10 there.  
 T     10 and 10 is 20. Yep.  
 B     Ok, is that  $\frac{1}{4}$  here?  
 T     This  $\frac{1}{4}$  here.  
 B     So when you split it in half, you are saying that is  $\frac{1}{4}$ .  
 T     Yep.  
 B     Listen, so when you split it in half, and there is 10 here and 10 there, that's  $\frac{1}{4}$  of the quilt patches?  
 T     (He doesn't respond).  
 B     So what is  $\frac{1}{2}$  of the quilt patches?  
 T     (He divides the cubes in half and smiles) One half would be this.  
 B     Aw, so not  $\frac{1}{4}$ ?  
 T     **It's  $\frac{1}{2}$ , but it,s still a quarter, cause, well... yeah, I'm a little bit confused.**  
 B     You are on the right track, this is a half and this is a half. How many quarters make a half.  
 T     (no answer)  
 B     You showed me with the green.  
 T     I stacked up 4 and took one of it.  
 B     You stacked up 4, 1 of 4 is a quarter.  
 T     .... And I just like cut one of it.  
 B     How can you show me that with 20?  
 T     Cut the whole thing.  
 B     You cut one of 10, so that's  $\frac{1}{10}$ <sup>th</sup>.

T Wait a second  
B It's very confusing.  
T **I'm stuck.**

As a researcher-observer, I observed that while working through the word problem, the student was not able to integrate what he seemed to know about fractions. Due to the difficulty experienced and our meeting time nearing its end, it was agreed that we would attempt the problem at the next meeting.

## **Day 5 – Interview #2**

This session involved a final attempt at the word problem and an interview. Once again, it was difficult for the student-participant to concentrate when he had access to cubes as he played with them while I tried to cue him to begin to think about the word problem. The student-participant's use of humour enriched the interaction and it helped to inspire us as we waded through challenging mathematics concepts. Within this atmosphere, the student-participant maintained a moderate amount of engagement in the mathematics setting. While the student-participant struggled with some of the mathematics concepts, he incorporated references to geometric shapes into the work we were doing. The next sample illustrates that the student-participant was able to visualize some geometric shapes and appropriately integrate the concept of a diagonal and rectangle into the conversation and the mathematics problem.

B Are you going to show me how the quilt could look differently?  
T **Ahhmmm, it could be a diagonal (he laughs).**  
B You had 2 rows of ten here and that didn't make a quilt, so now you have to try something different.  
T (Draws out 21 blocks)  
B Now you just tried 3 rows of what?  
T Three rows of ... 1, 2, 3, 4, 5, 6, 7.  
B What did I give you?  
T Twenty right here.  
B What else could you try?  
T Wait... 3. 6. 9. ... That will be too much, so right around here you would have to get rid of that.  
B That would be a funny looking quilt?  
T **A quilt with a whole in it (laughs).**

B What else could you do? How else could you make .... Try it with different shaped blocks, line them up differently, maybe....

T Uhhmm...

B You tried 2 x 10, 3 x 7 ....

T **I got it now. The flag just gave me an idea (He begins to make a shape of rectangle on the graph paper).**

B OK, that flag gave you an idea? ... Because?

T I don't know... it just gave me a little idea.

B It is shaped more like.....

T **Rectangle. It just gave me an idea**

B Go for it. The *Mi'Kmaw* Flag there?

T (He's drawing). Counts 1 to 20.

B Ohhhh. So you have on the graph paper here, something that looks like a square or a?...

T **Rectangle, I told you that thing gave me an idea.**

As we attempted to determine the number of coloured cubes required for the quilt, the student-participant struggled with finding  $\frac{1}{4}$  of 20. It seemed that although we had incorporated the use of cubes, diagrams of cubes, and pie diagrams during the past three interactions, the student-participant could not independently transfer the concept of  $\frac{1}{4}$  beyond 1 of 4 cubes. It seemed that he could not conceptualize  $\frac{1}{4}$  as 5 parts of 20, calling into question his understanding of equivalent fractions.

B And one quarter of the patches were yellow, how many would that be? If  $\frac{1}{4}$  were yellow. You have 4 rows of 5 and 5 rows of 4, so what would  $\frac{1}{4}$  be?

T (Make sound effects)

B So would that be one quarter?

T Yep.

B What's that?

T Quarter, quarter, quarter, quarter.

B **So how many quarters altogether?**

T **20, I mean 5**

B **Is there such thing as 5 quarters making a whole?**

T **No.**

B Ok. Try it another way, you are on the right track.

T (doesn't respond)

B So this is 4 blocks.

T **This is 3, which is 1 quarter. (He gestures to a group of four blocks).**

B So you are saying all those are  $\frac{1}{4}$ ?

T Well basically.

Once pie graphs were incorporated into the explanations, the student-participant began to show some understanding of  $\frac{1}{4}$  of 20 blocks and  $\frac{1}{5}$  of 20 blocks. Additional explanations and varied diagrams were required to help determine the actual number of blocks that represent  $\frac{1}{4}$  and  $\frac{1}{5}$

of 20. Once 4 rows of 5 blocks were created to represent the quilt, I turned the graph paper back and forth, 90 degrees, to solicit recognition of rows of  $\frac{1}{4}$  and rows of  $\frac{1}{5}$ . The use of concrete and abstract representational strategies appeared to facilitate the student-participant's learning process.

- B What if we change the graphics a little like that.  $\frac{1}{5}$ ? (I turned the grid of blocks that make up the quilt to show rows of five).
- T Actually,  $\frac{1}{4}$ .
- B Think of it as a whole big quilt. Show me  $\frac{1}{5}$  of the quilt.
- T **Boom (Points correctly).**
- B Ok, show me  $\frac{2}{5}$ ?
- T **Boom (Points correctly).**
- B and
- T  **$\frac{3}{5}$ , boom (Points correctly).**
- B  $\frac{4}{5}$ ?
- T **Boom,  $\frac{3}{5}$  (Points correctly).**
- B We know it should be something like this amount (Pointing to  $\frac{3}{5}$  of grid), don't we?

As a researcher-participant, I used demonstration, concrete and abstract representations, and guided practice to help the student-participant determine the actual number of coloured blocks that were required for each section of the quilt.

- B OK.... Show me how many are shaded in? How many shaded in of the 20? Count them?
- T 20.
- B Are they all shaded in?
- T Oh I get it now. (Counts to 11), 11.
- B Count them loud and carefully.
- T 12.
- B So we have to shade them in green.
- T (He shades them in.)
- B And ....
- T The rest are red. (He colours 3 blocks pink representing red).
- B **Now you proved it all really well, but you had to use a lot of different methods...** Can you show me with your blocks? If you were going to make this design and show it to your grandma?
- T (Sings to herself) 1, 2, 3, 4, 5 .... 12 of these, I don't think we have 12 of these, 3,4,5,6,7,8,9,10,11,12, pretty close. Now 3 rows....
- B Does that look like the picture, if you were showing grandma? OK... Will 3 rows of 3 do it?
- T Oops...4. , Last one is red. (He arranges the last 3 red blocks to resemble the diagram).
- B Awesome. So that's how you would show it... so to answer the questions... What colour is the greatest number of patches?
- T **(Excitedly and quickly answers) Green.**

During this session, I incorporated a larger sized graph paper for the production of diagrams. Interestingly, on this occasion, the student-participant did not experience any difficulty creating the correct size of the quilt as he could count the number of blocks very clearly (See sample 3, Appendix H). In this example, the student-participant did not erase blocks as he had in most other diagrams, but continued to struggle with the simple spelling of the words like green and least (See sample 3, Appendix H).

With the help of a final interview, the fifth session was intended to learn more about the child with NLD, to bring closure to the mathematics interactions, and to terminate the relationship between the student-participant and this researcher. This occurred on the last teaching day of the school year with the student demonstrating a degree of excitement to go home early. While we terminated the session, an arrangement was made for a later date to deliver a book and a thank-you card. As we ended the session, I asked an unscripted question, “*So what was it like doing this, the math?*” The student’s response to my question elicited an ambivalent response. As this was the end of the school year, I am unsure if the response was a reflection of his lack of interest in mathematics or his lack of interest in performing school work at the end of a school year.

- B      *So what was it like doing this? The math?*  
T      Good I guess, I can’t complain.  
B      Can’t complain (I laugh). Would you do it again?  
T      Kind of.  
B      Kind of, what does kind of mean?  
T      Probably.

During the interview it was difficult to get in-depth answers from the student-participant. He often joked or supplied brief responses. He maintained that mathematics was boring. His view of how and when mathematics could be used outside of school was limited, and he admitted, “*You do need it to get educated*” and that it was “*used in homework.*” When I asked what he would tell

his teacher to improve math class, he responded with suggestions such as: “*make it funner, put on a movie, use a calculator, have more games and use graphs*”.

Exploring strategies and feelings of another student who experienced difficulty in mathematics was challenging for the student-participant. His responses were sincere yet humorous. According to Telzrow and Bonar (2002), children with NLD may lack insight into other’s nonverbal responses and may experience difficulty taking the perspective of others. In the following example, the student-participant appeared to have difficulty taking the perspective of a fictitious student struggling with mathematics.

- B What would you tell a student if they were having difficulty with math?... Honestly...If someone said, “Hey, I’m having difficulty, what will I do?”
- T You never know what kind of math they are doing.
- B Yeah, if you knew some little trick to help them out... what would you do?
- T Well if they were doing the nine times tables, I would teach them the little trick.
- B The trick with your fingers. What else could you help them with?
- T I could help them with their subtracting.
- B Their subtracting...and if they were upset and crying, what would you do?
- T **Tell them to stop whining (He grins).**
- B Tell them to stop whining. Would you really? **Would you feel bad for them, or anything?**
- T **Kind of.**
- B Could you help a student out in math?
- T Yeah, I could ask them what’s going on?
- B What would you find out from that information...if you asked them what’s going on?
- T Why he was crying...
- B Hum...OK.
- T (He then became distracted).

As I concluded the interview, the student-participant once again recalled the successful mathematics test for which he had received a grade of 79. The delight in this mark appeared to have made an imprint on him. He also shared how he preps for a test (gathering pencils and an eraser for a test). When questioned about finishing tests on time, he acknowledged that he has had bad luck, “*As soon as I start the last question, I run out of time*”. It appears he views the time constraints he experiences during tests in terms of chance, not purposeful time management. The

student-participant also revealed that he tells his parents that he did his best when he has a poor test result. These are important words for educators to hear, a student's metacognition about his ability may be important in determining strategies for a child with NLD.

- B How did you react when you got the good mark when studied really hard with your dad?  
T You mean when I got a 79?  
B Yeah.  
T Pretty good.  
B **You seemed to always remember that mark.**  
T I cut **the mark off with the sticker.... And I taped it on to something, I don't remember what...** And my dad...when I brought it to his place...You know he said I wasn't that far off with the questions I got wrong.  
B Gooood... So you took the mark and the sticker of the test and stuck it someplace else?  
T **I think I taped it on the wall.**  
B **Is that so you will always remember?**  
T **Yeah.**  
B Awesome! Must be the best mark you ever got?  
T This year?  
B In math?  
T Yeah.

The student-participant's final comment about mathematics was, "*I'll use it (mathematics) just to be funny*".

To contribute to a better understanding of the student-participant's experiences in a mathematics environment, summaries of how the child with NLD conceptualizes mathematics, utilizes strategies, and his affect in a mathematics setting is provided. These summaries help to shape a more in-depth view of the student-participant and informed my suppositions about the child with NLD in a mathematics setting.

### **Child with NLD's Conceptualization of Mathematics**

Creating a sketch of the student-participant's experiences in mathematics has come about through the triangulation of multiple sources of data. The data collected guides my understanding

of how a child with NLD conceptualizes mathematics, experiences mathematics, and employs strategies in a mathematics setting (See Diagram 2). The observations and mathematics resource interactions that took place with the student-participant and the subsequent documentation of the process allow me to formulate a number of claims on how a child with NLD conceptualizes mathematics. The richness of the experience through the mathematics interactions permitted me to probe the student-participant and learn more about how he conceptualized mathematics and approached various mathematics exercises. Butler et al., (2003) indicates that research supports the use of manipulative devices for teaching mathematics. By asking the participant to illustrate and construct meaningful representations of fraction equivalence problems, I was able to develop an enhanced understanding of how the child functions in a mathematics environment. Attempts have been by researchers to describe operationally the varied aspects of NLD, specifically, visual imagery (Cornoldi, 2003 and van Garderen and Montague, 2003) mathematics problems solving (Owen and Fuchs, 2002) and even calculation errors (Rourke, 1987). By reviewing the content of the interviews, transcriptions, and field notes, I have found patterns of behaviour in the mathematics resource setting that depict some of the characteristics of a learner with NLD and how they conceptualize mathematics.

In following with the qualitative research tradition, the data analysis consisted of transcribing audio-recordings, organizing and coding recurring patterns, and formulating themes from the data. Recurring themes found in the transcriptions and field notes about the student-participant's conceptualization of mathematics were: an understanding of volume, size, and geometry, the incorporation of arithmetic skills, a difficulty with creating visual representations of a word problem, the formulation of guesses and counting errors, and challenges with fraction

equivalence. Through comparing and contrasting the coded information found in the transcriptions and field notes and commenting on the type of errors the student-participant made during the mathematics interactions supports my understanding of how a child with NLD organizes information and performs tasks using mathematics. The process of data analysis and accordingly, the triangulation of the data, clearly brought out salient themes. These themes are based on the environment that the child finds himself and these influence greatly the perceptions, emotions, and ultimately the voice of the child. Providing explanations for how the student-participant conceptualized mathematics is challenging as the mathematics experiences were time-limited.

Error analysis revealed that during the mathematics resource interactions, the primary errors that were recorded were simple counting errors, calculation errors, difficulty applying basic fraction knowledge to word problems, and difficulty visually creating concrete and abstract representations of equivalent fractions. An expansion and explanation of the student-participant's error pattern is presented, reflecting both the student-participant's voice and his interactions with me.

Rourke (1989) states that conducting an error analysis can assist with the inquiry into how the child with NLD learns mathematics. Retrieving arithmetic facts and storing information appeared to be problematic for the student-participant. During the mathematics interaction, the student-participant made errors in simple counting. For example, it was observed that he used a standard direction when counting, from left to right and used finger counting to problem solve. However, when counting manipulatives or counting blocks in a diagram, he would count an additional cube

or skip one. Studies have shown that children with MLD or MLD/RD commit more counting errors and use developmentally immature procedures more frequently than children without disabilities (Geary, 2004). When the student-participant was made aware of or detected his own counting errors, he would employ a self correction strategy, counting over. It was unclear whether the student-participant was distracted during the counting process or whether he was able to hold the numbers in memory as he counted. Simple calculation errors were also observed during the mathematics interactions. In particular, simple errors in addition and multiplication were observed. Without more detailed examples it is difficult to theorize about these sorts of errors. Geary (2004) speculates that deficits in the central executive area of the brain (See Figure 3), namely attention control, may disrupt the execution of mathematical procedures. Students may need to be taught to monitor the sequence of steps they employ to problem solve. It was observed that the student-participant would often generate guesses instead of developing a plan to problem solve an arithmetic problem.

According to Butler et al., (2003), the NCTM suggests that all young children should understand and represent commonly used fractions such as  $\frac{1}{4}$ ,  $\frac{1}{3}$ , and  $\frac{1}{2}$ . More specifically, in grades 3 to 5, all students should understand that fractions are parts of unit wholes, incorporate models to judge the size of fractions and generate equivalent forms of commonly used fractions, decimals, and percents. It was observed that the student-participant required extensive demonstration and guided practice to develop representations of equivalent fractions. Cornoldi et al., (1999) argues that young adolescents with high verbal intelligence and low visuospatial intelligence (one distinguishing characteristic of the NLD profile) presented marked deficits in a series of visuospatial working memory tasks that impact mathematics learning. The student-participant

appeared to have conceptualized  $\frac{1}{4}$ ,  $\frac{1}{3}$ , and  $\frac{1}{2}$  and demonstrated that he could develop visual models to represent these simple fractions. Through extensive cueing the student-participant appeared to understand how to order fractions from least to greatest. However, transferring this knowledge to other equivalent fractions was a lengthy task and required extensive guided practice. Questions posed in my field notes were: has the student-participant developed a spatial representation of the commonly used fractions or do his graphomotor skills impede him in developing abstract models of fractions?

As there are a range of theories suggesting the root cause of the mathematics difficulties, it is difficult to ferret out what may have impacted the student-participant's difficulty with fraction equivalence during the mathematics interactions. Geary (2004) posits that a child's visuospatial system appears to support many mathematical competencies, such as those dealing with geometry and solving complex word problems. Mazzocco (2003) suggests that of the MD subtypes, the cognitive features of a visuospatial subtype MD are least understood because of the lack of empirical studies of visual-spatial performance in MD children. Further investigation into how children with NLD call upon their conceptual and procedural knowledge to solve mathematical problems may reveal more about the mathematics difficulties experienced by children with NLD.

### **Child with NLD's Strategies for Problem Solving**

The data collected highlighted the participant's voice: how he abstracts meaning from mathematics and how he strategizes in a mathematics setting. Two classroom observations followed by three mathematics interactions were designed to explore how the student-participant

solved problems. The three mathematics interactions used fraction equivalence exercises to glean what strategies a child with NLD uses in a typical mathematics setting. Session 1 presented the student-participant with opportunities to explore fractions and fraction equivalence by using various textbook diagrams (See Page 245-246, Appendix G). In Session 2, a fraction equivalence word problem was presented as well as an exercise that reviewed creating parts from wholes (See Page 247-248, Appendix G). Finally during Session 3, the student-participant was asked to solve a detailed word problem that incorporated the concept of fraction equivalence (See Page 249, Appendix G). Throughout each session, I played the role of researcher-participant where I became very involved in the phenomenon being studied. As researcher-participant I examined how the student-participant conceptualized mathematics, incorporated mathematics strategies, and experienced each session. Within this role, I became involved in the process; I identified the lesson's objective, demonstrated steps to solving problems, prompted and cued the student-participant, encouraged independent problem solving, provided positive feedback when he demonstrated good problem solving strategies, and provided corrective feedback when errors were noticed.

Throughout each session, the student-participant and I were thoroughly involved in collaborative problem solving. The interactions involved cycles of task analysis, strategy use, and self monitoring. During the sessions, I encouraged the student-participant to engage in meaningful work, to discuss his learning processes, and to celebrate his emerging understandings around fraction equivalence. Guiding the student-participant through the exercises provided opportunity for me to observe his inclusion of mathematics strategies and to hear his rationalizations for their use. Specific strategies emerged as I worked with the student participant; he often requested

assistance or waited for cues to complete exercises, he used songs, finger tricks, and memorization to multiply; he articulated a need for parental support when preparing for mathematics tests and practicing homework, and he utilized concrete and abstract representations of fractions.

Through the process of data analysis, I reviewed the transcripts and learned that a significant practice emerged as the most used strategy by the student-participant. The student-participant relied on cueing and prompting from the teacher while in the classroom and from me during the mathematics resource sessions. In fact, he named teacher cueing (“*by making her annoy me to do my work*”) as a strategy that assists him in a mathematics environment. Teacher guided practice involves providing prompts and cues as the student attempts to solve problems (Butler et al., 2003). While this is a regular practice in one-on-one teaching environments, the student-participant appeared to be heavily reliant on this strategy to solve problems in any setting. Although I repeated directions and assisted the student-participant to reconstruct approaches to mathematics problems, it was apparent that he could not readily tap into his previously learned knowledge about fraction equivalence. As this was a time-limited study, there was insufficient evidence to comment on whether the student could perform independent practice over time.

There are many rationales as to why the student-participant relied on cueing and prompting to complete the mathematics exercise. The most obvious reason is that he could not decide what to do. Montague (2002) notes that teaching students how to decide what to do is a cognitive process that is essential for mathematical problem solving instruction. Explicitly teaching the student-participant a set of problem solving strategies to help him to translate and transform a problem

into something understandable, and subsequently, formulating a plan to solve a mathematics problem, may need to be developed. Owen and Fuchs (2002) uncovered only seven studies in 2002 that focused on systematic strategy instruction for mathematics with elementary student with LD. Systematic instruction asks the student to follow a series of steps or procedures to facilitate conceptual learning and problem solving. Explicit instruction in mathematics problem solving strategies may help students to move beyond rote application of basic skills to become mathematical problem solvers and analytical thinkers (Owen and Fuchs, 2002).

The use of songs, rhymes, finger tricks, and memorization are strategies that may account for a reliance on rote procedural knowledge when doing arithmetic, and subsequently, problem solving. The student-participant may have weak conceptual knowledge of calculation, impeding the fluency of his calculation skills. While the student proudly demonstrated a rote procedural strategy for multiplication (finger trick, Appendix I), without conceptual knowledge, he may lack an understanding of the underlying arithmetic principles in mathematics. Kaufman, Handl, and Thony (2003) suggest that integration of procedural (knowing how to) and conceptual (knowing why) knowledge is essential for flexible and adaptive applications of numerical and arithmetic knowledge. Evidence for the need of both procedural and conceptual knowledge became apparent when the student-participant openly indicated that when no one is looking, he uses a calculator or multiplication table to find answers to mathematics questions. This is an example in which the student-participant is not able to rely on his rote memory nor had a conceptual strategy to draw from in order to answer an arithmetic question.

Enlisting the support of parents or guardians at home is common practice in elementary grades. Often mathematics homework is sent home and parents are asked to provide demonstrations, guided practice, and review. Parental involvement may even be critical in the development of a positive disposition toward math (Furner and Duffy, 2002). The student-participant clearly articulated parental help as a positive strategy for experiencing success in mathematics (“*parents help the most*”). The student-participant supplied a poignant anecdote where he described his father’s recognition and acceptance of the nature of his errors as displayed on a test. This is an example of how practicing mathematics strategies at home is equally as important as advancing a child’s sense of self-worth in the process of learning mathematics. Butler (2002) suggests that low perception of self-efficacy undermines a student’s willingness to provide effort in tasks. More recently, educational researchers have begun to develop a range of instructional activities that promote the student’s learning, with some activities supporting the student’s construction of motivational beliefs. By developing a broader perspective in analyzing mathematics errors, the mathematics learner may present an effort that would showcase both procedural and conceptual knowledge.

Demonstrating mathematics problems with concrete and abstract representations of fractions was incorporated into the mathematics sessions. As researcher-participant, I encouraged drawings to translate and visualize word problems. Using manipulatives to make the fraction equivalence word problems more concrete appeared to benefit the student-participant, and it documented his progression through a mathematics problem. Specifically, graph paper, pie graphs, and cubes were observed to be constructive tools in representing mathematics concepts. The word problems with embedded fraction equivalence were challenging for the student-participant, and it appeared

that solving them with representative models was a favourable strategy. In one study by Butler et al. (2003), the use of graphic representations seemed to enable students who had forgotten an algorithm to solve problems by reasoning it out with a drawing.

While the use of manipulatives as a strategy for mathematics was observed in this study, the effective use of the manipulatives also became apparent. As noted in my field notes, the management of the student-participant's behaviour with the manipulatives was necessary as the cubes quickly became a distraction. Through the interaction with the student-participant, cubes represented both a source of enjoyment and a tool for exploring shapes (*"Oh, I love these sort of cubes... When I have these things around, all I prefer to do is build"*). It seems that the student-participant's voice might need to be considered: combining fun with mathematics problem solving could be an ideal learning ground, if well managed.

### **Child with NLD's Affect**

Evidence suggests that high levels of mathematics and technical skills are required for most jobs in the 21<sup>st</sup> century. Consequently, students will have to meet stringent mathematics skill requirements when entering job training programs. More recently, researchers have been focusing on developing mathematics strategies that ensure that all students have skills sets to meet the challenges of the 21<sup>st</sup> century. While the development of systematic mathematics strategies is ongoing, the experience, and indeed the disposition of the child within a mathematics learning environment, is not well documented. Math anxiety is defined by the NCTM (1989, 2000) as a negative disposition. As well, it has also been described as an inconceivable dread of mathematics that interferes with manipulation of numbers and problem

solving (Furner and Duffy, 2002). Whether the student's mathematics experience is labeled math anxiety, or negative disposition for mathematics, or being at risk for less positive attitudes toward mathematics (Butler et al., 2005), addressing the issue is important in order for children to be successful in learning mathematics.

This study attempted to learn more about the child with NLD's experience in a mathematics setting. When I asked the student-participant to rank his subjects from 1 to 10, with 10 being the favourite and 1 the least favourite, he scored, "Gym 10 and mathematics 1." As I probed for more information and asked what kind of mathematics he liked, he replied, "None". Again as I tried to solicit more information about his experiences learning mathematics and whether he would change anything about mathematics, he exchanged few but pertinent words, "No more math". Clearly, the student-participant has a negative disposition toward mathematics and, indeed, expresses indifference toward mathematics.

It seems that the student-participant had some difficulty applying mathematics and problem solving to daily life situations. On one occasion, the student-participant made a mathematics connection with real life; he suggested that mathematics would be "used in a job". Making multidisciplinary connections with mathematics may be helpful in a school setting. Showcasing and incorporating the mathematics skills that are found in mapping, cooking, building, sewing, or playing computer games may assist students to make associations and encourage mathematics learning. Butler (2002) suggests that a theoretical underpinning of the self-regulated learner model is that the student needs to engage in meaningful work and that the work needs to tap into the student's previous knowledge to solve novel or real life problems.

“*Math isn’t fun*” are words that have been echoed by the student-participant and in many school hallways. Peers, parents, media, and even mathematics teachers may deliver covert and overt messages that create an inevitable perception that mathematics can never be fun. A student’s or a parent’s lack of success with mathematics may also encourage a miscommunication about mathematics and engender stereotypes about mathematics. Hence, diminished expectations of mathematics achievement may become perpetuated within families, within peer groups, and more specifically, within populations of students with learning disabilities. Teaching strategies that foster positive and constructive conversations about mathematics may transform the alarming statistic that only 7 percent of Americans possess a positive disposition about mathematics. Creating opportunities for children to say, “*math is my favourite subject*”, or “*mathematics is fun*”, would be noteworthy words for educators to hear. A student’s sense of enjoyment in a mathematics class and his metacognition about his abilities could foster engagement in mathematics.

Furner and Duffy (2002) suggest that teachers might consider assessing students’ disposition toward mathematics. The NCTM (2000) provides a list of pertinent questions that the teacher may use to survey a mathematics class. The NCTM suggests that this survey establishes a class baseline which may gauge the changes in class attitudes over time. A student’s confidence using mathematics, willingness to persevere with mathematics tasks, interest and curiosity, reflective thinking and appreciation for the value of mathematics are important features of the assessment. During this case study the opportunity for further investigation into the student’s attitude about mathematics was limited.

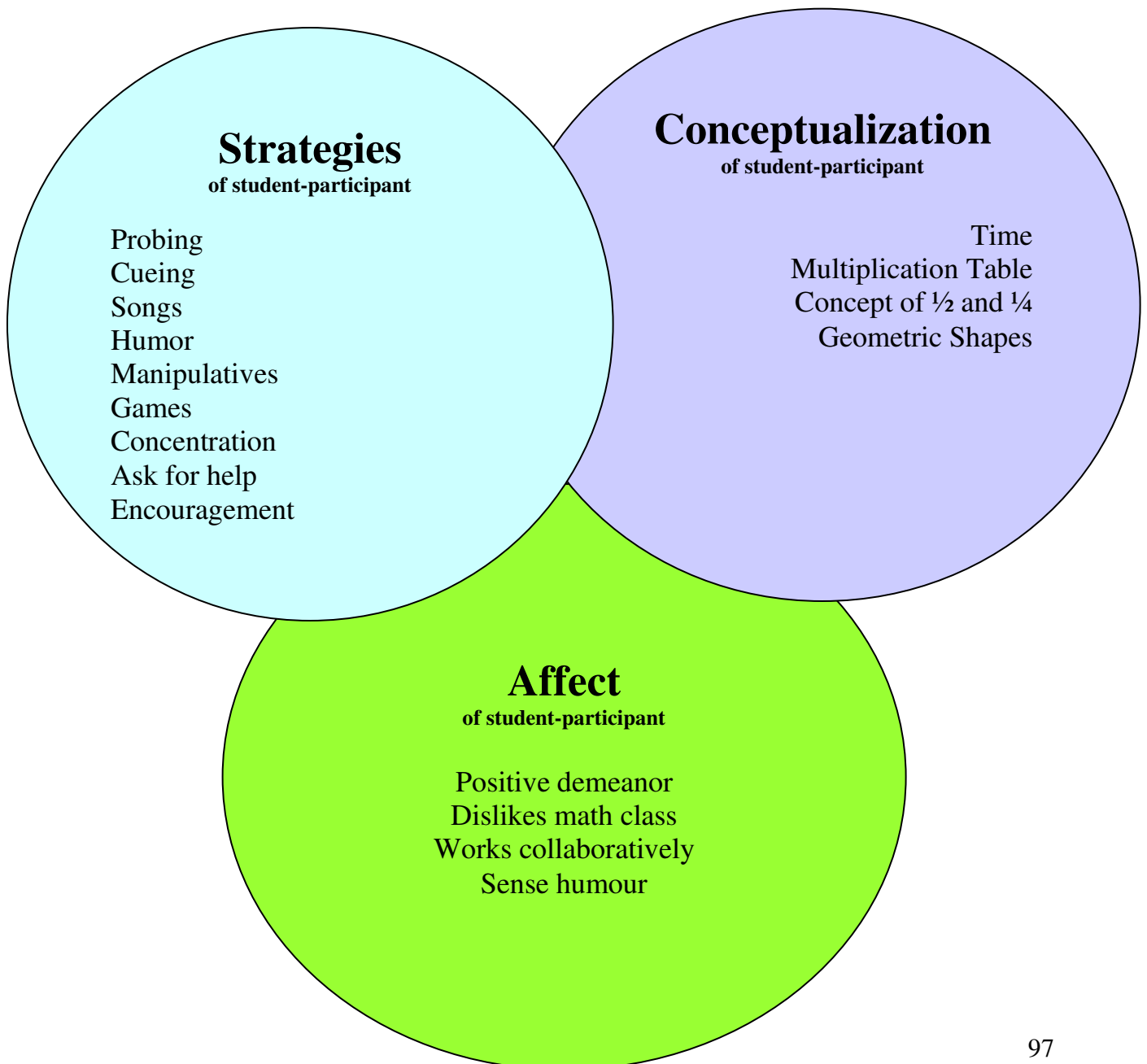
The presence of the student-participant's sense of humor enhanced this research study. At no time did the student refuse to engage in the mathematics exercises or demonstrate frustration. Employing humor was a daily part of our interactions. It was apparent that the student-participant was relaxed in my presence and openly shared his thoughts and feelings with me. As researcher-participant, I openly laughed at the student-participant's humorous comments. Building a rapport with the student-participant was facilitated by his and by my sense of humor. The student-participant seemed to find occasions to easily and appropriately joke during the mathematics exercises and exhibited a very positive disposition while we worked in a mathematics setting. The student-participant's final comment about mathematics, "*I'll use it (mathematics) just to be funny*" resonates as an important line found in the transcriptions. Did the student-participant mean that mathematics should be fun or did he mean that mathematics has limited uses, it is a joke? Whatever his intended message, creating a positive perception about mathematics may be one of the most important strategies educators would want to incorporate into lessons.

Interestingly, the child with NLD has been characterized as exhibiting poor social functioning such as speech prosody, misinterpretation of body language, and failure to understand jokes and sarcasm (Telzrow and Bonar, 2002). It was evident that the student-participant had developed an age appropriate sense of humour. This qualitative study affirmed my belief that children with NLD may become more clearly understood when heard in varied research settings.

Drawing from the mathematics interactions, the classroom observations, the interviews, the student-participant clearly demonstrated and articulated how he conceptualized mathematics,

employed strategies when attempting mathematics problems, and the feelings he had as he worked through mathematics exercises. To encapsulate the interpretations of the student-participant's voice, a schematic model is presented (Diagram 2). This view showcases the salient themes that emerged from this research. It is understood that this representation of the child's experience in a mathematics environment is not exhaustive.

**Diagram 2 - Schematic View of the Child with NLD in a Mathematics Setting**



## **Perceptions of the Researcher-Student Participant Relationship**

As previously noted, I played the role of a researcher immersed in the environment in which I was observing and interacting. In this chapter, I have attempted to reflect my role as a researcher-observer in the classroom, and as a researcher-participant in the mathematics interactions. Within these two settings, I was able to engage in rich conversations about learning mathematics. In qualitative research, the researcher is the primary instrument of data collection, and therefore interdependency within the interactions is assumed (Merriam 1998). I made every effort to set aside my assumptions about a child with NLD in order to interact sincerely with the student-participant and learn more about the phenomenon being studied. Personal memos, field notes, and recordings from the conversations with the student-participant were generated in an attempt to be more reflective as I interacted each day with the student-participant. These documents aided me to put my assumptions and beliefs aside and to focus on the child's experience.

A question qualitative researchers need to ask themselves is not whether the research process is impacted, but how the researcher identifies and accounts for the impact on the analysis. On several occasions, during a moment of interviewing, I redirected and spontaneously generated questions I thought would build rapport and gather more information about how the student-participant experiences mathematics. Such conversations as those about computer games, his community, the weather, school activities, were all topics that enhanced the researcher-participant relationship. On other occasions, as I reviewed the field notes and recordings of the mathematics interactions, I reflected on how I might approach the student-participant in order to encourage more independent mathematics problem-solving. Deciding to review errors, to provide positive feedback, and to introduce different manipulatives were this researcher's

decision and were a product of my reflections at the end of each session. By targeting errors, I learned more about the strategies he employed and how he solved problems. As I used words such as, “*awesome*”, it seemed to prompt him to continue to engage in the process. The use of concrete and abstract manipulatives also created an impact, as it demonstrated a degree of engagement in the mathematics as well as assisted me in learning more about the phenomenon. The data analysis helped to verify the rigour of this research. The researcher’s role, the nature of the interactions, the triangulation of the data, and the interpretations of perceptions of the student-participant not only offered rich descriptions, they also helped to account for the reliability and validity of the research.

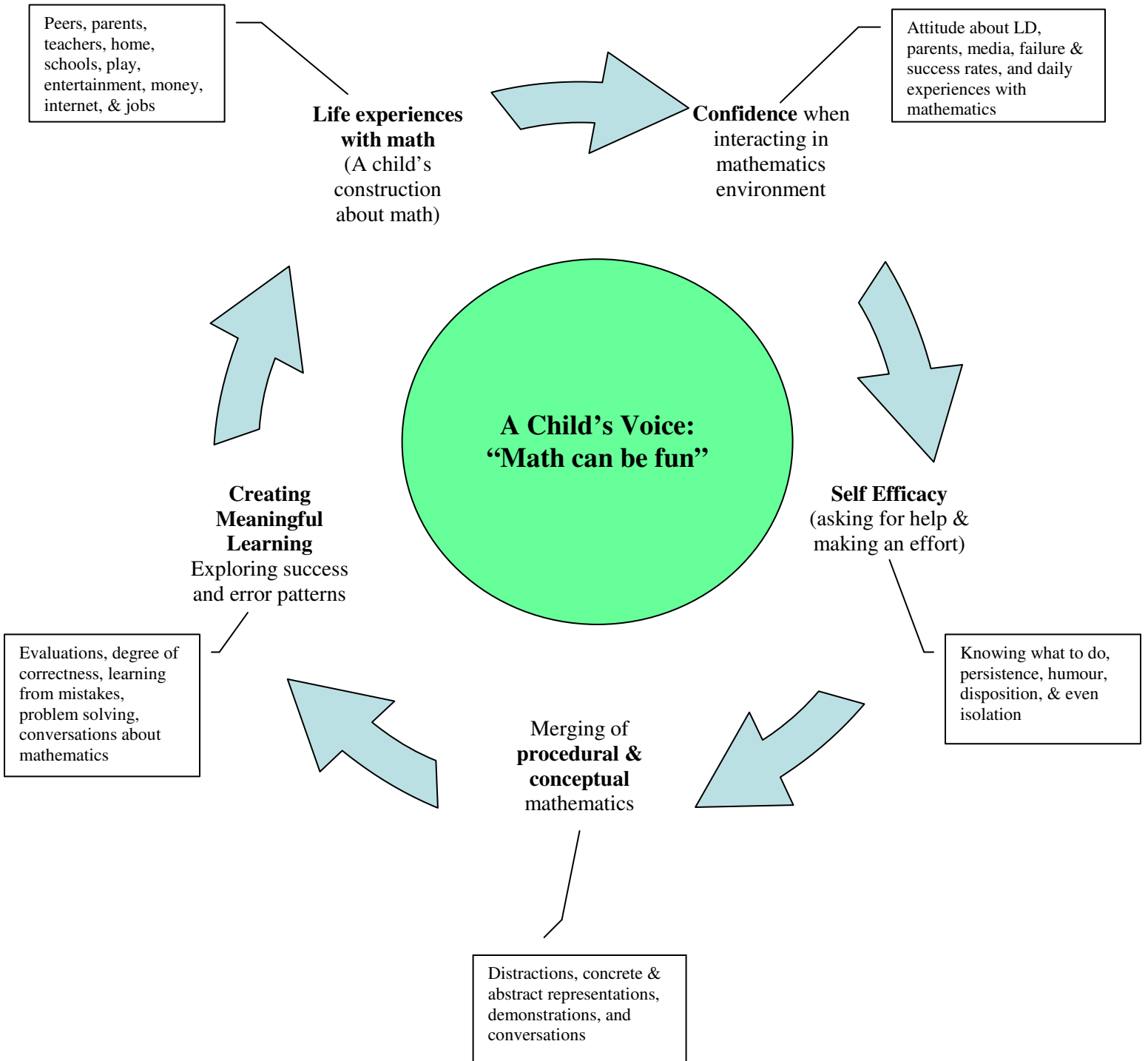
The case study took place in a school setting, a stable and typical place where mathematics conversations take place. It is assumed that as a researcher-participant, I was a catalyst for change, but change that took place within the school setting (Merriam, 1989). By utilizing school-based mathematics materials and by incorporating some of the mathematics principles suggested by the NS Mathematics Curriculum, I attempted to provide a mathematics environment that was free of biases which would help me to demonstrate the individual characteristics of how a child with NLD experiences, conceptualizes, and solves problem within a mathematics setting.

As I learned more about the how the child experienced mathematics, hunches about how the child operated in the mathematics environment began to occur. Issues around concentration, confidence, and disposition began to emerge as underlying factors that impact mathematics learning. Segments of data that supported my hunches were coded. According to Merriam

(1998), the unit of data should reveal information relevant to the study and stimulate readers to think beyond the piece of data itself. The salient excerpts of data have been presented in this study and offer the reader a schematic view of the child with NLD in a mathematics setting (See Diagram 2).

Linking the rich descriptions with the research categories has helped to develop a model to describe how a child with NLD might perceive mathematics (See Diagram 3). This model helps to demonstrate the many factors that may lead a child to have either a positive or negative experience in a mathematics setting. Conversations with a child with NLD have enabled me to illuminate notable factors that impact the experience in a mathematics environment. The model is presented as a cycle. This implies that its construction is of a child's making, provided his or her environment empowers him or her to have conversations about his or her experiences with mathematics. These experiences may in turn assist a child to create meaningful learning. Butler (2002) suggests that in order for children to become self-regulated learners, "students' construction of knowledge is shaped and constrained by the language and tools available in social and cultural contexts." Drawing from various sources of research may help us learn more about the child with NLD in a mathematics environment. Flexible qualitative research designs such as the case study help us to convey the voice of the child with NLD.

**Diagram 3 – Empowering a Child with NLD to Make Meaningful Learning**



## **CONCLUSION**

### **Thesis Summary and Review**

Over the past thirty or more years, researchers have delineated specific NLD characteristics. While Rourke (1995, 1998, 1999, 2000) has been a leading researcher in the field of this LD subtype, there are criticisms of his NLD Model and his posited etiology. As researchers learn more about learning disability subtypes, they propose alternative ways to view NLD. Visual-spatial impairments, mathematics learning disability, reading comprehension difficulty, and social skill deficits have all been associated with this LD subtype.

Impairments in tactile-perception, visual-spatial organizational impairments, and difficulty with psychomotor coordination have been documented as characteristic of the NLD subtype (Rourke, 1989, 1995, Galway 2004, and Saerlier-van den Bergh, 2002). A mathematics disability is often described as a hallmark of this syndrome. Accordingly, the child with NLD's mathematics difficulties has been integrated into much of the recent literature. While many studies highlight the extent of the dysfunction of a child with NLD, few studies feature the child's strengths. The child with NLD often is verbose, and therefore, has the facility to inform researchers about his learning. At the time of the writing of this paper, gaps existed in the literature about how the child with NLD experienced mathematics. The voice of the child with NLD and his experience in a mathematics setting is seldom articulated, and subsequently, obscured by the quantifiable data that presently exists about the NLD syndrome.

Developing a research model that captures how a child with NLD experiences, conceptualizes, and solves problems in a mathematics setting was the goal of this research paper. Producing an

opportunity for the child with NLD to convey his experiences in a mathematics setting has shaped my research findings. Using a single subject case study design in a school setting, I attempted to capture the essence of a child with NLD in a mathematics environment. As a researcher-observer and a researcher-participant, I gathered data by means of interviews, observations, and interactions with a child with NLD in a mathematics setting. Through a constant comparative method of data analysis, the child with NLD's experiences, conceptualization, and problem solving ability in a mathematics setting guided my research. Uncovering particular incidents from the observations, interviews, and the interactions, was contrasted with data found within the transcriptions, field notes, and mathematics sample exercises. Within this time limited qualitative study, the rich conversations about mathematics became more important than the quantity of incidents embedded in the data.

The development of categories and the interpretive commentary about the voice of the child has supplied a framework for looking at what influences a child with NLD's mathematics experience. By interacting with the child with NLD and asking him to construct representations of fraction equivalence problems, I found patterns of behaviour in the mathematics setting that reflect the disposition of a learner with NLD. The narrative included in this thesis addressed the research questions and helped me to construct a schematic representation of how the child with NLD conceptualized mathematics (See Diagram 2). The child with NLD seemed to rely heavily on strategies such as: probing, one-on-one cuing, songs, games, and humour. This is an important finding in this study as it highlights the student-participant's reliance on rote procedure and collaborative social interaction when solving, strategizing, and conceptualizing mathematics. Because the NLD syndrome is typically characterized by well-developed auditory perception,

rote memory, and verbal expression (Galway, 2004, Rourke, 1995, and Saerlier-van den Bergh, 2002), utilizing these assets could position a child with NLD with a strategy to talk through mathematics problems. Employing strategies that encourage conversation between parents, teachers, and peers, about mathematics, may foster a deeper understanding of mathematics (Butler et al., 2005). Engaging a child with NLD in expanding his ability to direct his learning in more meaningful ways may also encourage a more positive disposition about mathematics.

Movement from procedural to conceptual mathematics problem solving was evident with the incorporation of manipulatives such as: blocks, pie graphs, and graph paper diagrams. Analysis of the interactions in the mathematics setting advance Geary's (2004) notion that children with a compromised visuospatial ability are more likely to experience difficulty with spatially represented information, therefore, impacting their conceptualization of mathematics. Consequently, it has become apparent that intervention programs tailored to the specific needs of arithmetic disability subtypes ought to feature multiple representations of mathematics problems. Indeed, Venneri et al. (2003) concluded that children with VLD experience difficulty with some processes that govern calculation, especially those loading on visuospatial abilities. Therefore, educators should consider the development of strategies that could assist a child with NLD to become aware of the kinds of available strategies he employs. Additionally, through conversations about mathematics learning, the child with NLD could be encouraged to track the sort of effective mathematics representations that has helped him to solve problems.

Embedded in the five mathematics interactions were compelling themes. The child with NLD's experiences in a mathematics setting provided significant contextual information in relation to learning mathematics. Life experiences, level of confidence, the degree of self efficacy, and the

merging of procedural and conceptual mathematics learning were found to be significant factors that could positively or negatively impact a child with NLD. Advancing a model that empowers a child with NLD to create meaningful learning developed the descriptive narrative supplied by the student-participant (See Diagram 3). As educators encounter students with NLD in a mathematics setting, it is inevitable that they will be exposed to the variety of challenges that have been identified as characteristic of a learner with NLD. The invitation to all educators is to become truly engaged, concerned, and open-minded to the way in which a child with NLD learns, thereby, becoming aware of the subtle cues exhibited and the voice of the child with NLD. Within a contextual teaching stance the learning environment may become enlarged for the learner with NLD.

### **Limitations of the Study**

Several limitations encountered in the process of conducting this study should be considered when interpreting the data. The study was conducted at the end of a school year which may have negatively influenced the child with NLD's attitude about mathematics. The end of year is often a time when students' enthusiasm is sluggish and interaction tempered with some indifference. A follow-up study scheduled at a different time may reveal other view points about mathematics. The interview questions in this study did not draw out in-depth responses. Engaging a younger or older child with NLD may reveal different findings about mathematics learning. The questions did not specifically address how a child's life experiences, parents, and peers have influenced his attitudes about mathematics. Further research around mathematics interactions with peers within the classroom may help to illuminate the subtle influences peers may have on mathematics learning. Research that reports error analysis of mathematics' assignments and tests may provide

other valuable information about the way a child with NLD conceptualizes mathematics. Caution should be exercised when attempting to generalize this study as it was a time-limited single-participant case study.

### **Implications for Future Research**

Broadening the research on NLD suggests considering the whole child, his learning environment, his attitudes, his abilities, and his challenges. Narrative research may inform researchers about the rationale behind the way in which a child with NLD abstracts information from mathematics problems and brings meaning to mathematics applications. Activating the voice of a child in a research setting may facilitate a better understanding of the student's metacognition about his learning process and the unique efforts made when problem solving.

Assuming that the attitudes of family, peers, and indeed, teachers may play a significant role in misrepresenting mathematics; researchers might consider creating research environments that encourage the construction of mathematics through the use of discussion and real life engagement. Expanding the research environment to include constructive conversations about mathematics may help to make audible a child's different ways of understanding mathematics.

Given that narrative abilities clearly draw from upon social-emotional, cognitive and linguistic knowledge and abilities (Losh and Capps, 2003), and because children with NLD are loquacious, utilizing narrative practices as a research tool may assist researchers to develop a rich sense of the child with NLD. Furthermore, when researchers give voice to student-participant's narratives, the student's perspective is endorsed (Sanchez and Fried, 1997) and the narrative has

the potential to inform professional practices. Researchers, educators, parents are challenged to view the child with NLD as a social activist who has a natural ability to inform our views about learning capabilities.

As mathematics applications in a real life setting are often challenging and generate a negative affect, researchers may want to consider exploring the strategies children employ to bypass their negative disposition. Tracking the incorporation of humourous and entertaining materials in a mathematics environment may help to shape a model for effective learning that results in children having fun in a mathematics environment.

It was the goal of this research to reveal how the child with NLD navigates in a mathematics setting. Demonstrating how a child with NLD represents mathematical concepts and interacts in a mathematics setting supports the notion that children's engagement in a learning environment may be best represented when they are asked to communicate about their learning process. Accessing a child's perspective about mathematics may assist educators in developing interventions that facilitate meaningful learning for a child with NLD. A major contribution of this study is the rich contextual narratives that helped to shape the way in which educators might view a child with NLD. The findings in this study are reported in such a way that it can be of use to researchers and educators as excerpts of the mathematics interaction accentuate the individual learner with NLD. The case study design produced a phenomenological analysis of the unique way a child with NLD learns.

Appendix A

**Tables and Figures**

**Table 1 - Revised Rules for Classifying NLD Children**

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Revised Rules for Classifying Children (ages 9-15 years) and Percentage of Cases for Which Each Rule Applied in the Combined and Probable Categories in Phase 2

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**Rules For Classifying NLD**

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1. Less than two errors on simple tactile perception and suppression vs. finger agnosia, finger dysgraphesthesia, astereognosis composite greater than 1SD below the mean (90.9%)
2. WRAT/WRAT – R standard score for Reading is at least 8 points greater than Arithmetic (85.7%)
3. Two of WISC/WISC –R Vocabulary, Similarities, and Information are highest of the Verbal scale (77.9%)
4. Two of WISC/WISC – R Block Design, Object Assembly, and Coding subtests are the lowest of the Performance scale (76.6%)
5. Target Test at least 1 SD below the mean (63.6%)
6. Grip strength within one standard deviation of the mean or above vs. Grooved Pegboard Test greater than one standard deviation below the mean (63.6%)
7. Tactual performance Test Right, Left, and Both hand times become progressively worse vis-a-vis the norms (59.7%)
8. WISCWISC- R VIQ > PIQ by at least 10 points (27.3%)

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Pelletier, Ahmad, and Rourke, 2001

**Table 2 - A Summary of Rourke's (1989) NLD Model**

	<b>Assets</b>	<b>Deficits</b>
<b>Primary</b>	Auditory perception Simple motor Rote memory	Tactile perception Visual perception Complex psychomotor Novel material
<b>Secondary</b>	Attention (auditory; verbal)	Attention (tactile; visual) Exploratory behaviour
<b>Tertiary</b>	Memory (auditory; verbal)	Memory (tactile; visual) Concept formation Problem solving
<b>Verbal</b>	Phonology Verbal reception Verbal repetition Verbal storage Verbal associations Verbal output (volume)	Oral motor-praxis Prosody Phonology- semantics Content Pragmatics Function
<b>Academic</b>	Graphomotor (late) Word decoding Spelling Verbatim memory	Graphomotor (early) Reading Comprehension Mechanical arithmetic Mathematics Science
<b>Socioemotional</b>	Variability	Adaptation to novelty Social competence Emotional stability Activity level

**Table 3 - Subtypes of Learning Disabilities in Mathematics (Geary, 2004)**

Cognitive and performance features	Neuropsychological features	Genetic features	Developmental Features	Relation to RD
<b>Procedural Subtype</b>				
<ul style="list-style-type: none"> <li>- Relatively frequent use of developmentally immature procedures</li> <li>- Frequent errors in the execution of procedures</li> <li>- Poor understanding of the concepts underlying procedural use</li> <li>- Difficulties sequencing the multiple steps in complex procedures</li> </ul>	<p>Unclear, although some data suggest an association with left hemispheric dysfunction and, in some cases, a prefrontal dysfunction</p>	<p>Unclear</p>	<p>Appears in many cases, to represent a developmental delay</p>	<p>Unclear</p>
<b>Semantic Memory Subtype</b>				
<ul style="list-style-type: none"> <li>-Difficulties retrieving mathematical facts, such as answers to simple arithmetic problems</li> <li>- For facts that are retrieved, there is a high error rate</li> <li>- For arithmetic, retrieval errors are often associates of number in the problem</li> <li>- RTs for correct retrieval are unsystematic</li> </ul>	<ul style="list-style-type: none"> <li>-Appears to be associated with left hemispheric dysfunction, possibly the posterior regions for one form of retrieval deficit and the prefrontal regions for another</li> <li>- Possible subcortical involvement, such as basal ganglia</li> </ul>	<p>Appears to be heritable deficit</p>	<p>Appears to represent a developmental difference</p>	<p>Appears to occur with phonetic forms of RD</p>
<b>Visuospatial Subtype</b>				
<ul style="list-style-type: none"> <li>-Difficulties is spatially representing numerical and other forms of mathematical information and relationships</li> <li>- Frequent misinterpretation or misunderstanding of spatially represented information</li> </ul>	<p>Appears to be associated with right hemispheric dysfunction, in particular, posterior regions of the right hemisphere, although the parietal cortex of the left hemisphere may be implicated as well</p>	<p>Unclear, although the cognitive and performance features are common with certain genetic disorders</p>	<p>Unclear</p>	<p>Does not appear to be related</p>

## Figure 1 - Interventions for Students with NLD

### Interventions for Psychomotor and Perceptual Motor Deficits

#### *Remedial Interventions:*

- Specified training/practice in handwriting accuracy and speed
- Direct instruction in functional perceptual skills such as reading facial expressions, understanding gestural communication, and reading maps and graphs

#### *Compensatory Interventions:*

- Extended time for completion of written tasks
- Handwriting aids, such as word processor or scribe
- Reliance on multiple choice over essay tests when examining content knowledge
- Organizing work sheets with a limited number of clear, well spaced prompts
- Teacher-prepared lecture guides to minimize need for note taking
- Use of oral or written directions and explanations instead on visual maps and schemas

#### *Instructional/therapeutic Interventions:*

- Adapted physical education with emphasis on developing functional recreational activities
- Early and sustained training and practice in keyboarding
- Occupational therapy to enhance perceptual and psychomotor deficits

### Interventions for Arithmetic Deficits

#### *Remedial Interventions:*

- Direct instruction in computation using verbal mediation to rehearse sequential steps
- Graph paper to assist in column alignment when completing math problems
- Use of calculator or matrix of arithmetic facts
- Instructional/therapeutic interventions
- Verbal rhymes and memory aids to teach math facts
- Colour-coded math work sheets to cue left-right directionality
- Interventions to improve synthesis and integration
- Direction instruction in organizational schemas and checking strategies
- Preteaching/reteaching to illustrate and reinforce relationships and distinctions among concepts

#### *Compensatory Interventions:*

- Commercially or teacher prepared chapter summaries and study guides
- Rehearsal strategies that rely on verbal mnemonics

#### *Instructional/Therapeutic Interventions:*

- Strategy training in specific skill areas, such as written expression
- Graphic organizers, especially those with sequential/linear components

## **Intervention for Problem-Solving Skills**

### ***Remedial Interventions:***

- Direct instruction and rehearsal of appropriate responses in various situations

### ***Compensatory Interventions:***

- Reference list to rote “rules” to direct behaviour

### ***Instructional Interventions:***

- Problem-solving instruction and practice, such as those found on many educational web pages

## **Intervention for Social and Interpersonal Skills**

### ***Remedial Interventions:***

- Direct instruction in social pragmatic skills, such as making appropriate eye contact, greeting others and requesting assistance
- Teaching strategies for making and keeping friends

### ***Compensatory Interventions:***

- Vocational guidance toward careers that minimize interpersonal skills, if appropriate
- Choosing structured, adult-directed, individual or single-peer social activities over unstructured or large group events

### ***Instructional Interventions:***

- Social skills training, target critical skills, match training to individual behavioural deficits/excesses, train in natural settings, and use functional approach to generalization
- Interpersonal rules, social stories, and social scripting
- Pragmatic language therapy to address skills related to topic maintenance, verbal self-monitoring, and appropriate social communication

## **Intervention for Psychosocial Adjustment Problems**

### ***Remedial Interventions:***

- Self monitoring to reduce symptoms of inattention and impulsive behaviour

### ***Compensatory Interventions:***

- Investigation of other features of NLD syndrome in preschool/primary age children who display symptoms of ADHD
- Relaxation skills to compensate for pervasive anxiety
- Increasing access to pleasant events to address depressive symptoms

### ***Instructional/Therapeutic Intervention:***

- Educator/parent awareness training concerning risk for depression and suicide
- Student insight counseling about NLD features, interventions, and prognoses
- Cognitive behavioural interventions to enhance positive self-schema and reduce cognitive distortions

**Source:** Telzrow, C. and Bonar, A. (2002). Responding to students with nonverbal learning disabilities. *Teaching Exceptional Children*, 34(4).

## Figure 2 - Characteristics and Indicators of NLD Syndrome

### Primary Characteristics of NLD

### Possible Indicators of the NLD Syndrome

**Stronger verbal than perceptual cognitive skills**

- Higher Verbal OQ than Performance IQ scores
- Stronger on verbal than visual attention and memory tasks

**Weak psychomotor and perceptual motor skills**

- Physically awkward: slow to skip, ride bike, or tie shoes
- Difficulty with tracing, cutting, and colouring
- Poor handwriting and notebook organization

**Deficiency in arithmetic**

- Better reading and spelling than arithmetic performance
- Problems with number alignment and directionality
- Confusion of mathematical symbols and problem-solving sequences

**Difficulty with novel and complex tasks**

- Rote memory performance superior to tasks requiring integration and synthesis
- Reliance on automatic verbal responses in novel situations

**Poor problem-solving skills**

- May be inflexible, unable consider alternative actions
- Difficulty with changes in routine

**Social and interpersonal deficits**

- Misinterprets social cues: may be too impulsive, too familiar
- Tendency to be teased or bullied; prone to social withdrawal
- Pedantic, “little professor” style of communication
- Unusual speech prosody, mechanical speech
- Difficulty understanding jokes or sarcasm
- Limited self-awareness; unrealistic career choices

**Psychosocial adjustment problems**

- Evidence of inattention and hyperactivity during preschool and primary grades
- Higher prevalence of anxiety and depression during adolescence

**Source:** Telzrow, C. and Bonar, A. (2002). Responding to students with nonverbal learning disabilities. *Teaching Exceptional Children*, 34(4).

Appendix B

**Letters**

## Letter of Intent to School Board

I am a graduate student in the Faculty of Education, School Psychology Program at Mount Saint Vincent University. As part of the requirements for my Masters of Arts in School Psychology thesis, I am conducting research under the supervision of Dr. Geneviève Boulet. I am seeking your permission to participate in my study, *Conveying Mathematical Experiences: the Voice of a Child with Nonverbal Learning Disability*. The purpose of the study is to examine the experience of a child with nonverbal learning disability (NLD) in a mathematics setting. I am interested in learning about how the child with NLD navigates in the mathematics classroom, how he/he conceptualizes mathematics, and how his/her experience in a mathematics setting impacts his/her emotional responses. It is my hope that the student's voice may become a powerful instrument that informs us about his/her abilities and disabilities and inevitably influences the interventions that are employed for this LD subtype.

The research involves a single subject case study that will require a review of the child's records, observations in the classroom, interviews, and interactions with a student with NLD in the mathematics resource room. The participant will be in Grade 4-6 and will require three 40-minute sessions between the student and researcher over a 3 week period. An audio recording of the interview sessions will be produced and then destroyed at the end of the data analysis. During the 5 sessions, a pre and post interview will take place as well as 3 sessions where the researcher will interact with the child as he/he works with grade appropriate mathematics problems. The mathematics teacher and/or the resource teacher will be consulted to establish the least intrusive manner to conduct this research as well as to ensure that the mathematics sessions are supportive and grade appropriate for the child. I would begin the study in June, 2006, with the goal of completing the study by end of June, 2006.

The results of the study will be reported in a narrative format after the data is analyzed. The participant and parents in the study will be assured of confidentiality for his/her involvement in the case study. All personal identifiers to the person and identifiers of the school and School Board will be omitted from the text of the thesis. The school board's participation is completely voluntary. The School Board, will have the right to withdraw from this study at any time without penalty. The identity of the school, the student and teachers involved in the study are to be kept confidential. The school, the personnel, and the student-participant will have the right to withdraw from this study at any time without penalty. The study will take place in a school setting with minimal risk to the participant as the foremost goal.

Permission to participate in this study will be obtained from the principal and staff of the school and informed consent will be obtained from the parents, and from the student. Copies of the sample letters and consent forms are attached.

If you have any questions about this study, please contact Bernadette Campbell at [REDACTED] or you may contact Dr. Geneviève Boulet, at 457-6305, [genevieve.boulet@msvu.ca](mailto:genevieve.boulet@msvu.ca). This research activity has met the ethical standards of the University Research Ethics Board at Mount Saint Vincent University. The University Research Ethics Chair is not directly involved in the study, but if you have any questions or concerns about

this study, you may contact the UREB Chair by phone at 902-457-6350 or by e-mail at [research@msvu.ca](mailto:research@msvu.ca).

Sincerely,

Bernadette Campbell  
Graduate Student, MSVU School Psychology

Dr. Geneviève Boulet  
Professor  
Faculty of Education  
Thesis Supervisor, MSVU

## **Letter of Intent to the Principal of the School**

I am a graduate student in the Faculty of Education, School Psychology Program at Mount Saint Vincent University. As part of the requirements for my Master of Arts in School Psychology thesis, I am conducting research under the supervision of Dr. Geneviève Boulet. I am seeking your permission to participate in my study, *Conveying Mathematical Experiences: the Voice of a Child with Nonverbal Learning Disability (NLD)*. The purpose of the study is to examine the experience of a child with nonverbal learning disability (NLD) in a mathematics setting. I am interested in learning about how the child with NLD navigates in the mathematics classroom, how he/she conceptualizes mathematics, and how his/her experience in a mathematics setting impacts his/her emotional responses. It is my hope that the student's voice may become a powerful instrument that informs us about his/her abilities and disabilities and inevitably influences the interventions that are employed for this LD subtype.

The research involves a single subject case study that will require a review of the child's records, observations in the classroom, interviews, and interactions with a student with NLD in the mathematics resource room. The student participant will be in Grade 4-6 and will require five 40-minute sessions between the student and researcher over a 3 week period. An audio recording of the interview sessions will be produced and then destroyed at the end of the data analysis. During the 5 sessions, a pre and post interview will take place as well as 3 sessions where the researcher will interact with the child as he/she works with grade appropriate mathematics problems. The mathematics teacher and/or the resource teacher will be consulted to establish the least intrusive manner to conduct this research as well as to ensure that the mathematics sessions are supportive and grade appropriate for the child. I would begin the study in June, 2006, with the goal of completing the study by end of June, 2006.

The results of the study will be reported in a descriptive format after the data is analyzed. The participant, parents, and teachers in the study will be assured of confidentiality. All personal identifiers to the person and identifiers of the school will be omitted from the text of the thesis. The school's participation is completely voluntary and the school understands that the identity of the student and teachers involved in the study are to be kept confidential. The school, the personnel, and the participant will have the right to withdraw from this study at any time without penalty. Enclosed is a consent form that asks a Grade 4-6 teacher and resource teacher to be consulted for this study. The study will take place in a school setting with minimal risk to the participant as the foremost goal.

This is a single subject case study that will require the school's assistance in the selection of a single student participant. As principal, I ask for your support in forwarding the enclosed flyer to the parent of a qualifying participant who meets the criteria for this study. The criteria are: a Grade 4-6 student diagnosed with NLD by a Nova Scotia School Psychologist. This student must be experiencing difficulty with mathematics and receives resource support. If more than one participant is willing to take part in this study, the child who most closely meets the criteria and is in a school that is readily accessible to the researcher will be chosen.

Permission to participate in this study will be obtained from the parents, and from the student. Copies of the sample letters are attached.

If you have any questions about this study, please contact Bernadette Campbell at [REDACTED] or you may contact Dr. Geneviève Boulet, at 457-6305, [genevieve.boulet@msvu.ca](mailto:genevieve.boulet@msvu.ca). This research activity has met the ethical standards of the University Research Ethics Board at Mount Saint Vincent University. The University Research Ethics Chair is not directly involved in the study, but if you have any questions or concerns about this study, you may contact the UREB Chair by phone at 902-457-6350 or by e-mail at [research@msvu.ca](mailto:research@msvu.ca).

Sincerely,

Bernadette Campbell  
Graduate Student, MSVU School Psychology

Dr. Geneviève Boulet  
Professor  
Faculty of Education  
Thesis Supervisor, MSVU

## **Letter of Intent to the Teacher(s) of the School**

I am a graduate student in the Faculty of Education, School Psychology Program at Mount Saint Vincent University. As part of the requirements for my Master of Arts in School Psychology thesis, I am conducting research under the supervision of Dr. Geneviève Boulet. I am seeking your permission to participate in my study, *Conveying Mathematical Experiences: the Voice of a Child with Nonverbal Learning Disability (NLD)*. The purpose of the study is to examine the experience of a child with nonverbal learning disability (NLD) in a mathematics setting. I am interested in learning about how the child with NLD navigates in the mathematics classroom, how he/she conceptualizes mathematics, and how his/her experience in a mathematics setting impacts his/her emotional responses. It is my hope that the student's voice may become a powerful instrument that informs us about his/her abilities and disabilities and inevitably influences the interventions that are employed for this LD subtype.

The research involves a single subject case study that will require a review of the child's records, observations in the classroom, interviews, and interactions with a student with NLD in the mathematics resource room. The student participant will be in Grade 4-6 and will require five 40-minute sessions between the student and researcher over a 3 week period. An audio recording of the interview sessions will be produced and then destroyed at the end of the data analysis. During the 5 sessions, a pre and post interview will take place as well as 3 sessions where the researcher will interact with the child as he/she works on grade appropriate mathematics problems. A consult with the mathematics teacher and/or the resource teacher will be required. As the mathematics teacher and/or resource teacher of a child with NLD in Grade 4-6, I will ask your assistance to establish an appropriate time in your class schedule to conduct the classroom observations and to interact with the child in a mathematics resource room. The sessions are not intended as a substitute for resource. To ensure that the mathematics sessions are supportive, complement the current mathematics teaching, and are grade appropriate for the child, I will ask your advice on Grade 4-6 mathematics exercises that a child with NLD could work on while I observe. As mentioned, these three interactions are an opportunity for me to observe how the student interacts with mathematics, how the child conceptualizes mathematics, and how he/her experience in a mathematics setting impacts his/her emotional responses. I would begin the study at the beginning of June, 2006, with the goal of completing the study by the end of June, 2006. June is a time when resource services terminate and when students are practicing skills, rather than learning new concepts.

The results of the study will be reported in a descriptive format after the data is analyzed. The participant, parents, and teachers in the study will be assured of confidentiality. All personal identifiers to the person and identifiers of the school will be omitted from the text of the thesis. Your participation is completely voluntary and the identity of the school, teacher and student involved in the study are to be kept confidential. The school, the personnel, and the participant will have the right to withdraw from this study at any time without penalty. Enclosed is a consent form that requests your participation in the study. The study will take place in a school setting with minimal risk to the participant as the foremost goal.

If you have any questions about this study, please contact Bernadette Campbell at [REDACTED] or you may contact Dr. Geneviève Boulet, at 457-6305, [genevieve.boulet@msvu.ca](mailto:genevieve.boulet@msvu.ca). This research activity has met the ethical standards of the University

Research Ethics Board at Mount Saint Vincent University. The University Research Ethics Chair is not directly involved in the study, but if you have any questions or concerns about this study, you may contact the UREB Chair by phone at 902-457-6350 or by e-mail at [research@msvu.ca](mailto:research@msvu.ca).

Sincerely,

Bernadette Campbell  
Graduate Student, MSVU School Psychology

Dr. Geneviève Boulet  
Professor  
Faculty of Education  
Thesis Supervisor, MSVU

**Teacher / Resource Teacher Consent Form**

I, \_\_\_\_\_ (Teacher /Resource Teacher) give permission to be consulted by a MSVU researcher , Bernadette Campbell , as part of the examination of how a child with NLD experiences the learning of mathematics. I understand that any identifying information will be kept strictly confidential by the researcher.

I agree to keep confidential the name of the child involved in the study.

\_\_\_\_\_  
Teacher 's Signature

\_\_\_\_\_  
Resource Teacher's Signature

Date: \_\_\_\_\_

*One signed copy to be kept by the researcher, one signed copy to be kept by the school, and teacher(s).*

Please return to: Ms. Bernadette Campbell  
PO Box 198 Mabou, NS, BOE 1XO

## Letter of Consent to Parents and Child

I am a graduate student in the Faculty of Education, School Psychology Program at Mount Saint Vincent University. As part of the requirements for my Master of Arts in School Psychology thesis, I am conducting research under the supervision of Dr. Geneviève Boulet. I am seeking your permission to allow your child to participate in my study, *Conveying Mathematical Experiences: the Voice of a Child with Nonverbal Learning Disability (NLD)*. The purpose of the study is to examine the experience of a child with nonverbal learning disability (NLD) in a mathematics setting. I am interested in learning about how the child with NLD navigates in the mathematics classroom, how he/she conceptualizes mathematics, and how his/her experience in a mathematics setting impacts his/her emotional responses. It is my hope that the student's voice may become a powerful instrument that informs us about his/her abilities and disabilities and inevitably influences the interventions that are employed for this LD subtype.

The research involves a case study that will require a review of your child's records, two observations in the classroom, and five interactions with your child (two interviews with your child and three interactions using grade appropriate mathematics exercises) in a resource room. The review of your child's records will provide a broader understanding of your child and his/her learning profile, no parts of your child's records will be reproduced. Your child will be asked to participate in five 40-minute sessions over 3-4 week period. As mentioned above, it is my hope that the five sessions will capture your child's experience within a mathematics setting. During the five sessions, a pre and post interview will take place as well as 3 sessions where the researcher will observe your child as he/she works with grade appropriate mathematics problems. An audio recording of the interviews will be produced and then destroyed at the end of the data analysis. The mathematics teacher and/or the resource teacher will be consulted to establish the least intrusive manner to conduct this research as well as to ensure that the mathematics sessions are supportive and grade appropriate for your child. I would begin the study at the beginning of June, 2006, with the goal of completing the study by the end of June, 2006. June is a time when resource services terminate and when students are practicing skills, rather than learning new concepts. Your child will not have any additional workload as a result of participating in this study.

The results of the study will be reported in a descriptive format once the data is analyzed. The participant in the study will be assured of confidentiality for his/her involvement in the case study. All personal identifiers to the person and identifiers of the school will be omitted from the text of the thesis. Your participation is completely voluntary and your child will have the right to withdraw from this study at any time without penalty. The study will take place in a school setting with minimal risk to your child.

This letter requests your consent as well as your child's to be a participant in this study. If you and your child agree to be part of this case study, I ask that you sign the attached form granting permission and return it to the address enclosed. As a token of appreciation, a book will be given to your child at the end of the five sessions with a signed note from the researcher.

If you have any questions about this study, please contact Bernadette Campbell at [REDACTED], [REDACTED] or you may contact Dr. Geneviève Boulet, at 457-6305, [genevieve.boulet@msvu.ca](mailto:genevieve.boulet@msvu.ca). The School Board and your child's principal have given me permission to conduct this study. If you have further questions on the research, you may contact

Jack Beaton at [REDACTED]. This research activity has met the ethical standards of the University Research Ethics Board at Mount Saint Vincent University. The University Research Ethics Chair is not directly involved in the study, but if you have any questions or concerns about this study, you may contact the UREB Chair by phone at 902-457-6350 or by e-mail at [research@msvu.ca](mailto:research@msvu.ca).

Sincerely,

Bernadette Campbell  
Graduate Student, MSVU School Psychology

Dr. Geneviève Boulet  
Professor  
Faculty of Education  
Thesis Supervisor, MSVU

**Student and Parent Consent Form**

I, \_\_\_\_\_ (Parent/guardian) give permission for my son/daughter \_\_\_\_\_, to participate in the case study that examines how a child with NLD experiences the learning of mathematics. I understand that any identifying information will be kept strictly confidential.

I, \_\_\_\_\_ (student name) agree to participate in the study that examines my experience in a mathematics setting. I understand that I will not be forced to participate and am free to withdraw from this study at any time.

\_\_\_\_\_

\_\_\_\_\_

Parent/guardian's Signature

Student's Signature

Date: \_\_\_\_\_

*One signed copy to be kept by the researcher, one signed copy to be kept by the parent.*

Please return to: Ms. Bernadette Campbell  
PO Box 198 Mabou, NS, BOE 1X0

Appendix C  
**Interview Questions**

## **Interview Questions**

### First Interview:

1. Tell me about your favourite subject? Why do you enjoy it?
2. In mathematics, how do you feel as a student?
3. What tricks or shortcuts might you use when completing a mathematics problem?
4. Describe what it's like doing mathematics homework? Tests?
5. Suppose you had to teach mathematics, what would you like to teach?
6. If you could change one thing about learning mathematics, what would it be?

### Post Interview:

7. How would you describe your mathematics school work to a new student in your school?
8. If you had an opportunity, what would you like to tell your teacher about your mathematics class?
9. What would you say to a student who is having difficulty in mathematics?
10. Where would you use mathematics outside of school?
11. How do you react when you when you receive a good grade in mathematics?

Appendix D  
**Parent Flyer**



**A Mount Saint Vincent University  
School Psychology student  
needs your help....**

- Is your son or daughter in Grade 4-6?
- Has your son or daughter been diagnosed with Nonverbal Learning Disability?
  - Does your son or daughter receive resource in mathematics?
- Would your son or daughter be interested in interacting with a school psychology student to share his/her experiences in mathematics?
- Are you interested in learning more about mathematics disabilities?
- And would you like your child to support a Mount Saint Vincent University research study that hopes to learn more about the child with Nonverbal Learning Disability?

**If so....**

**Contact: Bernadette Campbell at**

**██████████ or ██████████**



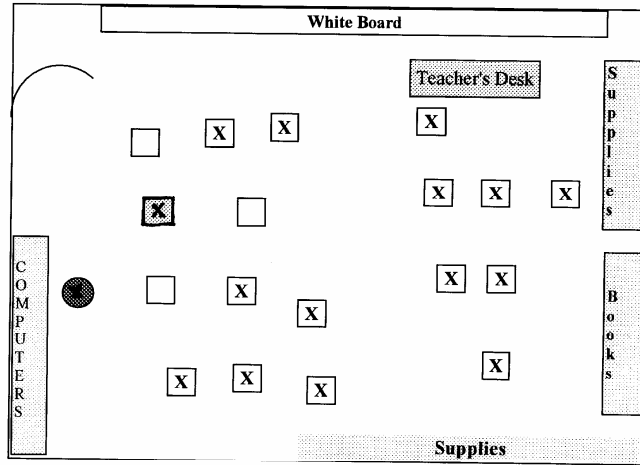
Appendix E  
**Schedule of Interactions**

## Schedule of Interactions with Student-Participant





<b>JUNE 2006</b>						
SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
				1	2	3
4	5	6	7	8	9	10
11	12 Principal calls to confirm a possible participant	13	14 Meet with parents of student- participant	15 Meet with Teacher & Consent Forms Signed	16 <b>Observe in Math Class</b>	17
18	19	20 <b>Observe in Math Class</b>  <b>Interview Session #1</b>	21 <b>Session # 2</b>	22	23 <b>Session # 2</b>	24
25	26 <b>Session # 3 Interview</b>	27	28	29	30	

Appendix F  
**Classroom Sketches**

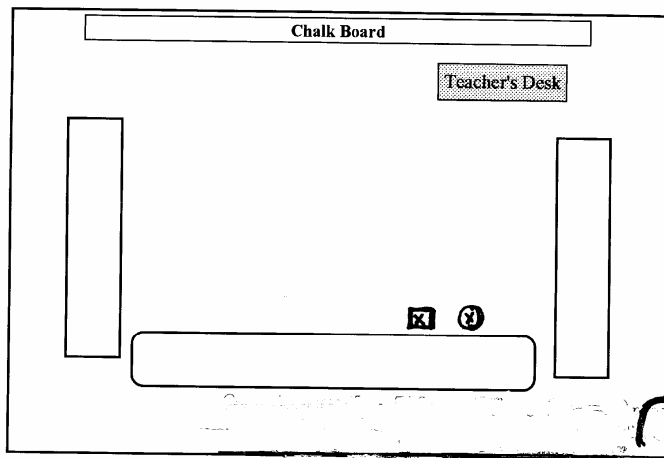
- Classroom Sketch



Legend:

-  Student-Participant
-  Researcher
-  Other Students
-  Door Entrance

- Resource Room Sketch



Appendix G

**Mathematics Textbook Exercises**

## Show and Share

Share your work with another pair of students.  
Compare the fractions you wrote for each colour.  
How did you know which fractions to write?  
Describe any patterns you see  
in the fractions for each colour.

This rectangle was made with Colour Tiles.

What fraction of the rectangle is green?  
How many different fractions can you write?  
*How do you do not see a fraction?*

- ▶ There are 24 tiles in the rectangle.  
12 tiles are green.

$\frac{12}{24}$  of the rectangle is green.

- ▶ There are 12 groups of 2 tiles.  
6 groups are green.

$\frac{6}{12}$  of the rectangle is green.

- ▶ There are 8 groups of 3 tiles.  
4 groups are green.

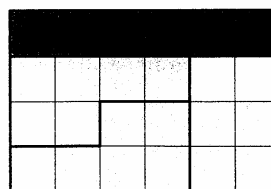
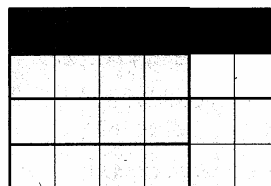
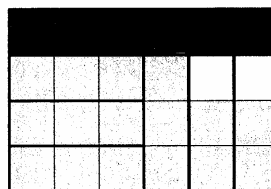
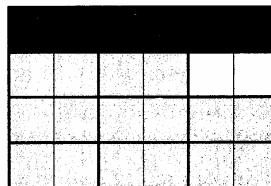
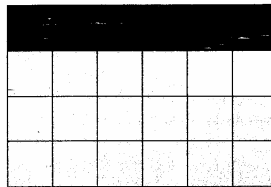
$\frac{4}{8}$  of the rectangle is green.

- ▶ There are 6 groups of 4 tiles.  
3 groups are green.

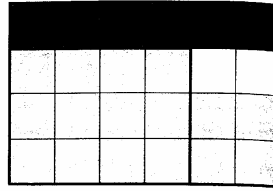
$\frac{3}{6}$  of the rectangle is green.

- ▶ There are 4 groups of 6 tiles.  
2 groups are green.

$\frac{2}{4}$  of the rectangle is green.



- Finally, there are 2 groups of 12 tiles.  
1 group is green.  
 $\frac{1}{2}$  of the rectangle is green.



$\frac{1}{2}, \frac{2}{4}, \frac{3}{6}, \frac{4}{8}, \frac{6}{12},$  and  $\frac{12}{24}$  represent the same amount.  
They are equivalent fractions.

- There are patterns in the equivalent fractions.

$\frac{1}{2}, \frac{2}{4}, \frac{3}{6}, \frac{4}{8}, \frac{6}{12}, \frac{12}{24}$

The numerators are multiples of the least numerator, 1.

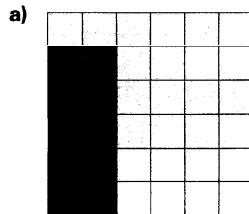
The denominators are multiples of least denominator, 2.



There are other fractions equivalent to  $\frac{1}{2}$ .  
I could use different rectangles to find equivalent fractions with denominators such as 10, 14, and 16.

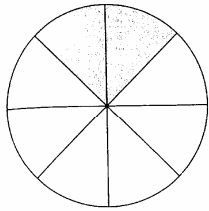
Use Colour Tiles or grid paper when they help.

1. What fraction of each figure is blue?  
How many different fractions can you write each time?

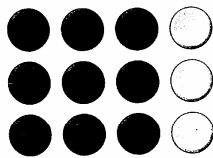


Find as many equivalent fractions as you can for each picture.

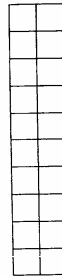
a)



b)



c)



3. Write 3 fractions that are equivalent to  $\frac{2}{5}$ . Explain how you did it.

June 20/2006

Handwritten student work for question 3, showing three horizontal lines with scribbled-out text and a ruler-like scale below.

4. Draw a picture to show each pair of equivalent fractions.

a)  $\frac{1}{4}, \frac{3}{12}$

b)  $\frac{2}{3}, \frac{8}{12}$

c)  $\frac{3}{5}, \frac{12}{20}$

5. Rhonda, Apak, Kayla, and Sunil each ordered a large pizza.

Each pizza was cut into slices of equal size.

\* Rhonda's pizza had 6 slices, Apak's had 8, Kayla's had 10, and Sunil's had 12.

Abak) \* spelling error

Each student ate his or her own pizza.

Rhonda ate 3 slices, Apak ate 4, Kayla ate 5, and Sunil ate 6.

Sunil says he ate the most because he ate 6 pieces.

Rhonda says everyone ate the same amount.

Who is correct? Use pictures, numbers, and words to explain.

### Reflect


How can you tell if two fractions are equivalent?  
Use numbers, pictures, or words to explain.

### Numbers Every Day

#### Calculator Skills

Find 2 ways to determine the quotient of  $156 \div 6$  without pressing the  $\div$  key.

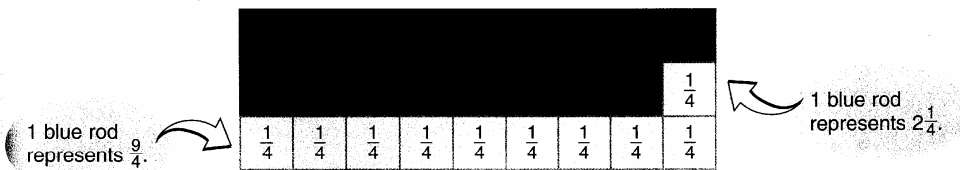


Suppose  = 1 whole.

What fraction does a blue rod represent?



Two pink rods fit on the blue rod, with some of the blue rod left over.  
There are 2 wholes with some left over.  
The length left over is the length of a tan rod.  
One tan rod is  $\frac{1}{4}$  of one pink rod.



$2\frac{1}{4}$  and  $\frac{9}{4}$  are equivalent.



Use Cuisenaire rods or paper strips when they help.

- Which scoop would you use to measure each amount?  
How many scoops would you need?



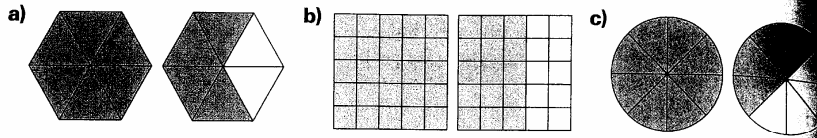
- $2\frac{1}{4}$  cups
  - $2\frac{1}{2}$  cups
  - $1\frac{2}{3}$  cups
  - $3\frac{1}{2}$  cups
- Look at question 1. How many different ways can you use the scoops to measure each amount?  
Record each way.

**Numbers Every Day**

**Number Strategies**  
Find each product.

$12 \times 16 = \square$   
 $24 \times 16 = \square$   
 $12 \times 32 = \square$   
 $24 \times 32 = \square$

3. What fraction does each picture represent?  
Write an equivalent fraction for each.



4. Are the fractions in each pair equivalent?  
How do you know?

a)  $3\frac{2}{3}$  and  $\frac{11}{3}$

b)  $\frac{13}{8}$  and  $1\frac{5}{8}$

c)  $2\frac{3}{4}$  and  $\frac{9}{4}$

5. Kendra mowed her lawn in  $2\frac{1}{2}$  h.  
Mario mowed his lawn for  $\frac{1}{4}$  h, then stopped.  
He did this 7 times.  
Who spent the most time mowing the lawn?  
How do you know?



6. Carlo baked pies for a party.  
He cut some pies into 6 pieces  
and some into 8 pieces.  
After the party, more than  $2\frac{1}{2}$   
but less than 3 pies were left.  
How much pie might have  
been left?  
Show how you know.



7. How can you find out if  $2\frac{1}{2}$  and  $\frac{10}{4}$   
name the same amount?  
Use words, numbers, and pictures to explain.

## Reflect

When you see an improper fraction,  
how can you write it as a mixed number?

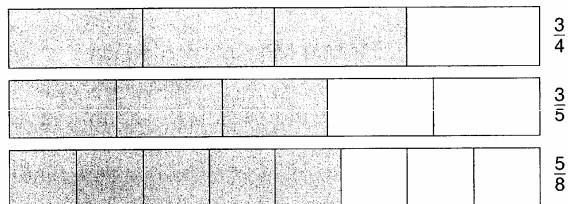
When do you use fractions  
and mixed numbers at home?  
Explain.



Here are 3 ways to order fractions.

- Order  $\frac{3}{4}$ ,  $\frac{3}{5}$ , and  $\frac{5}{8}$  from least to greatest.

Fold or measure, then colour, 10-cm strips of paper.

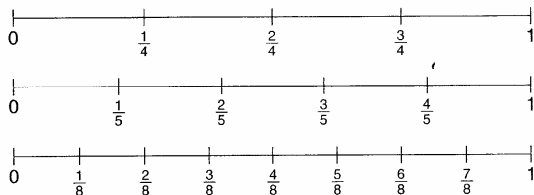


The least fraction is the shortest coloured strip.

The order from least to greatest is  $\frac{3}{5}$ ,  $\frac{5}{8}$ , and  $\frac{3}{4}$ .

- Order  $\frac{2}{5}$ ,  $\frac{1}{4}$ , and  $\frac{5}{8}$  from least to greatest.

Draw number lines.



$\frac{1}{4}$  is to the left of  $\frac{2}{5}$ .

$\frac{2}{5}$  is to the left of  $\frac{5}{8}$ .

The order from least to greatest is  $\frac{1}{4}$ ,  $\frac{2}{5}$ , and  $\frac{5}{8}$ .

- Compare pairs of fractions with the same numerator or denominator.

Compare  $\frac{3}{8}$  and  $\frac{3}{5}$ .

Both fractions have the same number of parts, 3.

Since one-fifth is greater than one-eighth,  $\frac{3}{5}$  is greater than  $\frac{3}{8}$ .

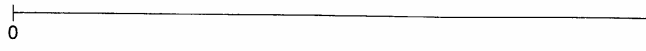
Compare  $\frac{3}{4}$  and  $\frac{5}{8}$ .

Find equivalent fractions with eighths.

$$\frac{3}{4} = \frac{6}{8}$$

$$\frac{6}{8} > \frac{5}{8}, \text{ so } \frac{3}{4} > \frac{5}{8}$$

5. Use 3 copies of a 12-cm number line like the one below.



Show halves on one line.

Show thirds on another line.

Show sixths on the third line.

Use the number lines to order these fractions from least to greatest.

a)  $\frac{2}{2}, \frac{1}{3}, \frac{3}{6}$       b)  $\frac{1}{6}, \frac{2}{3}, \frac{5}{6}$

6. Use grid paper.

Draw pictures to represent 3 fractions that are greater than  $\frac{3}{5}$ .

Each fraction should have a different denominator.



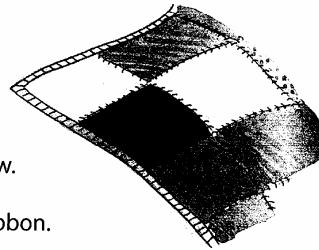
7. A quilt has 20 patches.

One-quarter of the patches are yellow,

$\frac{3}{5}$  are green, and the rest are red.

What colour are the greatest number of patches?

The least number of patches? Show how you know.



8. Jessica and Ramon each have the same length of ribbon.

Jessica cut her ribbon into eighths.

Ramon cut his ribbon into twelfths.

Jessica sold 6 pieces and Ramon sold 8.

Who sold the most ribbon? How did you find out?

9. Which is greater,  $\frac{2}{3}$  or  $\frac{2}{5}$ ? How do you know?

10. Compare the fractions in each pair.

Copy each statement. Write  $>$ ,  $<$ , or  $=$ .

How did you decide which symbol to choose?

a)  $\frac{4}{5} \square \frac{4}{10}$

b)  $\frac{3}{8} \square \frac{2}{8}$

c)  $\frac{2}{3} \square \frac{4}{6}$

d)  $\frac{1}{4} \square \frac{1}{3}$

## Reflect

Use pictures, words, or numbers to explain which is greater,

$\frac{7}{8}$  or  $\frac{3}{4}$ .

Appendix H

**Samples of Student-Participant's Mathematics Work**

3 24 5

June 20, 2006

12 green

$\frac{12}{24}$  green

$\frac{6}{24}$  red

$\frac{4}{24}$  blue

$\frac{2}{24}$  yellow

Pg. 246

June 20, 2006

1a  $\frac{6}{36}$  blue

b.  $\frac{10}{40}$  blue

Pg. 247

June 20, 2006

2. a)  $\frac{2}{7}$

$\frac{2}{7}$  blue

b)  $\frac{9}{12}$

$\frac{9}{12}$  red

$\frac{3}{12}$  yellow

c)  $\frac{4}{20}$  yellow

$\frac{16}{20}$  white

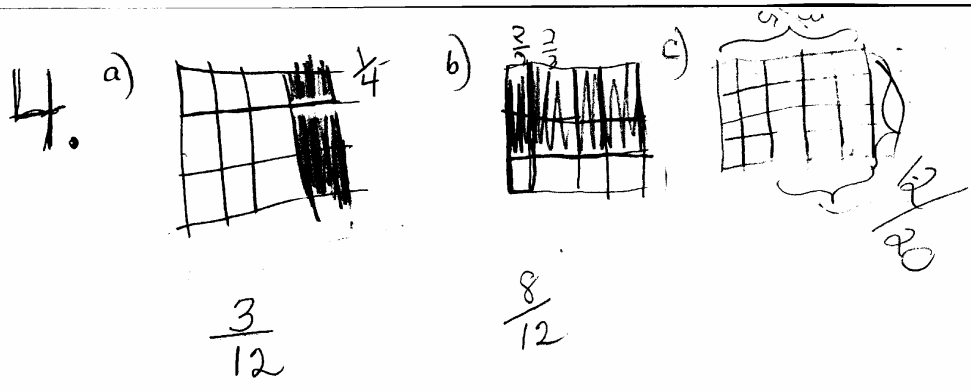


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$$3. \frac{5}{10} = \frac{10}{20} = \frac{20}{40} = \frac{2}{5}$$

$$\frac{2}{5} = \frac{4}{10} = \frac{\cancel{16}}{15} = \frac{8}{20}$$

✓



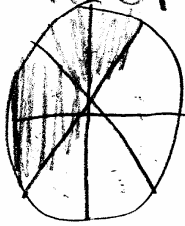
June 20th / 2006  
Pg. 245 - 246

Sample 1

June 21/06

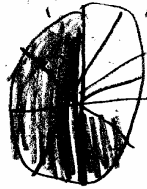
1)  $\frac{3}{4}$ ,  $\frac{9}{12}$

Rinonda

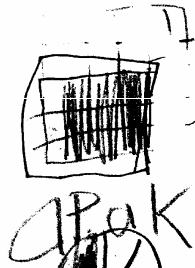


$\frac{4}{8}$

Kalay



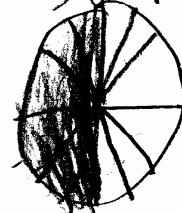
$\frac{5}{10}$



Apak

$\frac{4}{8}$

Sunil

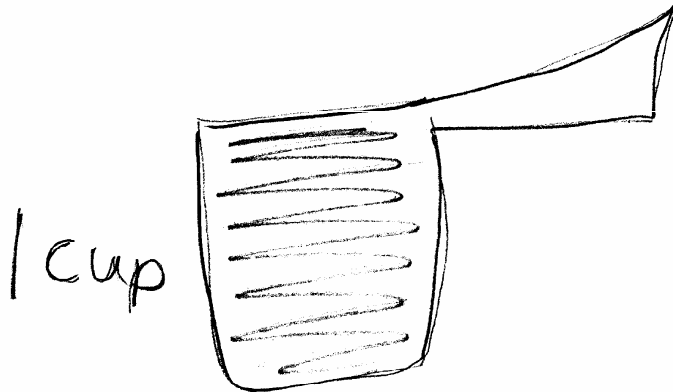
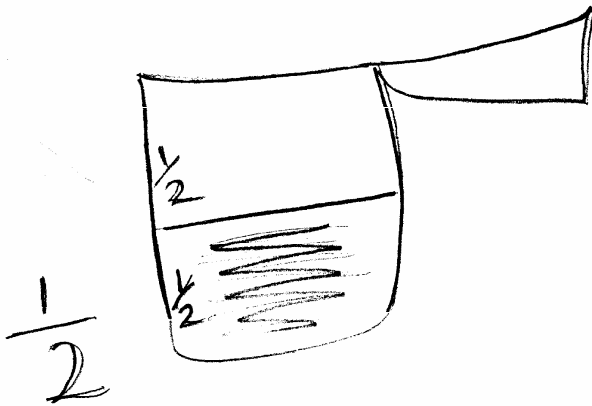
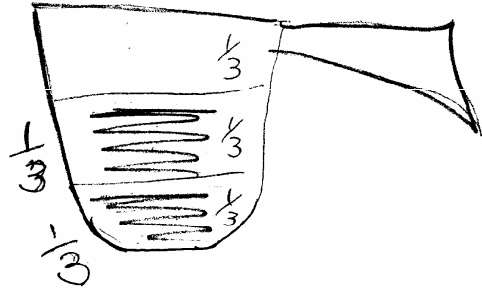
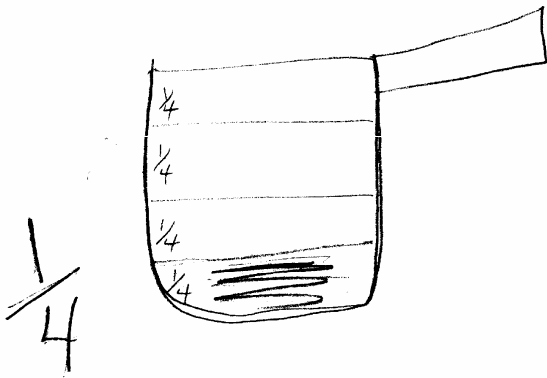


$\frac{6}{10}$

Rinonda was rite  
because they all ate  
hafe

June 21/06

Explained by MSVU Student.



Pg. 249

Woll

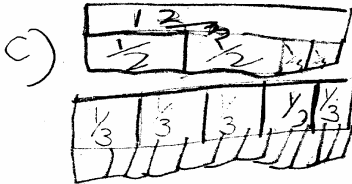
June 21/06



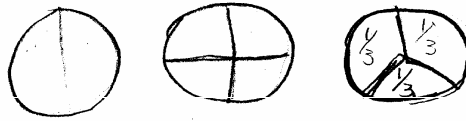
1)  $4\frac{1}{2}$  cups and  $1\frac{1}{4}$  cup



$5\frac{1}{2}$  cups =  $2\frac{1}{2}$  cup



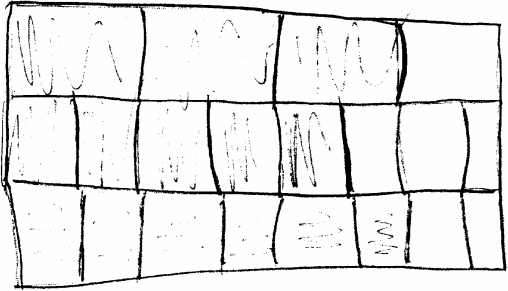
$5\frac{1}{3}$  cups =  $1\frac{2}{3}$



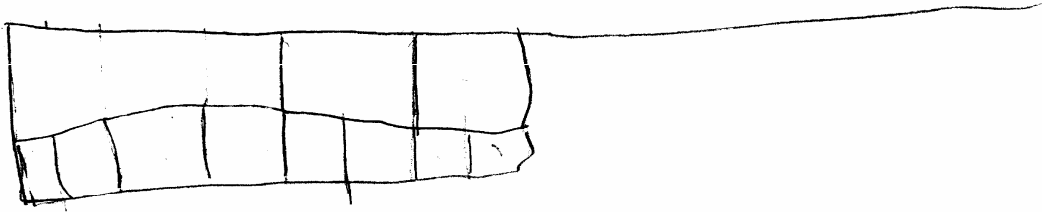
d) 6 and a half cups =  $3\frac{1}{2}$

Sample 2

June 23/08

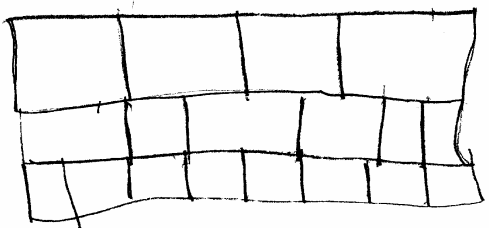


$\frac{3}{5} > \frac{3}{8}$



$$\frac{3}{5} > \frac{3}{8} \quad \frac{3}{8} < \frac{3}{5}$$

Sample 2

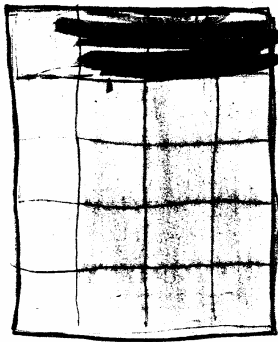
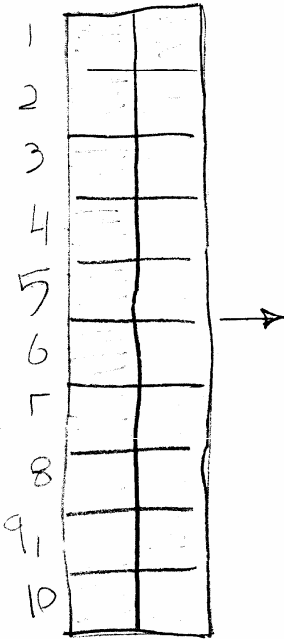


$$\frac{7}{8} > \frac{4}{6} > \frac{3}{4}$$

Sample 3

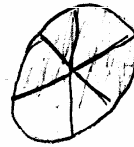
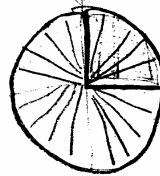
#7 June 26/06

#



green  
has the  
most.  
red  
is the  
lost.

$\frac{1}{4}$

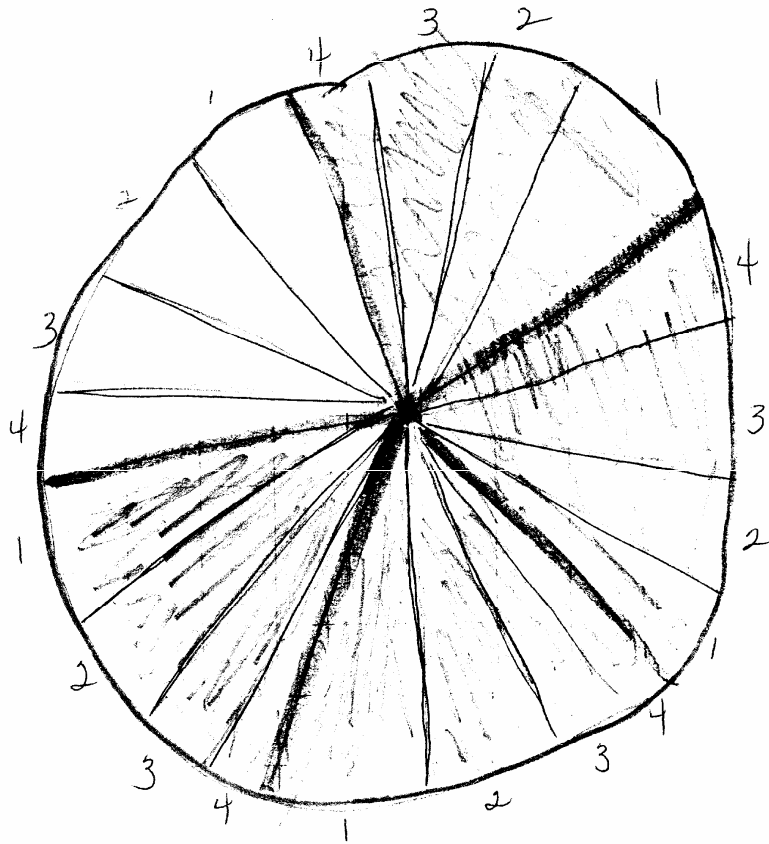


Produced on graph papers,  
illustrations are without error.

Spontaneously  
creation  
last day.



June 26/06



$$\frac{1}{4} = 5 \text{ Pie pieces}$$

$$\frac{1}{5} = 4 \text{ Pie pieces}$$

Appendix I  
**Mathematics Strategy**

## Appendix H

### The 9 Times Table Trick

1. Hold your hands in front of you with your fingers spread out.
2. For  $9 \times 3$  bend your third finger down. ( *$9 \times 4$  would be the fourth finger etc.*)
3. You have 2 fingers in front of the bent finger and 7 after the bent finger
4. Thus the answer must be 27
5. This technique works for the 9 times tables up to 10.

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