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A Critical Examination of Policy and Practice in the Transition Experience for Students with Math Learning Disabilities in Mumbai, India

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**A CRITICAL EXAMINATION OF POLICY AND PRACTICE IN THE TRANSITION EXPERIENCE FOR
STUDENTS WITH MATH LEARNING DISABILITIES IN MUMBAI, INDIA**

A Dissertation Presented

by

MELINDA SUE EICHHORN

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF EDUCATION

September 2014

College of Education

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**A CRITICAL EXAMINATION OF POLICY AND PRACTICE IN THE TRANSITION EXPERIENCE FOR
STUDENTS WITH MATH LEARNING DISABILITIES IN MUMBAI, INDIA**

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by

MELINDA SUE EICHHORN

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DEDICATION

This dissertation is dedicated to students in Mumbai with math learning disabilities / dyscalculia and their families and teachers.

ACKNOWLEDGMENTS

I would like to thank many people who have enabled me to complete this dissertation.

I would like to thank the Maharashtra Dyslexia Association in Mumbai for their support of this project. A special note of thanks to the psychologists that assisted me in screening secondary students. I am especially grateful to Ms. Masarrat Khan and Mrs. Kate Currawalla for their answers to my never-ending questions as I attempted to understand the Indian education system and policies for students with MLD.

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I give thanks to God for His strength, and for the perseverance He enabled me to have to complete this journey.

ABSTRACT

A CRITICAL EXAMINATION OF POLICY AND PRACTICE IN THE TRANSITION EXPERIENCE FOR STUDENTS WITH MATH LEARNING DISABILITIES IN MUMBAI, INDIA

SEPTEMBER 2014

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Although some research has examined the experiences of students with learning disabilities in Indian secondary schools (see Karande, Sholarpurwala, & Kulkarni, 2011; Karande, Mahajan, & Kulkarni, 2009), the role of policy in students' transition into post-secondary education has been largely unexamined. This study is a preliminary effort at providing an investigation of special education policy in Mumbai and the impact on students' transition to post-secondary education, especially in regards to mathematics. This study extends the current knowledge of students with learning disabilities in Mumbai by 1) taking an in-depth look at students with math learning disabilities specifically, 2) focusing on the transition between secondary and higher secondary education, and 3) examining the impact of current policies and procedures through the lens of critical pedagogy.

In this study, I gathered data on the math proficiency of secondary students with MLD and their typically achieving peers in Mumbai. Additionally, I conducted interviews with secondary students and post-college adults with MLD, as well as interviews with secondary math teachers and college lecturers in mathematics. I also observed post-secondary math classes in various colleges, collected survey data from math lecturers, and reviewed documents from educational institutions all over Mumbai.

The data from this mixed methods study revealed that, for this sample of students in Mumbai, secondary students with MLD do have gaps in their conceptual and procedural knowledge of mathematics as compared to their peers without MLD, especially in the areas of fractions, decimals, pre-algebra, and word problems. Through interview and survey data, secondary students with MLD also expressed frustration with geometry and algebra. The data also revealed that post-secondary students who take Secretarial Practice in place of math in junior college are not prepared for the degree college math course that follows. Additionally, post-secondary students with MLD expressed feelings of fear and judgment when asking for help in mathematics from college lecturers and peers. This suggests that there is a need for professional development among all educators, from primary to post-secondary, to raise awareness of MLD. Also, trying to mediate students' difficulties at the secondary or post-secondary level is too late; early identification of MLD and early intervention are necessary.

These findings will be useful for inclusive education advocacy groups in India as they work with policy makers and enforcers at the national and state level, as they revise policy and procedures for students with learning disabilities in Maharashtra and India.

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CHAPTER 1

INTRODUCTION

Imagine going to work and not being able to do your job. Now imagine that you can't leave your job. Imagine having to do that every day. This is what life is like for children with learning disabilities.

Dr. David Urion
Director, Neurology and Learning Disabilities Program
Children's Hospital, Boston
(PBS, 2002)

Statement of the problem

Students and adults with mathematics learning disability (MLD) are individuals that perform at a level substantially below their peers in mathematics, and their poor performance cannot be explained by any deficit in vision, speech, hearing, or intelligence. It is, in a sense, “unexpected underachievement” (Fletcher, Lyon, Fuchs, & Barnes, 2007, p. 27; American Psychiatric Association, 2013a, 2013b). Learning disabilities, which can occur in the areas of reading, mathematics, and/or written expression, contribute to students experiencing low self-esteem due to their poor academic performance and negative school reports (Fletcher et al., 2007; Gibson & Kendall, 2010; Lahane et al., 2013). Students with math learning disabilities have experienced years of failure and frustration in mathematics (Jones, Wilson, Bhojwani, 1997). In school, math is part of their job, yet they feel incapable of doing their job.

Approximately six percent of primary school children (grades 1–4) in India have a math learning disability (MLD) (Ramaa & Gowramma, 2002). This prevalence rate is comparable to the prevalence of reading disabilities, yet much less attention has been devoted to MLD in the literature (Murphy et al., 2007; Paulsen, 2005). Children with MLD are seriously understudied (Desoete, Roeyers, & De Clercq, 2004; Ginsburg, 1997; Hanich, Jordan, Kaplan, & Dick, 2001). Even less is known about these students as they progress through the Indian school system and transition from secondary school to post-secondary school. In fact, there are few previous

studies that focus on post-secondary students with MLD in the United States and around the world (Sullivan, 2005).

Pursuing higher education improves a student's chances in having a higher income, opportunities for career advancement, achieving status, and becoming part of a life-long professional network (Wehman & Yasuda, 2005). In regards to mathematics, students who master basic algebraic concepts have a greater opportunity to pursue higher-level math courses, post-secondary education, and have a technology-based career (Witzel, Riccomini, & Schneider, 2008). However, students with MLD are at a great disadvantage in pursuing post-secondary education and job options since they typically lag behind their peers in conceptual and procedural understanding of math knowledge, skills, and problem solving. According to Ramaa & Gowramma (2002), nearly half of the Indian students with MLD also have a learning disability in reading and writing. Although students with math learning disabilities in India have a complex profile of strengths and challenges, their difficulties in math may limit their options and opportunities within postsecondary education (Pennini, 2006).

We know very little about students with MLD in India. There has only been one peer-reviewed article specifically about identification and classification of MLD in India, which focused on primary students in the city of Mysore (Ramaa & Gowramma, 2002). There are a few other studies on learning disabilities in India, but these have focused on three types of learning disabilities (reading, writing, and math) together (Mogasale et al., 2012; Kulkarni et al., 2006; Karande et al., 2007, 2009). Some studies have recommended increased training for primary school teachers, early screening tools, and more remedial education and special educators in primary and secondary schools (Karande, Sholapurwala, & Kulkarni, 2011; Karande, Doshi, Thadhani & Sholapurwala, 2013; Unni, 2012). Although general awareness of learning disabilities has increased in India over the past decade, yet there is still a general lack of

awareness in schools (Karande, Sholapurwala, & Kulkarni, 2011; Karande, Mahajan, & Kulkarni, 2009). Other studies have examined the lack of uniformity for learning disability diagnosis and attempted to create alternative, simplified procedures, especially for students in vernacular-medium schools (Mogasale et al., 2012, Ramaa & Gowramma, 2002). However, most researchers do not take an in-depth look at math learning disabilities and none have examined the impact of policy and transitional issues in post-secondary education. Overall, the peer-reviewed literature on students with math learning disabilities in India is sparse.

Due to various policies concerning students with learning disabilities in Maharashtra and low awareness among teachers and parents, many students in Mumbai are not diagnosed with MLD or other learning disabilities until 8th standard or later. This is especially troublesome since students who fall behind in math in early primary school, stay behind, while those who start ahead in math generally stay ahead (Siegler et al., 2012). If students with MLD have fallen behind in mathematics in primary school and discover they have a learning disability when they enter secondary school, then what are the repercussions students face in mathematics as they transition to post-secondary education and into a career? Students with MLD eventually do learn basic math procedures in primary school, but are one to several years behind their typically achieving peers (Geary, Hoard, Nugent, & Bailey, 2012). Since students with MLD are supposedly already lagging behind their peers in primary school, this study hypothesized that students would remain behind their typically achieving peers to secondary school. If this gap widens during secondary school, what are the implications for students who opt out of math courses for 2-4 years, and then must take required math courses in post-secondary education? This study also examined the Indian education system's lack of options for students who may want to pursue a particular subject, but then are unable to because of counsel from secondary counselors or requirements of colleges. Because only one type math course is offered as a part

of degree program, students lack options or are required to take extra private classes to keep up with their peers.

Purpose statement

This mixed methods study addresses the transition issues students with MLD face as they move from secondary to post-secondary education. The intent of this convergent mixed methods study is to fill in some of the knowledge gap regarding Indian students with MLD and the way special education policy in Maharashtra impacts their transition from secondary to post-secondary education. In this study, I used a researcher-constructed screener to measure the relationship between math proficiency between secondary students with MLD and their typically achieving peers (that do not have MLD). This study provides an in-depth examination of the experiences of a group of individuals with MLD and their transition to different phases of secondary and post-secondary education using interviews, observations, and a document review with students, teachers, lecturers, and policy enforcers at various educational institutions in Mumbai. I combined quantitative and qualitative data to better understand the research problem by converging broad numeric trends and detailed views of participants.

Research questions

Research question 1: How prepared are students with MLD to enter post-secondary education?

- a) What math knowledge, skills, and learning strategies do students with MLD currently have?
- b) How do the math knowledge and skills of these students with MLD differ from students without MLD (comparison group)?

- c) What knowledge, skills, learning strategies, and other supports do these students with MLD need, based on their desired program of study in junior college and degree college and the math requirements of the courses in that program?

Research question 2: How do college math policies and procedures affect students with MLD?

Significance of the study

This study is the first step in beginning to understand the way special education policy and the current education system in India impacts students' math abilities and their post-secondary education options due to their math proficiency in secondary school. It is my aim that this study will contribute valuable information to the field of learning disabilities in India and will enable students with MLD to be more empowered in their job of studying and understanding mathematics.

Although some research has examined the experiences of students with learning disabilities in Indian secondary schools (see Karande, Sholarpurwala, & Kulkarni, 2011; Karande, Mahajan, & Kulkarni, 2009), the role of policy in students' transition into post-secondary education has been largely unexamined, especially in regards to mathematics. Additional research in the area of students with MLD in India is very necessary. First of all, research in the area of math learning disability is less well developed than research on reading learning disabilities (Mazzocco & Myers, 2003; Bryant, 2009). Further research will help us better understand the difficulties students with MLD face, as they attempt to actively engage in grade-level discussions and activities with their peers without MLD, and in their transition from secondary to post-secondary education. With more research and publication of findings in international and Indian education journals and newspapers, teachers, administrators, counselors, and parents will become more aware of math learning disabilities and the impact that current special education policy has on future post-secondary options. Although there are

a few scholars in India studying learning disabilities, little attention has been paid to math learning disability specifically, as well as to the impact of educational policy on students' transition to post-secondary education.

Organization of paper

This study examines the challenges faced by students with MLD during secondary and post-secondary education in India through quantitative data and collective case studies, or personalized stories of distinct or similar individuals (Brantlinger et al., 2005). In the next chapter, I review the literature on mathematical learning disabilities and instructional techniques that are proven by research to be effective for students with MLD. In the literature review chapter, I will also describe the context of Mumbai, India and Maharashtra's special education policy in regards to learning disabilities. I will describe the methodology of the study in depth in chapter three. I present the findings in chapter four and my conclusions and recommendations in chapter five. Based on the findings of this study, I have listed some implications for practice, policy, and research.

CHAPTER 2

LITERATURE REVIEW

Introduction

I have organized the literature into six sections. I begin with defining math learning disabilities in the global context, including causes, identification and prevalence, and the ways MLD manifests in the regular education classroom. The second section reviews the literature on instruction, comprising of global mathematics curriculum, instructional strategies for students with MLD, as well as a section on mathematics in Indian primary and secondary classrooms. In the third section, I continue my focus on India as I explore assessment, which encompasses Indian learning standards, curriculum, and standardized assessment. In the fourth section, I review the literature on current special education policy in India in regards to learning disabilities. Next, I review other factors that impact students and families with special educational needs in the Indian context in the fifth section. In the sixth section, I review transitional factors as student move to higher education in India. I conclude the literature review with my conceptual framework, which summarizes the intersection of the literature and the research problem.

Definition of Math Learning Disability (MLD)

Currently, there is no universal definition of math learning disability (MLD) (Mazzocco & Myers, 2003). Although there has been almost a century of efforts, problems with the definition of math “learning disability” still exist. There is still a lack of understanding as to which criteria classify MLD so that it is reliable and valid (Fletcher et al., 2007).

In 1925, Henchsen first used the term “acalculia” to describe deficits in arithmetic (Pennington, 2009, p. 234). Later on, behavioral neurologists created four subtypes: aphasic,

spatial, planning and perseveration, and semantic dyscalculia, since there are many cognitive components to arithmetic. Yet, mathematics is much more than just arithmetic. Although most research has focused on students' problems with arithmetic computations, there are many more math disorders beyond arithmetic disorders (Pennington, 2009; Fletcher et al., 2007).

In this study, I began to define children with mathematics learning disability (MLD) in accordance with the operational definition from the Diagnostic and Statistical Manual of Mental Disorders of "mathematics disorder (DSM-IV)" (American Psychiatric Association, 2000). However, during the course of the study, in 2013, the DSM-5 combined the diagnoses of reading disorder, mathematics disorder, disorder of written expression, and learning disorder not otherwise specified into the new category of "specific learning disorder", since these disorders commonly occur together (American Psychiatric Association, 2013a; 2013b). In the DSM-5, students with math learning disabilities, or specific learning disorder with an impairment in math, are "unable to perform academically at a level appropriate to their intelligence and age" in mathematics (American Psychiatric Association, 2013d, para. 4). These students' current skills in math are "well below the average range of scores in culturally and linguistically appropriate tests" of mathematics, and are not explained by "developmental, neurological, sensory (vision or hearing), or motor disorders" (American Psychiatric Association, 2013d). MLD is a neurodevelopmental disorder that impacts students across cultures and throughout their lives (Tannock, 2014; American Psychiatric Association, 2013a).

Causes

Math disabilities, or differences in math abilities, are multi-faceted and may be the result of difficulties in the following area(s) of learning: numeracy/number sense, working memory, visual-spatial processing, sequencing, processing speed, language, and attention (Allsopp, 2008; Raghubar et al., 2009; Little, 2009; Fletcher et al., 2007).

In the field of MLD, there is disagreement as to whether MLD is caused solely by a core deficit in number sense / numerosity, as Butterworth (2005) posits, or due to a more general deficit in working memory or spatial cognition, which is the view of Geary et al. (2004) (Pennington, 2009). These two theoretical perspectives or orientations are still under debate, which make it difficult to define MLD (Fletcher et al., 2007).

Additionally, Lewis (2011) posits that students with MLD process or manipulate numbers in an atypical way due to differences in cognitive abilities. Therefore, I want to emphasize that students with MLD may have deficiencies in performance, but this in no way implies that there is a deficiency in the individual (Lewis, 2011).

Deficits in number sense

Current research suggests that the underlying cognitive deficits of MLD may be rooted in number sense (Butterworth, 2005; Geary, Hoard, Nugent, & Bailey, 2012; Geary, Bailey, & Hoard, 2009; Gersten, Jordan, & Flojo, 2005; Berch, 2005; Mazzocco, 2005). Although the exact definition of number sense is still debated, it basically “involves children’s implicit understanding of the absolute and relative magnitude of sets of objects and of symbols (e.g., Arabic numerals) that represent the quantity of these sets” (Geary, Bailey, & Hoard, 2009, p. 266; Geary, 2013). Evidence suggests that students with MLD may have deficits in number sense, possibly even before they enter school (Geary, Bailey, & Hoard, 2009). Number sense is a fundamental math skill and permeates all aspects of learning math (Sood & Jitendra, 2007). Number sense is as important in mathematics as oral language skills and phonemic awareness are to reading (Hecht, Vagi, & Torgesen, 2007; Gersten & Chard, 1999). Number sense can be described as “the ability to see varied ways of representing a number and relationships among numbers;” it is a fluidity and flexibility with numbers (Sayeski & Paulsen, 2010, p. 14; Gersten & Chard, 1999; Gersten, 1998). Having a mental number line and an intuitive sense of the magnitude of

numbers is sometimes referred to as number sense (Dehaene, 1997; Schneider & Siegler, 2010; Krasa & Shunkwiler, 2009; Griffin & Case, 1997). Students with MLD may have impairment in their core understanding of numerosity, which includes the ability to subitize (Pennington, 2009). Subitizing is the ability to quickly enumerate small groups of objects, up to three or four elements; or, automatic recognition of small quantities (Mazzocco, 2008; Geary, Hoard, & Bailey, 2011). Subitizing is a quick, parallel process, which is replaced by sequential counting when the amount becomes four or more (Kroesbergen et al., 2009). Subitization “implies the ability to recognize quantities without counting them” (Dowker, 2005, p. 70). In previous studies, students with MLD count to three instead of subitize when shown three dots (Koontz & Berch, 1996; Butterworth, 2005). When students have an impaired ability to understand numerosity and to subitize, their development of counting and calculation strategies is adversely affected (Pennington, 2009).

Students must have number sense in order to defend and explain their solutions (Sayeski & Paulsen, 2010). It is a prerequisite for the development of higher level mathematics (Sood & Jitendra, 2007). Research has shown that children at risk for MLD may not differ from their peers on their accuracy of number sense tasks, but may complete the tasks much more slowly (Berch, 2005). Students with MLD lack the automaticity of their peers; this may also affect their ability to process information for more complex mathematical tasks if so much energy is expended on basic facts and combinations (Gersten & Chard, 1999). Overall, this is important since children with proficient number sense are likely to have greater achievement in mathematics in the future (Sood & Jitendra, 2007). Additionally, students build upon their number sense after the early grades. For example, students use number sense to connect two types of rational numbers (such as using benchmarks like $\frac{1}{3}$ to talk about the decimal, 0.3147). Students also use number sense to identify compatible numbers while simplifying algebraic

expressions (Example: $17 + 6x + 9 + x + 3 + 4x$). Students must continue to foster their number sense with every mathematical concept to develop conceptual understanding (Woodward, 2006).

Working memory deficits

Most activities in math require working memory (Krasa & Shunkwiler, 2009). Working memory is “the ability to hold a mental representation of information in mind while simultaneously engaged in other mental processes” (Geary et al., 2007, p. 88; Geary, 2013). Working memory is responsible for processing and short-term storage of information (Schuchardt, Maehler & Hasselhorn, 2008). Working memory is typically tested by forward and backward digit span on IQ tests, which involves repeating a verbal number string backward (Krasa & Shunkwiler, 2009). For the purposes of this research, I will use Baddeley’s (1986, 1996) model of specific working memory, which includes a central executive system, along with two subsystems: the phonological loop and the visuospatial sketchpad (Meyer et al., 2010; Baddeley, 2007).

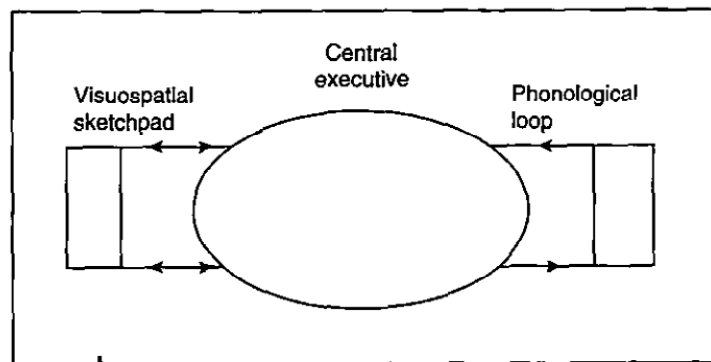


Figure 1: A simplified representation of the working memory model (Baddeley, 1986, p. 71; 2007, p.8).

The central executive, phonological loop, and visuospatial sketchpad can all be assessed (Geary, Bailey, & Hoard, 2009).

Central executive

Holding onto information and manipulating it takes attention, mental control, and organization. This requires tremendous mental energy and efficiency (Krasa & Shunkwiler, 2009). The central executive component of working memory is responsible for reasoning, decision-making, and coordinating between the phonological loop and the visuospatial sketchpad (Logie, 1995). The central executive system helps students with planning and monitoring the series of mathematical operations (Passolunghi & Cornoldi, 2008). It also enables students to suppress the retrieval of irrelevant information (Geary, 2013).

Phonological loop

The phonological loop enables a student to recall verbal information, as well as visual information that has been translated into phonologically-based code for memory storage. This could include visual information, such as objects, pictures, geometric forms, and letters that a student remembers by a specific name or description (Krasa & Shunkwiler, 2009; Logie, 2005). The phonological loop, which is sometimes referred to as verbal working memory, is involved in normal counting and mental arithmetic (Logie, 1995). Young students use finger counting to help them keep track of the count because their verbal working memory is not fully established. Additionally, when students are presented with horizontal problems in math, complex multiplication problems, and word problems, they must make use of their phonological loop (Krasa & Shunkwiler, 2009; Passolunghi & Cornoldi, 2008).

Visuospatial sketchpad

The visuospatial sketchpad is seen as complementary to the phonological loop. The visual component involves properties of items, including shape, color, and brightness, while the spatial piece refers to location of items in space, their relationship to each other, and movement or scanning / perceiving (Logie, 1995). Sometimes referred to as visual working memory, the

visuospatial sketchpad helps students create mental images, understand equivalency, predict outcomes, and compare numerosities (Krasa & Shunkwiler, 2009). The visuospatial sketchpad also supports students in written calculation, such as with maintaining columns with multi-digit numbers (Passolunghi & Cornoldi, 2008).

Students with MLD typically have poor working memory (Krasa & Shunkwiler, 2009; Passolunghi & Cornoldi, 2008; Fletcher et al., 2007; Geary, 2013). With working memory deficits, different components of working memory may be more important during different stages of mathematical learning. For example, the central executive and phonological loop components may play a more important role in the early stages of learning, while the visuospatial sketchpad may play an important role during the later stages of learning (Meyer et al., 2010). In the case of visuospatial working memory¹, Kyttälä and Lehto (2008) found that it was related to performance in solving math word problems, but it was not related to general performance on curriculum-based math tests (Kyttälä, 2008). Visuospatial working memory has also been linked to numerical estimation (Khemani, 2005; Fletcher et al., 2007; Krasa & Shunkwiler, 2009).

In general, students with working memory deficits have difficulty following instructions, even short instructions. These children often complain that they forgot what to do, or what they were instructed to do (Baddeley, 2007).

Students with MLD exhibit deficits in all of the three working memory systems, yet the central executive system may cause students the most problems (Geary, 2013). However, Butterworth (2005) mentions that MLD and deficits in working memory can and sometimes do

¹ Within working memory tests, the visuospatial sketchpad is assessed through Block Recall. In this test, the experimenter taps a block (or series of blocks), and the child's task is to duplicate the tapping in the same order as presented by the experimenter" (Geary, 2011a, p. 1543; Logie, 1995; Geary et al., 2012).

co-occur, yet there is no evidence that poor working memory is a causal factor in MLD. Geary et al. (2000, 2004) acknowledge the complicated relationship between MLD and working memory, since different aspects of working memory can be related to different mathematical skills. More research is required (Fletcher et al., 2007)

Executive functions

The mental abilities that students use for all intellectual activity and problem solving are referred to as executive functions. Executive functions include attention, working memory, sequencing, and self-control. Students with MLD often have impairments in these areas (Krasa & Shunkwiler, 2009).

Visual-spatial processing deficits

Number sense is fundamentally a spatial concept. Spatial ability is “a fundamental cognitive skill by which an individual comprehends the location of and relationships among objects in space” (Krasa & Shunkwiler, 2009, p. 34). Early on, students think about quantity through mental pictures or images. Young children have an implicit sense of “more” without counting or measuring. This is easier when comparing two values that are very different from one another. According to Weber’s Law, if two values are close in ratio, then it is more difficult to tell them apart (Krasa & Shunkwiler, 2009). For example, in the images below, distinguishing between option B (6 birds) and option C (7 birds) is more difficult than distinguishing between option A (3 birds) and B without counting.

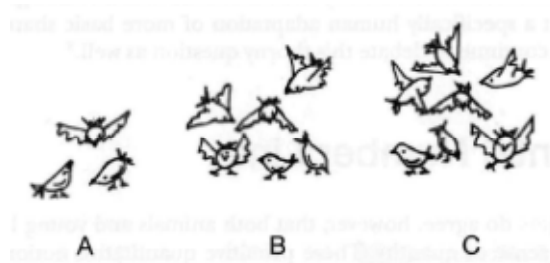


Figure 2: Weber’s Law – A collection of birds (Krasa & Shunkwiler, 2009, p. 18)

The same principle applies to linear distance. It is more difficult to distinguish between line Y and Z, rather than line X and Y, without measuring.

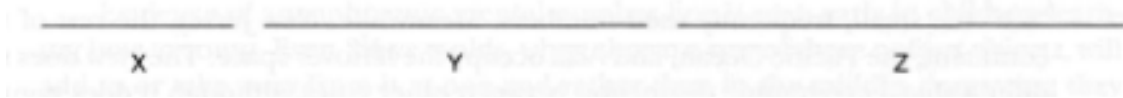


Figure 3: Weber's Law – Linear distance (Krasa & Shunkwiler, 2009, p. 19)

As they develop, students begin to apply Weber's Law to sequential ordering along a linear distance, such as the number line. By third grade, students are able to correctly proportion numbers on the linear number line using familiar round numbers, or benchmarks (Krasa & Shunkwiler, 2009). Students with MLD have slower reaction times on tests of number magnitude comparison as compared to peers, which could have roots in number sense and spatial skills (Landerl, Bevan, & Butterworth, 2004; Geary, Hanson, & Hoard, 2000; Pennington, 2009).

Number sense and spatial sense may be very much intertwined and researchers have found an association between spatial skills and accuracy in number line placement (Krasa & Shunkwiler, 2009). Additionally, Siegler and Opfer (2003) found that children's ability to correctly space numbers on number lines predicted math achievement (Dingfelder, 2005). For example, children that develop a linear number line earlier than their peers have higher math achievement, while other children use a logarithmic pattern (lower numbers spaced further apart than the higher ones, and bunching the higher numbers together at the end) (Siegler and Booth, 2004; Dingfelder, 2005). Yet, Barth and Paladino (2011) suggest that number line placement tasks are actually judgments of perceptual proportion and should be interpreted within the theoretical framework of proportion judgments as opposed to a logarithmic-to-linear representational shift. Additionally, estimation tasks that do not involve number lines, but other

numerical estimation tasks, such as estimating and labeling the number of items in a set, should be considered (Barth & Paladino, 2011).

However, more research needs to be done in the area of distinguishing between spatial and visual-spatial sense in regards to number sense. Krasa and Shunkwiler (2009) suggest further research of blind students' mental representation of numbers to examine purely spatial ability, which is not tied to vision.

Mental rotation

The association between spatial skills and mathematics becomes more apparent in adolescence when students delve deeper into geometry and math reasoning. One strong predictor of later math achievement is a complex spatial task known as mental rotation. Mental rotation is measured by tests that ask students to imagine objects turning around in various spatial orientations. These tasks are in two-dimensions for younger children and three-dimensions for older students. An example of two-dimensional questions would involve rotating shapes, figures, and alphabet letters (Krasa & Shunkwiler, 2009; Logie, 1995).

In the Mental Rotations Test, developed by Vandenberg and Kuse (1978), a criterion figure is on the left-hand side. In each line, there are two correct alternatives that have been rotated. The other two figures are incorrect distractors.

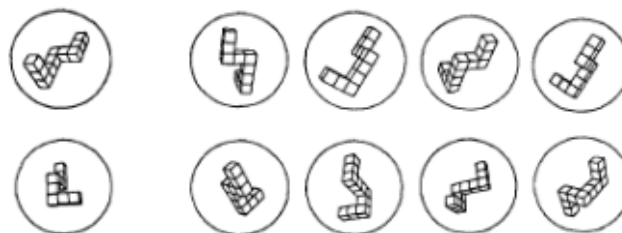


Figure 4: Sample items from the Mental Rotations Test² (Vandenberg & Kuse, 1978, p. 600).

²In the first item, the correct responses are the first and fourth images. In the second item, the second and third images are correct.

Mental rotation requires significant visuospatial working memory. More research must be completed, but thus far, differences in spatial ability can account for some differences in math ability (Krasa & Shunkwiler, 2009). However, Butterworth (2005) argues that spatial deficits do not lead to MLD.

Sequencing deficits

Students with MLD perform significantly worse on tests of planning and sequencing as opposed to typically achieving students and students with reading learning disabilities (Krasa & Shunkwiler, 2009). One such test is the Tower of London, in which students must create a sequence of steps in order to rearrange colored balls on a series of pegs to match a goal position with as few moves as possible (Shallice, 1982; Krasa & Shunkwiler, 2009).

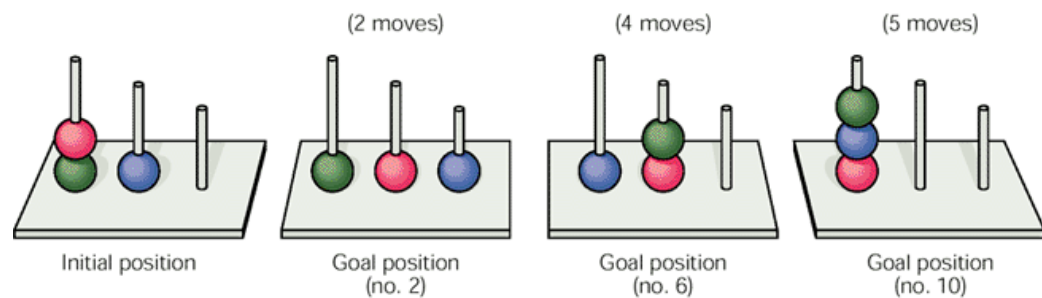


Figure 5: Examples of problems on the Tower of London Test (Saper, Iversen, & Frackowiak, 2000, p.358; Shallice, 1982, p. 204).

Slow processing speed

The brain takes in information through the eyes and ears and then processes and analyzes it through a system of complex circuitry. The part of the brain that is responsible for instantaneously recognizing numerals is called the visual word-form area, which is required for efficiently calculating numbers. There are connections between the visual word-form area of the brain and the phonological and speech areas. For most people, these connections work

together seamlessly. However, for students with difficulties in mathematics, there are disruptions in this circuitry (Krasa & Shunkwiler, 2009).

Most of the research completed in this area has been with people with traumatic brain injury, and more mathematical neuroscience research must be done to further understand numerical processing in children's brains, especially those with MLD (Krasa & Shunkwiler, 2009). However, faster processing ability allows a student to efficiently use their working memory and other cognitive resources (Fletcher et al., 2007).

Language difficulties

Language plays an important role in a student's ability to solve a mathematical problem, whether orally or in written form. Students with MLD may have difficulty with syntax, or the "sequencing of words" (Krasa & Shunkwiler, 2009, p. 128). Students must understand the syntax of the mathematical problem, and then make a plan with sequential steps for solving it (Krasa & Shunkwiler, 2009). Mathematical language can be dense and abstract, from mathematical vocabulary to the syntax of word problems (Krasa & Shunkwiler, 2009; Little, 2009).

Students may also have difficulty with expressive language, which can affect students' ability to engage in small and whole-group discussions (Bryant et al., 2006). In a study by Butterworth (2005), students with MLD reported that they did not understand what the teacher was saying. The students said that they did not forget what he/she said, but that they did not even understand it. Also, students reported that small distractions would make them lose track of what they were doing (Butterworth, 2005). Language difficulties can be compounded if students are distracted or disorganized and can lead to difficulties in math skill acquisition (Krasa & Shunkwiler, 2009; Fletcher et al., 2007).

Attention deficits

The most well-known impairment of attention is Attention-Deficit (Hyperactivity) Disorder, and typical characteristics include distractibility, disorganization, poor sustained attention, and at times, hyperactivity and impulsivity (Krasa & Shunkwiler, 2009). Attention deficits are measured by behavioral rating scales completed by parents and teachers based on long-term behavioral observations (Raghubar et al., 2009; Krasa & Shunkwiler, 2009). Students with ADHD, on average, solve fewer math problems and are less accurate than their peers (Krasa & Shunkwiler, 2009). At times, when a child's working memory is overloaded, their attentional efficiency withers (Berch, 2011). A child's working memory deficit may be misinterpreted as a difficulty with attention or motivation by a teacher (Baddeley, 2007).

In a study by Shalev, Auerbach, and Gross-Tsur (1995), children with MLD had significantly more attention problems than typically achieving students. The students' attention problems were consistent with ADHD profiles (Shalev et al., 1995).

Summary of causes and contributing factors of MLD

Students with MLD typically have an average or above-average level of intelligence (usually measured by IQ tests), but their deficits in the above-mentioned areas interfere with their acquisition of math skills and results in low achievement (Impecoven-Lind & Foegen, 2010; Fletcher et al., 2007). Many of these areas may overlap and impact one another, such as the executive functions, and can cause students to have tremendous difficulty while doing mathematical tasks (Krasa & Shunkwiler, 2009).

It is presently unclear how MLD should be subtyped and classified, and some components are not fully understood (Raghubar et al., 2009). Pennington (2009) argues that analyzing mathematical disorders is more complicated than analyzing a disorder like dyslexia, where the impaired skill of recognizing printed words is much more narrow. Currently, the

knowledge of the numerical competencies that are impaired in MLD are not as developed as in reading and writing learning disabilities (Fletcher, et al., 2007).

Identification

Allsopp (2008) argues that there is no single type of math learning disability; instead there are math learning disabilities. Or, as Dowker (2005) phrases it, there is no such thing as arithmetic ability, instead there are arithmetic abilities. Students with MLD are a heterogeneous group; yet, there are some overarching characteristics and deficits that most students share (Strawser & Miller, 2001).

Math learning disabilities often become apparent in primary school and students' difficulties can persist into high school, college years and adulthood (Desoete, Roeyers, & De Clercq, 2004; Mazzocco, Devlin, & McKenney, 2008). However, according to VanDerHeyden (2008), early identification and mathematics intervention for students with MLD can repair current deficits and prevent future ones from forming (Siegler & Ramani, 2008).

Current methods of identification

With the reauthorization of the Individuals with Disabilities in Education Act (IDEA) in 2004, states and districts in the United States must show comprehensive evidence of underachievement and insufficient progress with research-based interventions in the regular classroom, in order to qualify for special education services for a learning disability. Also, the underachievement cannot be due to exclusionary factors, such as mental retardation, sensory deficits, serious emotional disturbance, limited English proficiency, and lack of opportunity to learn. This is known as the Response-to-Intervention (RTI) process or model(s) (Fletcher et al., 2007; Fletcher, n.d.). Schools may identify students using a mass screening tool and probe assessments in core areas (Fletcher et al., 2007). The RTI models usually involve multiple and comprehensive assessments with specific attempts of targeted intervention. However, the goal

of RTI is not only identification of learning disabilities or to determine eligibility for special education, but to enhance educational opportunities for all students (Fletcher et al., 2007). RTI has involved extensive professional development for teachers and enhanced collaboration between regular and special education teachers (Cortiella, 2008).

The previous model of identification, which measured a discrepancy between intelligence / aptitude (IQ tests) and achievement on a single occasion, has been determined to be unreliable (Fletcher et al., 2007; Fletcher, n.d., Tannock, 2014). Currently, with RTI models, the discrepancy is measured over time (Fletcher et al., 2007). However, the reauthorization of IDEA (known as Individuals with Disabilities Education Improvement Act or IDEIA), still technically allows schools to use the IQ/achievement discrepancy, but it strongly encourages the use of RTI instead (Hallahan, Pullen, & Ward, 2013). The new Diagnostic and Statistical Manual of Mental Disorders (DSM-5) has also eliminated the IQ-achievement discrepancy requirement and instead involves evidence of symptom persistence for at least six months, despite extra help or targeted instruction (Tannock, 2014). Yet, the aptitude-achievement discrepancy model is still used to determine LD eligibility in India.

There are differing methods of identifying students with Mathematic Learning Disabilities and determining eligibility for special education services. Some schools identify children that are functioning one or two grade levels below their expected grade as having learning disabilities. Other schools use a score on a standardized assessment to identify students (Eastburn, 2010). In this case, students qualify as having a math learning disability if they perform in the low average range, or below the 35th percentile, on standardized math achievement tests that measure math calculation and math reasoning (Mazzocco, 2007; Karande, n.d.; Eastburn, 2010). In the United States, states substantially differ from one another in the way they identify students (Cortiella, 2008).

The Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) definition of learning disability is a severe discrepancy (in some cases, more than two standard deviations) between a student's achievement in math and his/her age, schooling, and level of intelligence (IQ), and significant impairment in real-life activities that require math (APA, 2004; Geary, 2011a; Sparks & Lovett, 2009b; Allsopp, 2008). In most research studies, students with MLD "score at or below the 10th national percentile on mathematics achievement tests grade after grade, perform poorly on many mathematical cognition tasks, and tend to have low-average scores in reading, working memory, and general intelligence (IQ)" (Geary, Hoard, & Bailey, 2011, p. 1; Geary, 2011b; Murphy et al., 2007; Geary, 2013). However, researchers, such as Fletcher et al. (2007), insist that learning disabilities exist on a continuum of severity, instead of at cut-off points on the achievement distribution.

Preventative screening

Researchers have been developing early childhood screening tools to predict math difficulties in the early grades (Krasa & Shunkwiler, 2009). In fact, all students can be screened in kindergarten for difficulties in mathematics, including some tasks that are powerful predictors of MLD (Desoete et al., 2009; Griffin & Case, 1997). On questions of numerical comparison on and off the number line, students with strong number sense consistently perform better (Krasa & Shunkwiler, 2009; Jordan et al., 2009). Students with MLD exhibit more counting errors and use immature strategies, as compared to typically achieving peers (Geary, Hoard, Byrd-Craven, & DeSoto, 2004; Jordan & Hanich, 2000). For children with MLD, the nature of their errors differs from children without MLD. Their math (fact) retrieval performance is slow, error-prone, effortful, and inaccurate (Mazzocco, Devlin, & Mc Kenney, 2008). As teachers screen students, they should not just be concerned with the student's right or wrong answer, but also with the method the student used to obtain an answer. MLD may not be detected if only accuracy is

measured. Students with MLD will obtain a correct answer but use immature strategies, whereas typically achieving peers will recall the answer from memory (Butterworth, 2005).

Children with MLD typically have a low start point on math achievement tests and show slow growth as compared to typically achieving peers (Geary, Hoard, Nugent, & Bailey, 2012). If these early math deficits are remediated immediately, then students may not fall further behind their peers in math skills (Desoete et al., 2009). Addressing slow growth usually requires several simultaneous types of remedial and instructional interventions (Geary, Hoard, Nugent, & Bailey, 2012). . Interventions may be particularly effective if they are early (Dowker, 2005; Nelson & Sheridan, 2011).

However, due to various policies concerning students with learning disabilities in Maharashtra and low awareness among teachers and parents, many students in Mumbai, India are not diagnosed with MLD or other learning disabilities until 8th standard or later (Karande & Gogtay, 2010). By this time, it is difficult to remediate the many misconceptions that students have formed about mathematical ideas.

Unfortunately, there is no consensus regarding which of the early predictors could be used as screeners to identify children with math difficulties. Counting, conceptual counting, number sense and magnitude comparison, early arithmetic skills, and IQ may be promising early predictors for MLD (Stock, Desoete, & Roeyers, 2010). Typically, schools begin identifying students as having learning disabilities around third grade (Fuchs et al., 2013). Yet, preventative screening and intervention can begin as early as kindergarten (Krasa & Shunkwiler, 2009; Jordan et al., 2007).

Prevalence

It is estimated that approximately 5-8% of the population is affected by MLD (Murphy et al., 2007; Paulsen, 2005; Geary, 2004; Ramaa & Gowramma, 2002; Geary, 2013). The estimated

prevalence varies due to criteria and statistical techniques used to analyze the data (Krasa & Shunkwiler, 2009). The prevalence rate of MLD is comparable to the prevalence of reading disabilities, yet MLD is underrepresented in the literature (Grégoire & Desoete, 2009; Mazzocco, 2007; Murphy et al., 2007; Paulsen, 2005). MLD is not caused by poor or low-quality instruction, but it can be a primary cause of mathematical difficulties (Mazzocco, 2007).

It is difficult to give an actual percentage of prevalence of MLD since it is very rare for students to be referred for an evaluation solely for math difficulties (Krasa & Shunkwiler, 2009; Pennington, 2009). Pennington (2009) reports that it was extremely uncommon for his clinic to have a child referred for specific MLD, but the cases for specific reading learning disabilities was much higher in comparison. If students struggle in mathematics, it is assumed that they have weak math skills, and may not be referred for a formal evaluation (Krasa & Shunkwiler, 2009).

Prevalence of MLD in India

It is difficult to truly enumerate the prevalence of MLD in India due to lack of awareness among teachers, psychologists, doctors, and parents; lack of statistics available from the different curricular Boards; etc. Also, there are many vague definitions of learning disabilities in the current research (Desoete, Roeyers, & De Clercq, 2004). Currently, “overlapping concepts and terms are frequently used to deal with a wide range of phenomena relating to children who have difficulties with mathematical problem solving” (Desoete, Roeyers, & De Clercq, 2004, p. 57). There is currently only one peer-reviewed article about Indian students with math learning disabilities, and the researchers identified nearly 6% of the population of primary school students in Mysore as having MLD, as well as a 1:1 ratio for the male/female ratio of students with MLD (Ramaa & Gowramma, 2002).

However, at a government hospital in Mumbai, doctors feel that the Western literature reports a higher incidence of MLD than has currently been diagnosed in India. For example, in

the past 4-5 years, only about 9 students have been certified as having MLD alone, out of 3,000-4,000 students (much less than 1% of all diagnoses). However, this is an estimate because, as a government hospital, they are not allowed to release information to the public (anonymous, personal communication, March 26, 2013).

Due to the lack of uniformity of diagnosing learning disabilities, it is difficult to present an accurate picture of the number of students with MLD in the country. There are no standardized measures available for students who study in vernacular-medium schools (where the language of instruction is not English) (Al-Yagon et al., 2013). Also, there is a debate as to whether standardized tests used in Western countries, such as the Woodcock-Johnson or the Wechsler Intelligence Scale for Children (WISC) are culturally appropriate for Indian students who are studying in English-medium schools (Al-Yagon et al., 2013). The WISC does have an Indian adaptation test available for IQ, yet there are no standardized measures for academic achievement (M. Khan, personal communication, March 6, 2014). At this point, centers like MDA use the academic achievement battery standardized on the U.S. and U. K. population, but place emphasis on “error analysis and give a qualitative report with rationales for diagnosis and accommodations” (M. Khan, personal communication, March 6, 2014). The LD clinics at Nair and Sion government hospitals also use tests that are not standardized on the Indian population, while K.E.M. government hospital uses curriculum-based tests for students in English-medium schools (Al-Yagon et al., 2013). More research needs to be done in order to develop curriculum-based tests for diagnosis of learning disabilities in India, especially in the 21 official languages, apart from English (Al-Yagon et al., 2013).

Dyscalculia

In India, the term “dyscalculia” is used instead of MLD. In the literature, these terms are occasionally used synonymously (Butterworth, 2002; Williams, 2012). The term was first used

extensively by Kosc (1974) and is still used by cognitive neuroscientists today (Williams, 2012). However, according to the American Psychiatric Association (2013d), the term “dyscalculia” is not listed as a disorder name or in the diagnostic criteria, due to the multiple definitions that exist. Psychiatric diagnoses are categorized by the Diagnostic and Statistical Manual of Mental Disorders, which now has a 5th edition (American Psychiatric Association, 2013b). Better known as the DSM-5, the manual is published by the American Psychiatric Association and covers all mental health disorders for both children and adults used in North America (American Psychiatric Association, 2013b; Williams, 2012). The DSM – 5 suggests that if a clinician uses the term dyscalculia, then they should mention if the child also has difficulties in math reasoning, in addition to arithmetic facts and calculations (American Psychiatric Association, 2013a).

Even though the term “dyscalculia” is not recommended by the American Psychiatric Association (2012, 2013d), doctors in government hospitals in India continue to use it. One prominent doctor told me that “the term dyscalculia is used because of the psychiatric definition,” referring to the DSM-IV (anonymous, personal communication, March 26, 2013). Yet, the term “dyscalculia” is not used in the definition or the diagnostic criterion for Mathematics Disorder (315.1) of the DSM-IV (text revision) or DSM-5 (American Psychiatric Association, 2000, 2013d). However, the DSM-5 acknowledges that learning deficits in mathematics are sometimes referred to as “dyscalculia” internationally (American Psychiatric Association, 2013c)

The “dyscalculia” referred to in this study is “developmental dyscalculia,” as opposed to “acquired dyscalculia,” which usually occurs in adults as a result of a stroke or traumatic brain injury (Williams, 2012). However, in the majority of this study, the term “MLD” will be used.

The most common diagnosis in government hospitals is dyslexia and dysgraphia (learning disabilities of reading and written language). The next most common diagnosis is

dyslexia, dysgraphia, and dyscalculia (exact statistics were not available for public information). At this government hospital, doctors have observed that students have strong calculation skills, yet struggle with higher level application and geometry (anonymous, personal communication, March 26, 2013). NCERT Director, P. Sinclair, remarks that teachers and parents in India focus on the calculation aspects of mathematics, but actually, it is more about reasoning (personal communication, July 5, 2013).

Special Education policy in India

In discussing prevalence of MLD in India, one must understand current special education policy in India. There are only six states (out of 28 states and 7 union territories) that are open to the concept of Learning Disability (Goa, Gujarat, Karnataka, Kerala, Maharashtra, and Tamil Nadu) (Al-Yagon et al., 2013). It is difficult to give an estimate of the prevalence of any learning disability in India due to the lack of policy and procedures in the field of LD. The national government does not currently recognize “learning disability” or any type of mathematics disorder, so there are no uniform guidelines for assessment, diagnosis, or certification. There is also extreme lack of awareness of learning disabilities among teachers (Unni, 2012; Al-Yagon et al., 2013). ADHD is not a recognized category of disability, in both the national and state governments (Al-Yagon et al., 2013).

The landmark legislation in India regarding disabilities is The Persons with Disability (PWD) Act, 1995 (Rehabilitation Council of India, personal communication, August 6, 2013). In the PWD Act, there are ten categories of disabilities: blindness, low vision, leprosy-cured, hearing impairment, locomotor disability, mental retardation, and mental illness. In 1999, Autism, Cerebral Palsy, and Multiple Disabilities were added with the National Trust for Welfare of Persons with Autism, Cerebral Palsy, Mental Retardation and Multiple Disabilities Act (Ministry of Social Justice and Empowerment, 2009b).

The PWD Act 1995 currently has a 2011 draft amendment pending in Parliament (Rehabilitation Council of India, personal communication, August 6, 2013; Shelar, 2013; Unni, 2012). According to the Ministry of Social Justice and Empowerment, the proposed changes in the PWD Act include adding to Section 27 to include “education of children with learning disabilities” (2009a, p.3). If the amendment is approved, the government

shall take necessary steps to ensure that: (i) Learning disabilities in children are detected at the earliest; (ii) Suitable pedagogical and other measures are taken so that the child is enabled to overcome such disabilities at the earliest, and is able to fully develop its potential.

Explanation: For the purpose of this section, “learning disability” means a disorder which affects the child’s ability to either interpret what he sees and hears, or to link information from different parts of the brain. Learning disability includes children with conditions known as attention deficit disorder, dyslexia, dysgraphia, dyscalculia and dyspraxia.

(Ministry of Social Justice and Empowerment, 2009a, p. 38).

It is unclear as to when this amendment is expected to be reviewed and voted upon (Rehabilitation Council of India, personal communication, August 6, 2013). Without uniform guidelines and general awareness of LD, it is extremely difficult to report on the prevalence of MLD in India. There could be huge numbers of students who are undiagnosed.

Prevalence of MLD in relation to Reading Learning Disabilities

Some students may show evidence of comorbidity³, having both reading and math learning disabilities. Studies around the world suggest that mathematical and reading disabilities co-occur in 17% to 43% of children, depending on the eligibility criteria used (Grégoire & Desoete, 2009; Raghubar et al., 2009; Desoete, 2008; Fuchs & Fuchs, 2002; Geary, 2011b). In the Ramaa and Gowramma (2002) study, more than 50% of the students with MLD also had learning difficulties in reading and writing. MLD and reading LD may co-occur due to a common underlying deficit in long-term semantic memory (Geary, 1993; Fletcher et al., 2007).

³ Co-morbidity refers to the “co-occurrence of one or more diseases or disorders in an individual” (Desoete, 2008, p. 15).

However, it is still unclear which primary cognitive mechanisms separate math learning disabilities from reading learning disabilities (Swanson, Jerman, & Zheng, 2009).

As compared to typically achieving peers, students with both mathematical and reading learning disabilities and those only with MLD both make more counting errors, persist with immature strategies, memorize less facts, and are slower to automatically apply math facts. However, the students with both reading and math learning disabilities are more impaired than students with MLD only. Therefore, having a reading learning disability, like dyslexia, along with MLD may exacerbate a student's math difficulties (Geary et al., 2004; Pennington, 2009; Fletcher et al., 2007). In fact, students with both MLD and Reading LD have more severe difficulties in all academic areas (Fletcher et al., 2007; Jordan, Hanich, & Kaplan, 2003). Students with only reading disabilities are presumed to have difficulty memorizing math facts due to poor phonological memory (Pennington, 2009).

Prevalence of MLD in relation to Attention Deficit Disorders

MLD also co-occurs with attention disorders, such as Attention Deficit (Hyperactivity) Disorder (ADHD). Co-morbidity of MLD and ADHD show more overlapping characteristics than those with co-morbidity of reading LD and ADHD, mainly due to the areas of strategy use, procedural learning, and working memory (Raghubar et al., 2009; Fletcher et al., 2007). It is estimated that 20% of students with learning disabilities in India also have ADHD (Karande, n.d.; Karande et al., 2007).

Manifestation of MLD in the regular education classroom

Characteristics

Due to deficits in number sense, working memory, visual-spatial processing deficits, sequencing, slow processing speed, language difficulties, and/or attention, students with MLD exhibit similar characteristics in the regular education classroom. They typically have difficulty

in the one or more of the following areas: conceptual and procedural understanding, basic facts, speed, visual-spatial skills, attention, and problem solving. Adolescents with MLD typically perform at a fifth-grade level in math and experience great difficulty with problem application (Maccini & Gagnon, 2002; Calhoon et al., 2007; Cawley, Baker-Kroczyński, & Urban, 1992; Council for Learning Disabilities, 2007).

Conceptual and Procedural understanding

Students with MLD may have deficits in procedural and/or conceptual competencies (Geary, 2004; Kyttälä, 2008). Procedural competencies refer to the ability to perform a task, such as counting 5 objects, while conceptual competencies refer to the understanding of why a procedure works and is legitimate (LeFevre et al., 2006; Stock, Desoete, & Roeyers, 2010; Booth, 2011).

Conceptual knowledge and procedural knowledge of mathematics develop together (Booth, 2011). If students with MLD have difficulty with conceptual knowledge of mathematics, it might influence their ability to execute procedural skills, such as multi-digit operations ($39+24$, 25×32). Students with weak conceptual understanding of mathematics may be limited to an “inflexible use of a learned procedure” and may not use a wide variety of the strategies and principles listed above (Dowker, 2005, p. 32). For instance, students may be competent in single-digit mathematics, but experience difficulty when applying the same concepts with multi-digit numbers. Students with conceptual deficits lack an awareness of the relationships between numbers and operations and may have difficulty linking the number relationships to new tasks (Dowker, 2005). Children with MLD may have gaps in their conceptual knowledge, including knowledge of counting, place value, and estimation (Geary et al., 2007). These gaps can affect the students’ procedural skills, as they fail to understand the problems that result from the misapplication of previously-learned strategies. For example, students may always

subtract the larger number from the smaller number ($52 - 28 = 36$), or the student may always regroup (borrow), even when it is not necessary ($56 - 23$; regroups the 56 to 4 and 16) (Dowker, 2005). In other words, students with difficulty in procedural skills may “fail to perceive that the procedure being adopted does not make mathematical sense” (Dowker, 2005, p. 33). If students with MLD lack fundamental prerequisite knowledge necessary to actively engage in grade-level discussions and activities, they will lag behind their peers (Sayeski & Paulsen, 2010).

Overall, students with MLD may lack conceptual and procedural knowledge to complete higher-level math problems, while others may run out of time because they use immature, time-intensive strategies and are not fluent in basic math facts (Calhoun et al., 2007). In a study by Mazzocco, Devlin, & McKinney (2008), students with MLD struggled with easy arithmetic problems (operands < 6 , operands of 10, duplicate operands, or multiples of 5 or 10; e.g., $4 \times 4 =$, $4 + 4 =$, $5 \times 8 =$) on a timed test in the eighth grade. For children with MLD, math fact difficulties will persist well beyond the elementary school years (Mazzocco, Devlin, McKinney, 2008).

Students need to have deep conceptual understanding of math concepts, such as fractions, in order to remember what they have learned. When students have a superficial understanding of math concepts, arithmetic procedures are easily confused with each other, especially in the case of fractions (Fazio & Siegler, 2011).

In fact, Siegler et al. (2012) found that knowledge of fractions and whole-number division in primary school predicts math achievement in secondary school more than whole-number addition, subtraction, and multiplication; verbal and nonverbal IQ; working memory; family education; and family income. Fractions and division are inherently related ($\frac{N}{M}$ means N divided by M), and mastery of whole-number division, like mastery of fractions, is required to solve many algebra problems (such as the quadratic equation). However, poor knowledge of

both division and fractions could lead students to give up trying to make sense of mathematics. Eventually, they rely on rote memorization to solve more difficult problems (Siegler et al., 2012).

Understanding fractions is one of the most important math skills that students need to develop. It is essential for understanding algebra and geometry and other aspects of mathematics. Yet, fractions have proven to be very difficult to understand for most students around the world (Hecht & Vagi, 2010; Fazio & Siegler, 2011).

Numerical combinations / basic facts

One of the most reported characteristics of children with MLD is poor fact retrieval (Mazzocco, Devlin, & McKenney, 2008; Gersten & Chard, 1999). Students with MLD may have difficulty with procedures, such as recalling basic facts, due to difficulty with long-term memory and working memory (LeFevre et al., 2005). Students with MLD can recall some facts, but they usually recall fewer facts and make more errors in retrieval than their typically achieving peers (Geary et al., 2012; Geary, 1993). In fact, students with MLD know, on average, about one-third of the math facts as compared to their peers without MLD. This can be seen as early as seven years of age and continues throughout high school (Jones & Riccomini, 2007). Learning and retrieving math facts is a common and persistent difficulty for students with MLD (Geary, 2013).

Students with MLD also tend to use more “immature computational strategies” when solving simple math combinations (Gersten, Clarke, & Mazzocco, 2007, p. 18). In this case, students may use finger counting and drawing concepts instead of mental math and fact retrieval when completing paper and pencil calculations (Mazzocco, 2007; Kyttälä, 2008; Geary, Bailey, & Hoard, 2009; Krasa & Shunkwiler, 2009). Most students typically shift from finger counting and verbal counting strategies for addition in second and third grade (Cho et al., 2011; Ashcraft & Fierman, 1982; Kaye, Post, Hall & Dineen, 1986; Geary, Widaman, Little & Cormier, 1987). Some students with working memory difficulties may have problems with long

mathematical procedures, or computations that involving many steps (LeFevre et al., 2005; Fletcher et al., 2007). In fact, procedural errors account for the largest cause of mathematical difficulties for students with MLD (Calhoon et al., 2007).

Students with MLD rely heavily on finger counting in the lower grades and commit many counting errors due to their working memory deficits (Geary, Hoard, Byrd-Craven, & DeSoto, 2004). Finger counting can reduce the working memory load of the task for the student (Passolunghi & Cornoldi, 2008). Students with MLD typically use less sophisticated and immature strategies in mathematics as compared to their peers (Geary, 2013).

Students with MLD also experience difficulty when problems are in a mixed format and involve more than one operation. For example, they may add when they should actually subtract. These errors could be caused by attentional difficulties and problems with shifting and inhibitory control (Rourke, 1993), but one study found this not to be entirely clear and called for more research in this area (Raghubar et al., 2009).

Speed

According to VanDerHeyden (2008), students with math learning disabilities typically “perform lower and grow at a slower pace relative to their peers in learning mathematics” (para. 2). Students with mathematical learning disability or math learning difficulties differ in pattern of development and strategies used when compared to typically achieving groups (Geary et al., 2007). Students with MLD usually struggle with “(a) upper level division of whole numbers; (b) basic operations involving fractions, decimals, and percentages; (c) multiplication of whole numbers; (d) multistep problems; and (e) regrouping and renaming” (Calhoon et al., 2007, p. 301). Students with MLD may also have difficulty using strategies and principles, such as the commutative ($a + b = c$ and $b + a = c$), associative ($(a + b) + c = a + (b + c)$), distributive ($(a + b) \times c = (a \times c) + (b \times c)$), and inverse (using $19 + 16 = 35$ to figure out $35 - 19$) properties (Dowker,

2005). Students may use time-intensive manual strategies, such as finger counting, to alleviate the strain on working memory. In one study, (Siegler and Jenkins, 1989), students with MLD continued to use immature counting strategies even after they learned efficient and more mature strategies (Calhoon et al., 2007).

Visual-spatial skills

Difficulties with visual-spatial skills tend to emerge in grades 4-9 when more advanced geometric concepts are introduced (Gersten, Clarke, & Mazzocco, 2007). Students also make use of spatial abilities in mathematics to correctly place and align the digits, especially in written mathematics and multi-digit problems. This includes a student's ability to understand the value of a digit within a number and its relation to other digits (Kyttälä & Lehto, 2008). A student's visual-spatial working memory might be impacted in different ways, depending on the presentation format (vertical or horizontal) or operation (LeFevre et al., 2005). Spatial abilities also affect a student's internal / imaginary number line, or representations of numerical relationships by spatial positions, such as numbers that are ordered from left to right, or top to bottom (Dowker, 2005; Kyttälä, 2008). Visuospatial deficits are typically associated with difficulties in geometry, estimation, and complex word problems because of the need to represent and manipulate information (Geary, 2004; Montague & Jitendra, 2006). Visual-spatial short term memory and visual-spatial working memory are so important to mathematical learning that tasks in these areas best predict later school mathematics outcomes, according to a 2008 study by Bull, Espy, & Wiebe (Mazzocco, 2008).

Attention

Students may exhibit impulsivity when computing math problems. When given the question, $4+8=?$, a young student may answer 5 or 9 due to the association with basic counting (Geary, Hoard, & Bailey, 2011). Additionally, attention deficits may be more reflected in

performance as opposed to understanding. Students with ADHD typically count slower and have difficulty comparing numbers close in value (Weber's Law) more so than their peers. However, their ability to place numbers on the number line is on par with peers. However, since math is cumulative and becomes more complex, older students with ADHD may eventually show gaps in understanding, especially if they have difficulties with organization (Krasa & Shunkwiler, 2009).

Problem solving

Word problems require students to "use the text to identify what information is missing, construct the number sentence, and derive the calculation problem for finding the missing number" (Fuchs & Fuchs, 2007, p. 399). Difficulty increases when more than one calculation is required, narratives increase, and/or irrelevant information are included in the word problem (Fuchs & Fuchs, 2007). Students' performance in math may also be impacted by reading and vocabulary deficits (Sullivan, 2005). Students with MLD may not attempt to understand the word problem, but instead, jump into calculations with the numbers mentioned in the problem, without confirming that the answer is meaningful (Kajamies, Vauras, & Kinnunen, 2010).

Instruction can also contribute to difficulties with problem solving. Some teachers and programs put so much emphasis on computation and fact retrieval that students with MLD may have limited exposure to problem solving (Maccini & Gagnon, 2002). In a similar manner, some students may have difficulty with word problems due to poor computational fluency. Computational fluency may interfere with mathematical comprehension in much the same way that poor decoding skills interfere with reading comprehension (Calhoon et al., 2007; Kilpatrick, Swafford, & Findell, 2001).

Word problems are also challenging due to working memory deficits. Students have to hold the information that they have read at the beginning of the problem and follow through

until the end of the problem. Additionally, word problems with missing information at the beginning of a problem (start unknown⁴) pose a problem for students with MLD (Krasa & Shunkwiler, 2009; Fuchs et al., 2013; Carpenter et al., 1999).

Sequencing deficits can also impact students with MLD and their ability to solve word problems. Students may find it difficult to organize the information presented in the problem, devise a plan, and complete all of the steps to solve it. Students may be confused as to where to begin, as well as estimating a reasonable result (Krasa & Shunkwiler, 2009). Students with sequencing deficits need to break down large tasks into manageable parts (Zheng, Flynn, & Swanson, 2013; Krasa & Shunkwiler, 2009).

Students with MLD have difficulties in certain areas of mathematics due to deficits in number sense, working memory, visual-spatial processing deficits, sequencing, slow processing speed, language difficulties, and/or attention. At times, the deficits are interwoven, and it is difficult to tease apart which deficit causes which difficulty.

Instruction

Children with math disabilities of differing natures will require different instructional approaches (Raghubar et al., 2009). According to VanDerHeyden (2008), early mathematics intervention for students with MLD can repair current deficits and prevent future ones from forming (Siegler & Ramani, 2008). However, math learning disabilities don't disappear with time, and students with MLD will continue to face the difficulties mentioned above as they enter secondary school and higher secondary education (Mazzocco, Devlin, & McKinney, 2008; Vogel, Fresko, & Wertheim, 2007). They may need continuous instructional intervention.

⁴ An example of a start unknown problem: "Mary had some crayons. Then she dropped three crayons on the floor. Now Mary has 5 crayons. How many crayons did Mary have in the beginning?" (Fuchs et al.; 2013, p. 394).

Curriculum

Students with MLD are impacted by the general education curriculum. Students are required to learn many new computational skills in one academic year. But, if students with MLD are not able to learn required skills adequately in 4th standard, how will they acquire the skills that are expected of them in the 5th standard (Calhoon et al., 2007)? In fact, past research studies have shown that students with MLD average only one year of growth for every two years or more of school; during adolescence, students with MLD average only one year of growth in grades 7 – 12 (Cawley & Miller, 1989; Warner et al., 1980; Calhoon et al., 2007; Geary et al., 2012). Difficulties in math persist over time, as evidenced by a study by Shalev et al. (2005). In a longitudinal study, 47% of students who had MLD in grade 5 continued to meet the criteria for MLD in grade 8 (Shalev et al., 1998). Six years later, 95% of students with MLD identified in grade 5 were performing in the bottom 25% in grade 11 (Shalev, Manor, & Gross-Tsur, 2005). Students with MLD's performance may plateau at the 5th or 6th grade level (Cawley, Baker-Kroczyński, & Urban, 1992; Council for Learning Disabilities, 2007).

Algebra

Algebra has been referred to as an academic passport or a “gateway to expanded opportunities” (Impecoven-Lind & Foegen, 2010, p. 31; Fennel, 2008; Lacampagne, Blair, & Kaput, 1995; Maccini, McNaughton, & Ruhl, 1999). But, in order to succeed in algebra, students need a strong foundation in the prerequisite skills needed for algebra, such as fractions, decimals, percentages, ratio and proportion, problem solving, and even basic multiplication (Fennel, 2008). As teachers work with students to attain mastery in the foundational skills, algebraic concepts, such as early experiences with equations, inequalities, the number line, and properties of arithmetic (such as the distributive property), can be integrated in the curriculum to make the transition to algebra a bit easier (Fennel, 2008).

It is imperative that students with MLD in India have access to algebra so that they are not held back by the “gatekeeper” to educational and economic success (Impecoven-Lind & Foegen, 2010, p. 32). In order to accomplish this, students must develop proficiency in foundational skills. This can be extremely difficult for students with MLD, since they may have struggled with mastery of basic skills early in their math development, such as with whole numbers and counting skills (Impecoven-Lind & Foegen, 2010; Geary, 2004). Also, students’ misunderstandings about number relationships and other fundamental math concepts may have a detrimental effect on their ability access and learn more sophisticated mathematical concepts (Ketterlin-Geller, Chard & Fien, 2008).

Mathematics has been referred to as “a house of cards,” since each concept requires “the coordination of lower level interrelated skills (e.g., reading numbers; understanding the base-10 number system; knowing arithmetic facts, carrying, borrowing, measuring), each of which is itself grounded on very basic conceptual and procedural knowledge (e.g., understanding the meaning of numbers or counting)” (Rousselle & Noël, 2008, p. 498). Students must learn the foundational skills for learning advanced mathematical concepts. If they do not, students’ mathematical difficulties will cumulate and worsen over time. Students who fail to understand whole numbers, number relationships, and fractions will fail algebra (Jordan et al., 2009). Some studies even suggest that preparatory arithmetic abilities learned in kindergarten (logical thinking abilities such as seriation⁵ and classification, and counting knowledge), as well as overall intelligence, are strong predictors for later proficient arithmetic abilities and school achievement (Stock, Desoete, & Roeyers, 2009; Desoete et al., 2009; Duncan et al., 2007). In

⁵ Seriation is defined as “the ability to sort a number of objects based on the differences of one or more dimensions while ignoring the similarities. In contrast, classification is the ability to sort objects based on their similarities on one or more dimensions” (Stock, Desoete, & Roeyers, 2009, p. 238; Stock, Desoete, & Roeyers, 2010).

other words, the strongest predictor for later achievement in mathematics and reading was school-entry mathematics skills (Duncan et al., 2007; Geary, Bailey, & Hoard, 2009).

Dowker (2005) indicates that the impact of poor arithmetical skills is greater than the influence of poor reading skills on employment prospects (Grégoire & Desoete, 2009; Every Child a Chance Trust, 2009; Siegler, 2007). People with poor numeracy skills are less likely to have full time jobs and their employment options are usually restricted to manual and lower-paying jobs (Dowker, 2005). Therefore, students must have access to the general education curriculum and national standards to ensure they have access to positive academic outcomes and to prepare them for future steps (Maccini & Gagnon, 2002). Students must master basic mathematical competencies to function in the day-to-day activities of the information and data-driven 21st century, to be employable, and earn wages (Every Child a Chance Trust, 2009; Geary et al., 2012; Walshaw & Anthony, 2008). While we want every child to have college readiness, we also want them to be ready for the workplace. In order to help them be ready for college and the workplace, we must ensure that they prepare in secondary school through the core curriculum, especially in the area of rigorous mathematics, and make certain that students' foundational skills are reinforced and mastered (ACT, 2005).

Proficiency in mathematics is influenced by the continued development and blending of critical component skills. When students with MLD have gaps in these crucial skills, they will struggle with many aspects of grade-level mathematics (Jones & Riccomini, 2007). Yet, the literature cites many strategies and methods that can help students with MLD succeed in secondary and higher secondary math classes.

Instructional strategies

Fuchs et al. (2013) have identified six general instructional principles that should guide remediation for students with MLD: instructional explicitness, instructional design that

minimizes learning challenges, strong conceptual basis for procedures, drill and practice, cumulative review, and motivators to regulate attention and behavior. Teachers must individualize instruction for students with MLD and have a deep understanding of various pedagogical strategies that support student learning (Bryant et al., 2006; Ma, 2010).

Explicit instruction

Explicit instruction helps students with MLD because the lessons are highly organized and structured (Montague, 2006; Bryant et al., 2006). Explicit instruction involves the teacher modeling the concept, skill, and process of the mathematical idea in a clear, transparent, and sequential manner (Allsopp, Alvarez-McHatton, & Farmer, 2010; Scheuermann, Deshler, & Schumaker, 2009). Teachers should also share conspicuous strategies with students. Strategies for problem solving are clear and explicit (Carnine, 1997; Stein, Silbert, & Carnine, 1997). In explicit instruction, the teacher models a plan, or strategy, which is specific to the particular mathematical problem, and students are strongly encouraged to adopt the same strategy or plan (Gersten et al., 2009).

Explicit instruction involves four phases (Hudson, Miller, & Butler, 2006). In the first phase, the teacher guides the students by using an advance organizer to review prerequisite knowledge and to introduce the lesson objective. The second phase is demonstration, in which the teacher models solving the problem and uses prompts and cues. Phase three is guided practice, and the students practice and apply the new math content that was demonstrated by the teacher. The teacher begins using prompts and cues, but they fades away supports gradually. The fourth and final phase is independent practice. The teacher can choose from a variety of independent practice formats to maintain student engagement (Hudson, Miller, & Butler, 2006; Strickland & Maccini, 2010; Shyyan, Thurlow, & Liu, 2008). Students are given immediate and corrective feedback in the last phase (Montague, 2006).

Additionally, the teacher can use a think-aloud to vocalize his/her strategy and thinking during explicit instruction (Faggella-Luby, Flannery, & Simonsen, 2010; Bryant et al., 2006). The teacher models a think-aloud by saying everything he or she is thinking and doing while solving a problem (Montague, 2006). Students are then encouraged to think aloud as they work or share their work with their peers (Ketterlin-Geller, Chard & Fien, 2008). When students verbalize their thinking and strategies, they anchor skills and strategies behaviorally (controlling impulsivity) and mathematically (Gersten et al., 2009). A reflective component can also be added to think alouds. Students can talk through decisions they made while solving the problem and reflect on their attempts. By using think alouds, students with MLD can gain insights into the mathematical processes and reach a higher level of understanding of mathematical principles (Gersten et al., 2009).

Explicit instruction can also be enhanced, as in the case of the Explicit Inquiry Routine (EIR). EIR integrates validated-mathematical teaching practices from the general education (inquiry, dialogue, manipulative devices) literature with explicit instruction to engage students in an interactive process of inquiry, while incorporating multiple modes (concrete, representation, and abstract⁶) of illustration and manipulation in order to develop understanding and procedural skills for an essential math concept (Scheuermann, Deshler, & Schumaker, 2009). In Scheuermann, Deshler, & Schumaker's (2009) study, 14 participants in grades 6 – 8 studied one variable equations using the EIR approach. The mathematical component (one-variable equations) was broken down into instructional bites (simple,

⁶ A multi-sensory approach to mathematics to build conceptual understanding, in which physical manipulatives are used at the concrete level (counters, blocks, algebra tiles, and geoboards); drawings, pictures, and virtual manipulatives are tools used at the semiconcrete or representational stage; and at the abstract level, students use mathematical notation (numbers, symbols, and variables). (Witzel, 2005; Witzel, Mercer, & Miller, 2003; Strickland & Maccini, 2010)

intermediate, and advanced) so that students mastered prerequisite skills. The next component of EIR was scaffolded inquiry, which involved three stages: Tell me how... (whole class, with the teacher), Tell your neighbor how... (with a peer), and Tell yourself how... (self-talk). In each stage, the students illustrated and manipulated the math problems using various modes of illustration, including use of objects, representations, and symbols. Each instructional bite was taught to mastery before moving on to the next bite. Eleven weeks after the instructional intervention, the students continued to maintain the mathematical skills for one-variable equations (Scheuermann, Deshler, & Schumaker, 2009).

Current mathematics reform movements advocate for an explicit instruction approach as opposed to a constructivist approach to teaching mathematics for students with MLD, since the latter lacks a sufficient research base. This is similar to the earlier debate in reading between explicit phonics instruction and whole language (Kinder & Stein, 2006; Fuchs et al., 2013). Explicit instruction enables students to better understand the structure and meaning of mathematics as compared to inductive, or constructivist, approaches (Fuchs et al., 2013).

Instructional design that minimizes learning challenges

In this instructional principle, teachers anticipate common misconceptions and eliminate misunderstandings (Fuchs et al., 2013). In their instruction, teachers can include worked examples and non-examples to check for students' understanding (Van de Walle et al., 2013). Worked examples are problems that are already worked out, and the students are prompted to explain the steps taken in the solution (Booth, 2011). In worked examples, students explain why the answer is correct. Teachers can also provide well-designed incorrect examples, or non-examples, for the students to explain why a common incorrect strategy is wrong (Booth, 2011; Siegler, 2002).

When students can identify examples and non-examples, teachers are able to assess that the students have obtained conceptual understanding. In essence, students make causal connections in explaining worked examples and non-examples. They are explaining why and how the procedure works, which exemplifies conceptual understanding (Siegler, 2002). Using both worked examples and non-examples has been more beneficial than simply using worked examples alone to promote student understanding and retention of concepts (Booth, 2011; Siegler, 2002).

One activity is shown in Figure 6, where students have to identify which figures are correctly divided into fourths and which ones are not, and why.

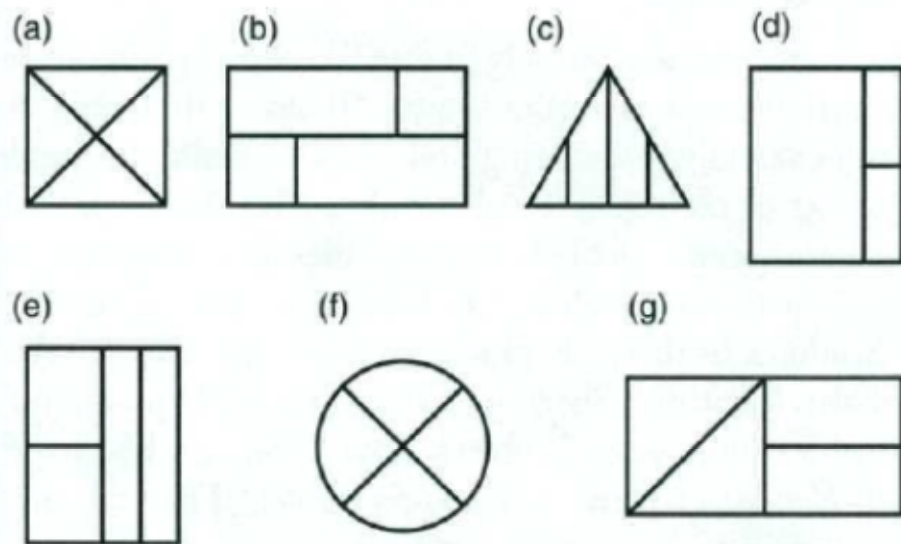


Figure 6. Examples and non-examples of fourths (Van de Walle et al., 2013, p. 297)

In Algebra, students can explain why $3x + 4x = 7x$ and why $3x + 4 \neq 7x$ to determine student understanding of variables and constants (Booth, 2011).

Teachers can carefully choose non-examples that exemplify common misunderstandings. For example, the Minnesota STEM Teacher Center lists student

misconceptions and common errors for each standard in mathematics from Kindergarten to grade 12 (Minnesota Department of Education, 2014).

Teachers can use other instructional strategies to minimize learning challenges. For example, in order to build students' number sense and understanding of the relationship between numbers, teachers can demonstrate the use of number lines to explain many mathematical concepts. Number lines allow children to represent number magnitude and quantity, while making numbers more meaningful. Discriminating among number magnitudes is an important prerequisite skill for estimating and understanding if your answer makes sense. Teachers can model and guide students to use benchmarks on number lines to locate other numbers. Number lines are also a useful instructional tool for representing and understanding fraction and decimal magnitude, as well as equivalency (Siegler & Booth, 2004). Number lines are also an effective assessment tool for understanding the way students process numerals and the magnitudes of numbers. In fact, accuracy in making placements on linear number lines is predictive of later mathematics achievement (Booth & Siegler, 2006; Geary et al., 2012).

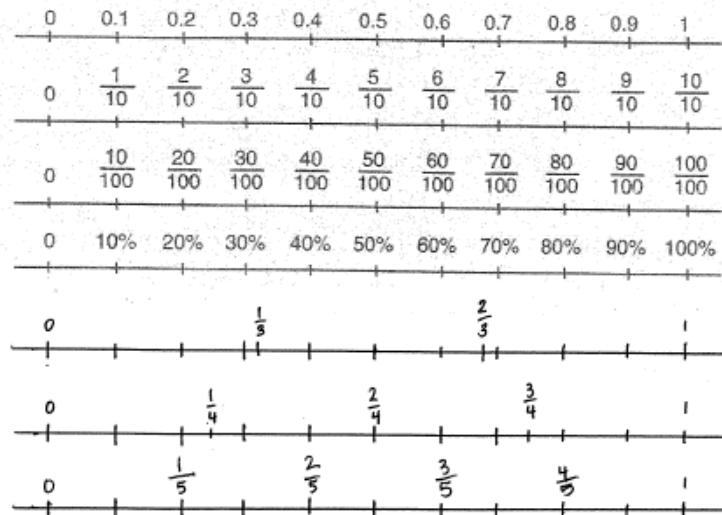


Figure 7: Stacked number lines for benchmark fractions, decimals, and percentages (author, 2013)

Strong conceptual basis for procedures

If students develop misconceptions, then it impacts their ability to comprehend new concepts (Booth, 2011). On the other hand, if students have a strong conceptual foundation about fundamental skills, then they will learn more about arithmetic (Booth, 2011). In order to remember mathematical concepts, students must understand the underlying structure of the problems (Fuchs et al., 2013).

Teachers can promote conceptual understanding by using objects or manipulatives (Maccini & Gagnon, 2000; 2006a; Bryant et al., 2006). This helps students understand concepts at a concrete level and internalize their understanding through multi-sensory learning. Concrete manipulatives should be accompanied with verbal explanation, and later transitioned to a representational drawing (Maccini & Gagnon, 2000).

Drill and practice

For drill to be most efficient for students with MLD, it must be combined with number sense instruction and strategy development. In the area of fact mastery, teachers should give students an inventory, to determine which facts they already know and the strategies they use to obtain their answers (Van de Walle & Lovin, 2006).

Memory

Students with MLD and memory deficits need strategy instruction in order to remember the sequence of steps required to solve a mathematical procedure or problem (Maccini & Gagnon, 2006b). Using these strategies will enable students to minimize the load on their working memory and improve their efficiency in completing mathematical tasks. Students will need repeated practice as they learn these strategies (Berch, 2011).

Students also need instruction in organization strategies for retention (cue cards of strategy steps, graphic organizers, mnemonics, and time for additional practice) (Maccini & Gagnon, 2006a; 2006b). An example of a mnemonic is the LAP strategy for adding and subtracting fractions with unlike denominators (“Look at the denominator and sign; Ask yourself the question, ‘Will the smallest denominator divide into the largest denominator an even number of times?’; Pick your fraction type” (Test & Ellis, 2005, p. 15; Maccini, Mulcahy, & Wilson, 2007). These instructional approaches are often combined, as in the case of the Xin, Wiles, & Lin (2008) study, in which schematic-based instruction incorporated a mnemonic checklist (DOTS (detect, organize, transform, solve), shown in Figure 8).

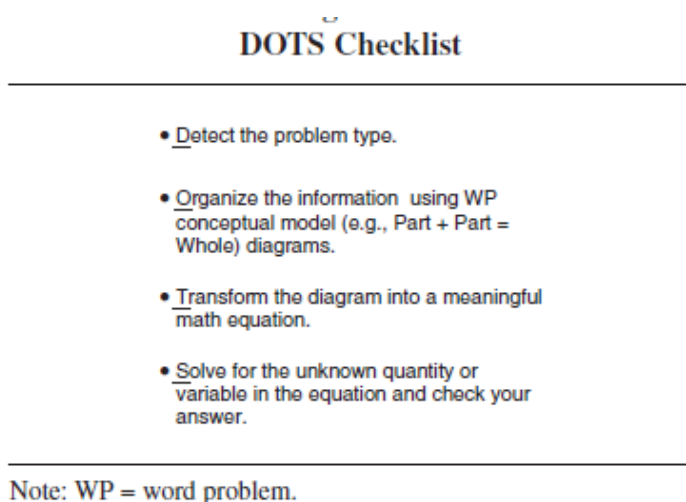


Figure 8. Example of a mnemonic checklist (Xin, Wiles, & Lin, 2008, p. 172)

Teachers can model the math concept using a graphic organizer⁷ (Ives, 2007). Students with MLD can also use mathematical graphic organizers to help visualize computational tasks (Sullivan, 2005; Cavanaugh, 2011). See Figure 9 below: start with the top block and follow the arrows to factor and solve.

⁷ A graphic organizer is a “spatial arrangement of words (or word groups) intended to represent the conceptual organization of text” (Stull & Mayer, 2007, p. 810).

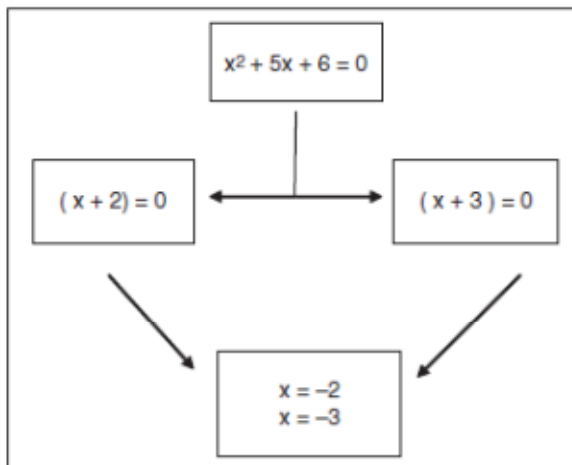


Figure 9. Graphic organizer for solving a quadratic equation (Strickland & Maccini, 2010, p. 44)

Graphic organizers can also help students understand the reasoning processes behind geometric proofs (Figure 10).

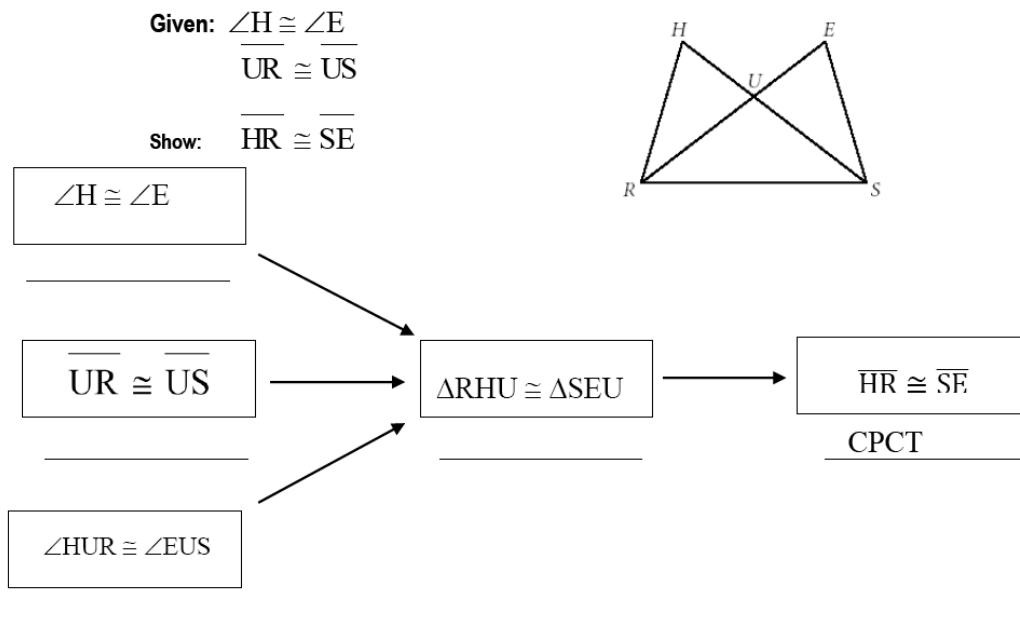


Figure 10. Graphic organizer for geometric proofs (Stevens, 2012)

Math graphic organizers (GOs) may be different than the ones used in reading and language classes. Math GOs may be as simple as: Formula, Substitute, Solve (Cavanaugh, 2011).

5) Find the area of that geometric shape:

- a) Area formula _____
- b) Substitute _____
- c) Solve _____

Figure 11. Graphic organizer for area (Cavanaugh, 2011)

Overall, graphic organizers help students organize and recall the steps in problem solving. Similarly, structured worksheets can help prompt students to use the correct steps and procedures (Maccini et al., 2008). An example of a structured worksheet is in Figure 12 below. These checklists can be faded away as students master the steps (Sayeski & Paulsen, 2010).

Strategy Questions	Write a check (✓) after completing each task or question
Search the word problem: Read the problem carefully	_____
Ask yourself: "What do I know? What do I need to find?"	_____ _____
Write down facts:	_____

Figure 12. Structured worksheet (Maccini et al., 2008, p. 27)

Teachers can also use graphic organizers, such as the Frayer model, to help students understand mathematical vocabulary (Frayer, Fredrick, and Klausmeier, 1969).

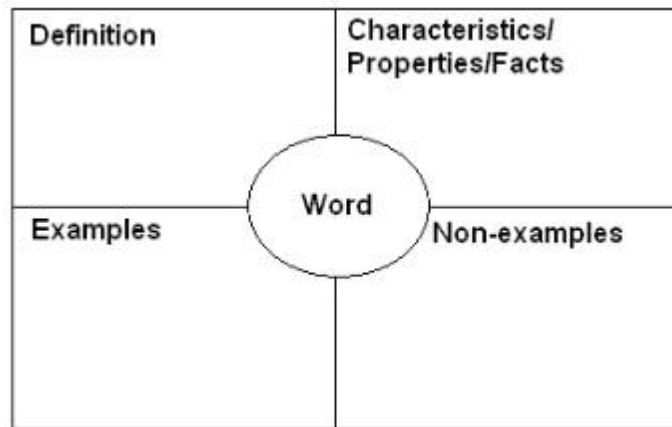


Figure 13. Frayer model (Canlas, n.d.; Frayer, Fredrick, and Klausmeier, 1969; Graves, 1986)

Technology

Technological tools can also help students with MLD perform and practice computational and problem solving tasks. Students with MLD can perform computational tasks using technology, such as a graphing calculator (Allsopp, Alvarez-McHatton, & Farmer, 2010; Steele, 2007). Graphing calculators and computer algebra systems can support students' procedural and conceptual understanding of difficult algebra tasks (Kieran & Saldanha, 2005; Strickland & Maccini, 2010). If students have access to computers, they can use virtual manipulatives to assist in solving computational tasks (Strickland & Maccini, 2010). Dehaene (1997) argues that calculators can help students concentrate on meaning and number sense. By observing a calculator's behavior, students can sharpen their number sense (Dehaene, 1997; Dowker, 2005). Calculators also serve as a memory aid (Dowker, 2005). Technological tools can add a multi-sensory component to lessons, which helps students with MLD that may have information process deficits. Teachers should combine instructional techniques, such as mnemonics, teacher modeling, guided practice, and real-life examples, with graphing calculator use and other technological tools to promote student understanding (Steele, 2007). It should be noted that the instructional practices accompanying the technology is more important to

student learning than the technology itself (Clark, 1983; Seo & Bryant, 2009; Seo & Woo, 2010). Also, computer-assisted instruction should be tailored to students with MLD's instructional needs (such as including interactive graphics that are simple and consistent, virtual simulation and interactive feedback) to increase conceptual understanding of the math content (Seo & Woo, 2010). Students respond positively to instruction that has a direct application to their needs and interests and provides an appropriate level of challenge to the student (Hudson, Miller, & Butler, 2006).

Explicit instruction alone may not motivate students to learn math. The "drill-and-skill approach" may have contributed to the students' difficulties earlier in their math careers, so they may be turned off to learning math through explicit instructional techniques (Levin & Calcagno, 2008, p. 185). Students become unmotivated and see no application for mathematical ideas when teachers use drill-orientated approaches (Woodward, 2006). On the other hand, some students learn best when they compute and problem solve in concept-rich contexts, such as in enhanced anchored instruction (EAI) (Gagnon & Bottge, 2006; Maccini et al., 2008; Strickland & Maccini, 2010; Evmenova & Behrmann, 2012). In EAI, students learn math through hands-on projects, such as designing and building. EAI makes use of the concrete, semi-concrete, and abstract sequence (Gagnon & Bottge, 2006). Furthermore, when problem solving is embedded in a real-world context, students are better able to activate their conceptual knowledge and have increased motivation, participation, and generalization skills (Maccini & Gagnon, 2000; Gagne, Yekovich, & Yekovich, 1993; Polloway & Patton, 1997). With EAI, students see how they use math and why they need to know the concepts (Woodward, 2006).

Various EAI-based programs have been successful in improving basic math skills and motivation to learn math among middle and high school students with MLD (Bottge & Cho, 2013). These programs have evolved to include multi-media based problems with an

accompanying computer-based learning model, as well as hands-on application (Bottge, Grant, Stephens, Rueda, 2010). Implementation of the programs has ranged from 21 days to seven months (Bottge, Rueda, LaRoque, Serlin, & Kwon, 2007; Bottge, Hienrichs, Mehta, Rueda, Hung, & Danneker, 2004; Gagnon & Bottge, 2006).

Cumulative review

Students also benefit from the “daily relooping of previously learned material” to review and reinforce skills (Shyyan, Thurlow, & Liu, 2008, p. 151). Students with MLD will need “booster sessions” for review and practice to maintain strategy use (Montague, 2006, p. 102). Students can engage in a warm-up exercise at the beginning of each class to activate prior knowledge and review foundational skills (Fuchs et al., 2013)

Motivators to regulate attention and behavior

Since students with MLD have repeatedly experienced failure in mathematics, they may be unmotivated in any math class (Fuchs et al., 2013). There are many instructional strategies that help students monitor their attention and break down difficult tasks, such as word problems, into manageable pieces and allow them to experience success.

Self-monitoring

One process that students with MLD typically struggle with is assessing the reasonableness of their answer (Poissant & Hirsch, 2004). Teachers can model this by estimating what their answer should be before actually solving it (Foegen, 2006). Van de Walle et al. (2013) refers to this as “thinking about the answer before solving the problem” (p. 165). For instance, students with MLD may have considerable difficulty solving word problems due to deficits in language, memory, and reasoning (Bley & Thorton, 1995; Montague, 2006). Students with MLD should think about the situation that is described in the word problem and what is

happening to the quantities. In other words, students can convert a word problem into a situation (Tucker, Singleton, & Weaver, 2006).

Similarly, self-monitoring is an effective strategy for helping students with MLD conquer word problems:

READ: Are there words I don't know? Are there number words?

RESTATE: What information is important? What is the question asking? What are the facts?

PLAN: How can I organize the facts using a diagram/model? What operation will I use? Circle or touch the sign. What might the answer be (What is the estimated answer)?

COMPUTE: What steps do I use? What is the answer? Did I get the same answer using the calculator?

CHECK: Does this answer make sense with the information I used? Is my answer close to my estimated answer? Did I use the correct units?

(adapted from Bryant et al., 2006; Miller, Strawser, & Mercer, 1996; Montague, 2006; van Garderen, 2006).

Woodward (2006) suggests laminating the self-monitoring guiding questions rather than make students memorize the strategic prompts. Self-monitoring is sometimes included in the process of self-regulation, which includes strategies to tell yourself what to do, ask yourself questions as you solve, and check yourself (Montague, 2006).

Word problem instruction

As students with MLD think about the situation in a word problem, it helps for them to "see" the situation (Tucker, Singleton, & Weaver, 2006). External visual representations and visualization have been effective strategies for students, especially in abstract topics, such as probability and algebra (Zahner & Corter, 2010; Foegen, 2008; Ketterlin-Geller, Chard & Fien, 2008). By using visual representation, students illustrate solution strategies for mathematical problems (Gersten et al., 2009). Students must be able to visualize the problem, or represent the written information as a mental structure or idea that holds mathematical meaning. Once the student has a mental idea, he/she can move onto planning how to solve the problem and executing the necessary procedures (Foegen, 2008).

However, students should not simply be instructed to “make a drawing.” They must have diagrammatic instruction so they successfully translate the word problem into a meaningful representation, which shows how the parts of the problem are related (van Garderen, 2006). One such approach is schema-based instruction, which helps students discover the deep structure, or schema, of math word problems. In schema-based instruction, students recognize and represent / map the word problem onto a diagram, then translate it into an equation (Jitendra et al., 1999; Jitendra et al., 2002; Maccini, Mulcahy, & Wilson, 2007; Maccini et al., 2008; Novick, Hurley, & Francis, 1999). Students develop a solution plan and select and apply appropriate arithmetic operations (Gick & Holyoak, 1983; Chen, 1999; Xin, Wiles, & Lin, 2008). As students use schematics, they build conceptual understanding of story problems, which increases algebraic reasoning, or symbolic thinking (Kilpatrick, Swafford, & Findell, 2001; Moses, 1997; Xin, Wiles, & Lin, 2008).

Teachers can continue to use explicit instruction to teach schema-based strategy instruction so that students learn which type of schematic diagrams to use based on the word problem given. Students also need explicit instruction to check the reasonableness of their answer as they compare their diagram to the problem type and their final answer (Xin & Jitendra, 2006). See Figure 14 for examples of diagrams that are schematic (shows spatial relationships) as opposed to pictorial (shows visual appearance) (van Garderen, 2007).

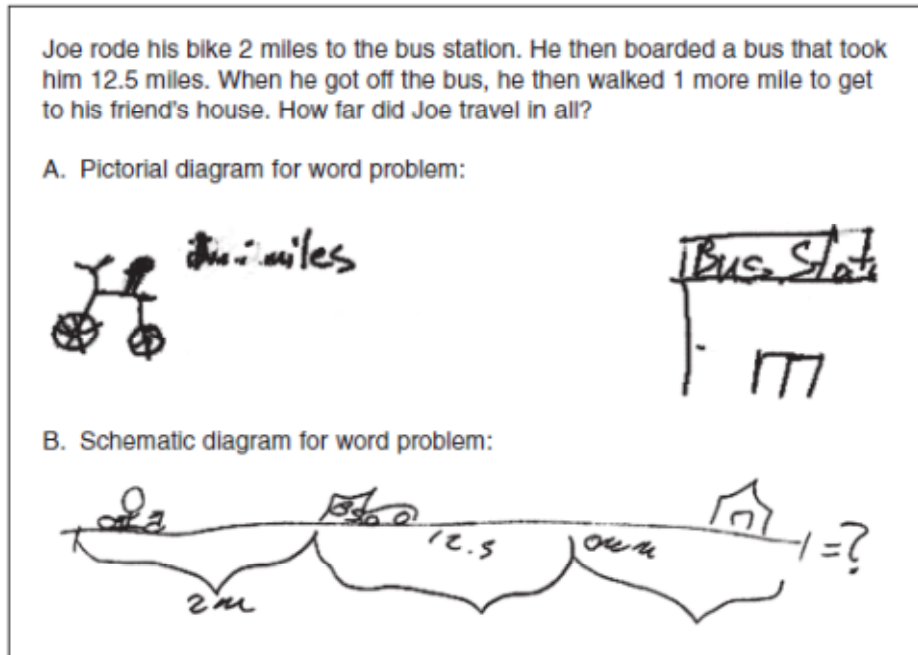


Figure 14. Diagrams for word problems (van Garderen, 2007, p. 544)

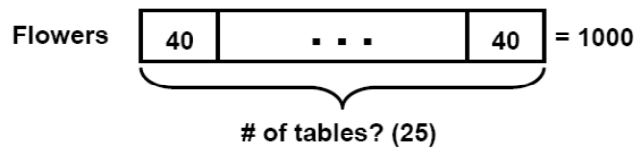
The Singapore Math curriculum uses a similar approach with model drawing to pictorially represent word problems. The model drawing approach involves seven steps:

1. Read the entire problem.
2. Decide who/what is involved in the problem.
3. Draw unit bar (or bars of equal length).
4. Chunk the problem, placing information on model as indicated.
5. Put the question mark in place.
6. Work computations to the side or underneath.
7. Answer the question in a complete sentence.

(Roswell Independent School District Singapore Math, 2008a, p. 1)

An example of a Singapore math model drawing is below in Figure 15:

3. At the wedding, 1000 flowers were arranged with 40 flowers on each table. How many tables were there?



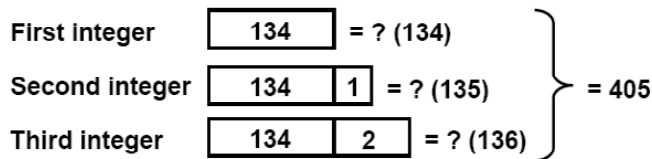
$$1000 \div 40 = 25$$

The wedding had 25 tables.

Figure 15. Model drawing for a quotative division word problem (Roswell Independent School District Singapore Math, 2008b, p. 1)

Figure 16 is an example of a Singapore math model drawing for algebra:

1. The sum of three consecutive integers is 405. What are the three numbers?



$$\begin{array}{r} 405 \\ - 3 \\ \hline 402 \end{array} \quad \begin{array}{l} 3 \text{ units} = 402 \\ 402 \div 3 = 134 \end{array}$$

The numbers are 134, 135, and 136.

Algebra

Let $x = 1^{\text{st}}$ integer

Let $x + 1 = 2^{\text{nd}}$ integer

Let $x + 2 = 3^{\text{rd}}$ integer

$$x + (x + 1) + (x + 2) = 405$$

$$3x + 3 = 405$$

$$3x = 402$$

$$x = 134$$

Figure 16. Model drawing for an algebraic word problem (Roswell Independent School District Singapore Math, 2008c, p. 1)

Teachers can model and think aloud these techniques and strategies for students so they can gain a better understanding of word problems.

Instruction overview

All strategy instruction should involve teacher modeling and think-alouds, followed by guided practice with teacher support, assistance, and feedback (Foegen, 2008). Explicit instruction can be blended with these approaches, such as extended time in the core curriculum, featured in a study by Ketterlin-Geller, Chard & Fien (2008). In their intervention, teachers used the four components of explicit instruction, except the central focus of the lesson

was information from the core curriculum that was covered in the math class that day. Teaching and re-teaching of vocabulary and fluency building were critical to this intervention, which mirrored the scope and sequence of the mathematics lesson during the regular school day (Ketterlin-Geller, Chard & Fien, 2008). Overall, students with MLD learn more from a combination of explicit instruction and strategy instruction (Bryant et al., 2006).

More is known about effective instructional practices for students with MLD compared to the content of the mathematical instructional interventions (Ketterlin-Geller, Chard & Fien, 2008). Additionally, more research needs to be done on mathematics interventions since fewer supplementary interventions in mathematics exist as compared to reading (Kilpatrick, Swafford, & Findell, 2001). Students with MLD can also benefit from accommodations, both during testing and instruction, to increase their access to mathematics and to demonstrate his/her knowledge and skills in ways that may differ from their peers (Olfiesh, 2007). Some accommodations include extended time on tests, assistive technology (including calculators), quiet learning/testing environment, access to a tutor, audio recording of lectures, notetakers, preferential setting, and tests read aloud (Olfiesh, 2007; Sharpe et al., 2005).

Teachers will have to individualize remediation and instructional techniques. No one instructional method will work for all students with MLD since their learning profiles are so diverse (Fuchs et al., 2013; Maccini & Gagnon, 2006b).

Instruction inside Indian primary and secondary classrooms

In the Indian education system, there are three types of schools by management: government, private aided, private unaided (World Bank, 2009; R. Arora, personal communication, July 4, 2013). These different types of schools are also associated with various Boards, or curricula, such as the Indian Certificate of Secondary Education (ICSE) Board, the Maharashtra State Board / Secondary School Certificate (SSC) Board, the Central Board of

Secondary Education (CBSE) Board, and the International General Certificate of Secondary Education (IGCSE) Board. There are 42 different Boards in India, but this study considers the four Boards that are most common in Mumbai: ICSE, SSC, CBSE, and IGCSE (R. Arora, personal communication, July 4, 2013). Primary education in India is sometimes defined as schooling up to 8th standard (although in some schools it ends at 4th or 5th standard), while secondary education ends at 10th standard. Eleventh and 12th standards are known as higher secondary or senior secondary school.

Language

In India, there are a multitude of languages that are spoken/read. Children in India are multi-lingual and bi-scriptal or tri-scriptal (Singh, 2013). Children that study in a private English medium school have to learn English, the state language (in Maharashtra, this is Marathi), and the national language (Hindi). In the case of Hindi and Marathi, there are only a few letters that differ between the two languages and both are in the Devanagari script. However, in Mumbai, many children speak other languages at home, such as Gujarati, which has a completely different script. Numbers are written differently in the Devanagari script than in the English/Roman script as well.

Private English medium schools are not a part of any of the government/centrally-sponsored schemes (R. Arora, personal communication, July 4, 2013). In fact, most parents want to put their children in private schools because there is some sense of teacher accountability. Government schools lack performance indicators for teachers as well as quality monitoring tools to measure school progress. There is no accountability for teachers in government schools if the students are not learning. "India needs teacher performance indicators. Everything is there, but children are not learning" (K. Sharma, personal communication, July 5, 2013). NCERT is currently wrestling with making the education system

and teachers more accountable, instead of putting the blame on students for their lack of learning. They recognize that training is the weakest link in the current educational system. There is no subject-specific training, especially in the area of mathematics. Quality issues in Indian education need to be addressed at multiple angles (M. Jain & K. Sharma, personal communication, July 5, 2013).

Assessment

India, as a nation, is incredibly diverse. With 28 states and 7 union territories, there are also 30 languages spoken by more than one million people. There are additional languages and dialects as well. Overall, it is very difficult to standardize a uniform assessment of learning, let alone of learning disabilities in India (Unni, 2012).

Learning Standards

Currently, India lacks complete measures of national education standards and there is no comprehensive Learning Standards document (Wipro Applying Thought in Schools, 2004; World Bank, 2009). The National Council for Educational Research and Training (NCERT)⁸ had previously developed Minimum Levels of Learning (MLLs) for primary mathematics, but these levels only covered up to 5th standard and were under review in 2005 following the revision of the National Curriculum Framework (NCF) (Chand & Amin-Choudury, 2006; Ministry Of Human Resource Development, 1997; NCERT, 2005a). In the 2005 NCF revision, NCERT shifted the focus from learning indicators and student output to social constructivism in learning (K. Sharma, personal communication, July 5, 2013). The NCF document does not list targeted skills that

⁸ NCERT is an academic institution, not a statutory body. NCERT can make suggestions to the state governments, which have the responsibility of implementing educational policy, but NCERT cannot prescribe (R. Arora, personal communication, July 4, 2013). NCERT can only advise (P. Sinclair, personal communication, July 5, 2013). NCERT gives the states freedom to adopt or adapt their advice, since the context is so varied from state to state (K. Sharma, personal communication, July 5, 2013).

students should know and be able to do. Instead, it gives broad and vague recommendations for the teaching of mathematics, such as embedding math in the child's experience and using technology (NCERT, 2005a).

Overall, the Indian education system has been guided by the patterns and requirements of the examination systems, instead of focusing on children's learning needs and context (NCERT, 2005b). NCERT has identified core issues of concern in regards to the present state of mathematics education in India, and has recommended a shift in focus from mathematical content to mathematical learning environments that foster student participation and success. In order for teachers to cultivate this type of learning environment and use a variety of instructional techniques, more preparation and training is greatly needed (NCERT, 2006c).

Following the NCF 2005 revisions, NCERT has developed quality indicators for elementary education, but these are only available for 3rd, 5th, and 8th standards (or stages) (A. Julka, personal communication, April 3, 2013; K. Sharma, personal communication, July 5, 2013). NCERT is in the process of developing learning standards based on the NCF, but these are not yet available (A. Julka, personal communication, April 3, 2013). Once the learning standards have been completed up to 8th standard (completion aim is September 2013), the process will be replicated for the secondary classes (K. Sharma, personal communication, July 5, 2013). For secondary and senior secondary classes, the Department of Education in Science and Mathematics (DESM) will be responsible for creating the mathematics standards once the primary standards are completed (K. Sharma, personal communication, July 5, 2013). The Department of Elementary Education at NCERT is also aiming to complete assessment standards by September 2013, in order to clarify the difference between assessment and evaluation (K. Sharma, personal communication, July 5, 2013).

NCERT is trying to remove the focus on student output and instead focus on learning. If the schools focus on the indicators, then the fear is that teachers will focus on the output, forcing students to memorize, in order to show they have reached the objective. Yet, no understanding and real learning may have occurred. According to NCERT Department of Elementary Education (DEE) Professor Kavita Sharma, “We are trying to make elementary education more constructivist-oriented than output-oriented. We want to see permanent and meaningful learning. We know that there must be evidence of learning. Sometimes kids are not showing grade-level skills. But, we don’t want to just give the learning outcomes; we want to focus on the processes (such as observation, analysis, etc.)” (personal communication, July 5, 2013). Also, learning and assessment should be contextualized since the various states in India are so diverse (R. Arora, personal communication, July 4, 2013).

Syllabi / Curriculum

Since comprehensive learning standards are not yet available, teachers strictly follow the textbook and the broad list of topics in the Board syllabus. The content of the textbooks have been developed by the state board and these are the only resources teachers have been given, especially in the secondary schools. NCERT has developed a syllabus for primary, secondary, and higher secondary classes based on the NCF 2005. NCERT also published model textbooks that are used in some CBSE and Kendriya Vidyalaya (CBSE schools for central government employees, including children of the Indian defense services personnel) schools, yet the various states, Boards, and schools can choose or develop their own textbooks. Some states adopt or adapt the NCERT textbooks and syllabus (R. Arora, personal communication, July 4, 2013). In India, there are no required minimum skill and knowledge standards against which student learning can be measured. Therefore, there is also no intervention required by the schools for students who are not meeting minimal learning levels.

The only current measurement of what students should know once they finish secondary school is the curriculum / syllabi. In New Delhi, the National Council of Educational Research and Training (NCERT) drafts syllabi and guidelines for students studying in the Central Board of Secondary Education (CBSE) schools from class I – XII. For class I – VIII, the state boards are responsible for the syllabi and guidelines. Since Mumbai is located in Maharashtra, many Mumbai schools follow the SSC board curriculum and exam guidelines. However, for class IX – XII, NCERT supplies approximately 70% of the content for the X and XII exams, while the individual states supply 30% of the content (National Network of Education, 2011).

Secondary schools place tremendous focus on the 10th standard exam. During the 9th standard class, teachers rush to finish the syllabus and begin teaching the 10th standard syllabus. Therefore, students are actually studying 10th standard concepts in 9th standard.

Since there are no national comprehensive learning standards in India, I have presented the topics covered in the syllabi instead (see Appendix A). Because this study involved participants from 7th – 10th standard, I have considered only the curricular content in mathematics for 7th – 10 standard. For each standard, the tables in Appendix A list the shared content among the CBSE, SSC, and ICSE Boards.

Many mathematical concepts and topics are common among the Boards, however, in 9th and 10th standard, the curriculum for CBSE (NCERT) and ICSE begins to go more in depth. The ICSE curriculum covers more difficult material than the other Boards.

Standardized testing

It is difficult to report on the skills students obtain by 10th standard in India. According to the World Bank (2009), no “comprehensive national-scale independent assessment of learning achievement at the secondary level has been conducted in recent years” (p. 34). Each state is responsible for the Board examinations, which vary greatly in quality and scoring.

Therefore, they are not comparable across states or time (World Bank, 2009). The passing score for Board examinations is 33% of the maximum marks, and students are not expected to master the full curriculum (World Bank, 2009). In 2005, the average Grade 10 examination pass rate was 64 percent, while for Grade 12 it was 69 percent (World Bank, 2009). Students from private English medium schools have not been a part of the national or international assessments listed below.

Trends in International Mathematics and Science Study (TIMSS)

Historically, India has not participated in many international assessments. In 2005, the World Bank applied the Trends in International Mathematics and Science Study (TIMSS) questions to secondary school students in the Indian states of Rajasthan and Orissa in grades 9 and 11 (World Bank, 2006; Kingdon, 2007; World Bank, 2009). The students' scores were lower than the international average (World Bank, 2006). The latest TIMSS study was conducted in 2011 and the results were available at the end of 2012. TIMSS is conducted every four years and measures the achievement of fourth and eighth grade students. However, India did not participate (TIMSS & PIRLS International Study Center, 2013).

Program for International Student Assessment (PISA)

In late 2008, the Indian government agreed to participate in the 2009 Program for International Student Assessment (PISA). However, only two Indian states, Tamil Nadu and Himachal Pradesh, participated in the PISA in 2010. Sixteen thousand students (15-year olds) from across 400 schools in the states of Himachal Pradesh and Tamil Nadu participated in the PISA (Indian Express, 2012). This marked India's debut in the PISA. It is worth mentioning that the PISA uses a broader content focus than the TIMSS to assess students' ability to apply math concepts to various contexts (Neidorf, et al., 2006; Maccini, Mulcahy, & Wilson, 2007). The PISA contains fewer multiple-choice items than the TIMSS; the PISA puts more emphasis on data

analysis and less on algebra than the TIMSS as well (Neidorf, et al., 2006). Students take the PISA when they are 15 years old (OECD, 2009). In the PISA study, Tamil Nadu ranked 72 and Himachal Pradesh 73, just ahead of the bottom-ranked Kyrgyzstan in mathematics and overall reading skills (Anirudh Sethi Report, 2011). Additionally, the PISA measures mathematical literacy, or “the ability of students to analyze, reason, and communicate ideas effectively as they pose, formulate, solve, and interpret solutions to mathematical problems in a variety of situations” (OECD, 2009, p. 14). Students may have performed poorly on the PISA due to the nature of the questions, which encourage students to apply what they have learned, when the Indian education system stresses memorization and rote learning. Overall, only students from four states have participated in some form of international assessments, which is not representative of the twenty-eight states and seven union territories of India.

According to NCERT faculty, the Ministry of Human Resource Development (MHRD) objected to this study, since they claim that it is difficult to compare students across states in India, let alone internationally (K. Sharma, personal communication, July 5, 2013). Government officials insisted that randomly selected schools from the two states for PISA included a large number of government and rural area schools (Indian Express, 2012). NCERT faculty members question the meaningfulness of such comparison studies. Professor Kavita Sharma asks, “What are you actually comparing in these studies? What is the purpose? Labeling? Like, ‘so and so’ comes at this place in the ranking?” (personal communication, July 5, 2013). Another NCERT professor, Ranjana Arora commented on the PISA assessment:

Our students were not exposed to these kinds of tests. Other countries are practicing these kinds of tests. Our children have not been exposed. What are the barriers in these assessments? What about language? What if they have a language barrier? What about context? India is a diverse country. Contextual differences are there. We need context-based tests. What about asking a Kerala child: What animal goes for hibernation? How can you do a standardized test? No animal goes for hibernation in

Kerala. This happens in north India. It is very difficult in India to set a standard. You have to contextualize your questions (personal communication, July 4, 2013).

Annual Status of Education Report (ASER)

The Annual Status of Education Report (ASER), which means “impact” in Hindi, is a nation-wide survey of children’s ability to read simple text and complete basic arithmetic tasks. ASER has been conducted in rural districts of India annually since 2005, and was started by the non-governmental organization, Pratham (ASER Center, 2014a). In the arithmetic section, children ages 5-16 are asked to recognize numbers below 100, solve a two-digit subtraction problem with regrouping, and divide a three-digit number by a single-digit number (ASER Center, 2014b). In 2012, nearly 50% of students in Standard 5 were unable to solve subtraction problems with regrouping, and more than 75% could not complete the division problems (ASER Center, 2012).

National Achievement Survey (NAS)

The National Achievement Survey (NAS) is NCERT’s attempt to assess learning levels across states in three key grade levels: standard 3, 5, and 7/8 in government and government-aided schools. The NAS was first conducted from 2001 – 2004 with the Baseline Achievement Survey, then again from 2005 – 2008 as the Mid-term Achievement Survey. The most recent data is from the third cycle, from 2009 – 2012 (Bhaduri & Singh, 2011). This study found that the mathematical achievement levels of Standard 5 students vary greatly across the state and union territories, with substantial differences between the highest performing areas (Uttar Pradesh and Tamil Nadu) and lowest performing areas (Puducherry and Andaman and Nicobar islands) (Tewari & Kumar, 2011). The third cycle data revealed no significant difference between achievement levels of girls and boys, or students of urban and rural areas. However,

minority⁹ students scored significantly lower than students from the general category. There is also great diversity between the highest and lowest-performing students in some states. Students in the bottom 25% are unable to solve basic calculations (Sarva Shiksha Abhiyaan Technical Cooperation Fund, n.d.). Overall, less than half of the standard 5 students could answer the question, “How much greater is 555 than 198?” and only one-third of students correctly identified the answer to a subtraction problem involving decimals (Sarva Shiksha Abhiyaan Technical Cooperation Fund, n.d., p.11)

According to NCERT faculty, ASER data is not reliable and is not completed scientifically (K. Sharma, personal communication, July 5, 2013). However, ASER and NAS have different designs and methodologies and were created for different purposes; therefore, their results are not comparable (ASER Center, 2014c). Both paint a very bleak picture of mathematics achievement in India, especially for minority students and those who are struggling.

Truly, the educational system of India is complex and more assessment, on a national and international scale, must be completed in order to understand what Indian students know in the area of mathematics and their current skill level.

Current special education policy and procedures for primary and secondary students in India

According to Indian disability legislation, students with disabilities are eligible for free schooling until age 18. However, students with learning disabilities do not qualify for this right, because LD is not a recognized disability by the government (J.P. Singh, personal communication, March 17, 2009). In general, there is a lack of awareness of learning disability in a majority of Indian schools (Karande, Sholapurwala, & Kulkarni, 2011). The Director of NCERT recognized the current lack of awareness and training for math learning disabilities and

⁹ Scheduled Castes (dalits, or untouchables), Scheduled Tribes (adivasi, or indigenous groups) and Other Backward Categories (other communities who have experienced discrimination listed with the National Commission for Backward Classes (2011)

early intervention in mathematics by saying: “We need to better understand how to identify math difficulties at an early level and what should be done for these children” (P. Sinclair, personal communication, July 5, 2013). Because learning disability has not been recognized by the Government of India, government funds cannot be utilized to hire remedial teachers in regular schools, to train regular teachers, or to develop psychoeducational tests in other Indian languages (Karande, Sholapurwala, & Kulkarni, 2011). Currently, the curricular Boards offer some accommodations for students with learning disabilities.

In order to obtain accommodations in the primary and secondary classroom or on exams, students with MLD must follow different procedures, depending on which type of school the child is in and which Board it is affiliated with (Madaus, Banerjee, & Hamblet, 2010). The Maharashtra state board (SSC board) and CBSE board require a government hospital certificate, signed by a civil surgeon, for the child to apply for educational provisions or accommodations. In Maharashtra, students can obtain certification of having a learning disability from a government hospital (Sion, Nair, or King Edward Memorial (KEM) hospitals, all of which are in Mumbai). Currently, students are certified as having “dyscalculia” and not “specific learning disability in math” from these government hospitals. Students from SSC board schools must have a letter from their school in order to obtain an appointment for psycho-educational testing at a government hospital. However, the ICSE board requires a detailed psycho-educational report, such as a report from the Maharashtra Dyslexia Association (MDA), to be eligible for educational provisions (M. Khan, personal communication, October 19, 2012).

Since there is still a lack of awareness of learning disability in Mumbai and Maharashtra, students are typically diagnosed in 7th standard or later. Most of the time, parents want their child to be eligible for the educational and exam provisions rather than to provide remediation and improve their child’s understanding (Karande, Mahajan, & Kulkarni, 2009).

Accommodations

Overall, students with math learning disabilities have access to various accommodations, based upon the Board of which that their school is a part, including modification to the general education curriculum. Since this study took place in Maharashtra, I will focus on the Boards that are present only in this state.

Secondary School Certificate (SSC) Board / Maharashtra State Board

Students with math learning disabilities in the SSC Board can opt to take lower level math and are tested at the 7th standard level during the 10th standard government exams (Kulkarni et al., 2006). However, they miss important math content covered in 8th – 10th standard since students with MLD can replace their math courses with work experience courses, such as typing at the secondary level. Students with MLD in the SSC also have the option to take a general math course during the 9th and 10th standard. When students opt for lower level or general math in the SSC schools, they do not receive any instruction in math. They either sit in the regular math class (and study on their own), or they go to the school library or an empty classroom, if it is available and there is supervision. There is no separate math class offered other than grade-level instruction (T. Davis¹⁰, personal communication, September 22, 2012).

In Maharashtra, the SSC Board offers provisions (accommodations) for students at all grade levels (M. Khan, personal communication, February 25, 2013). The SSC Board offers students with MLD extra time (30 minutes for 10th standard and one hour for 12th standard), 20 grace marks, and lower level math. Teachers should also ignore interchanged numbers (for instance, 12 written as 21). Students from Class 1-9 who fail exams should get 20 grace marks (bonus points) (MDA, 2014a).

¹⁰ pseudonym

The provisions were originally intended to function as a “corrective lens” and to help students with LD continue in regular education (Karande, n.d., slide 28; Karande, Sholapurwala, & Kulkarni, 2011, p. 516). However, these provisions, or accommodations, can lead to gaps in math content knowledge when these students transition to junior college (11th and 12th standard) and degree college.

Indian Certificate of Secondary Education (ICSE) Board

Students in the ICSE Board schools can choose to drop the math subject altogether after 8th standard. The ICSE Board only offers provisions to students in Class X and Class XII (M. Khan, personal communication, February 25, 2013). The ICSE Board offers extra time to students with MLD (15 minutes/per hour or 25% of total time extra). They also allow the use of calculator in some cases (must be recommended by a psychologist on the psycho-educational report). The test can also be read out to the student (MDA, 2014a).

According to P. Sinclair, National Council of Educational Research and Training (NCERT) Director, dropping mathematics is not an effective strategy. Students must engage in mathematical reasoning and logical thinking throughout secondary school in order to fully develop their understanding of mathematical processes (P. Sinclair, personal communication, July 5, 2013).

Central Board of Secondary Education (CBSE)

The CBSE Board only offers provisions to students in Class X and Class XII (M. Khan, personal communication, February 25, 2013). The CBSE Board offers an additional 1 hour for each paper that is 3 hours in duration (MDA, 2014a). Shorter exams have the following additional time requirements:

For paper of 2 ½ hours duration	50 minutes
For paper of 2 hours duration	40 minutes
For paper of 1 ½ hours duration	30 minutes

(Central Board of Secondary Education, 2008).

International General Certificate of Secondary Education (IGCSE)

The International General Certificate of Secondary Education (IGCSE) Board allows all students to use calculators, whether or not they have a learning disability. However, some schools do not allow students to use calculators until 8th standard (M. Mehta, personal communication, March 18, 2013). Students with MLD qualify for extra time, up to 25% of total time (University of Cambridge International Examinations, 2012). All students have the option to take core level math or extended (higher) level math. However, students are usually advised to take the extended level math since the core level math grading system automatically begins at C instead of A (M. Mehta, personal communication, March 18, 2013).

Perceived effects of accommodations in secondary school

A study by Kulkarni et al. (2006) has shown that SSC students' exam scores increase when they use the provisions for LD. Students who used the provisions showed a 22.53% increase in their exam scores as compared to when they did not avail the provisions of extra time and lower-level math (about half of the participants opted to take lower level math) (Kulkarni et al., 2006). However, these studies do not mention whether students' understanding of mathematics has increased due to the provisions. All we know is that students have passed the exam, with at least 35%. Also, these studies fail to mention the future repercussions when students drop math or take lower-level math, especially in regards to post-secondary education options.

Karande, Mahajan, & Kulkarni (2009) studied adolescents with LD and the impact of the school experience on their lives. The secondary students responded positively to having the provisions, which helped them score better marks and lowered their academic frustration. Yet

students did not like feeling different from their peers or being teased by their peers for having LD. Students also mentioned that some of their teachers insulted them or physically abused them because of their LD. This again reflects the need for teacher awareness of LD (Karande, Mahajan, & Kulkarni, 2009). When teachers lack knowledge of learning disabilities and the students' need for accommodations, they may form negative attitudes towards these students (Karande, Sholapurwala, & Kulkarni, 2011; Saravanabhavan & Saravanabhavan, 2001).

Numbers of students using the accommodations

In Appendix B, I have listed the number of students who applied for accommodations on the 10th standard exams for each Board; Appendix C lists the number of students in 12th standard that applied for accommodations. In most cases, the Boards have only given information about students with any learning disability (dyslexia, dyscalculia, and dysgraphia), so it difficult to assess how many students actually have math learning disabilities in Maharashtra since all learning disabilities have been combined. Additionally, there may be some students who have MLD but have chosen not to request the accommodations. Therefore, I cannot make any conclusions regarding prevalence of MLD from these data.

Even though the prevalence estimates of learning disabilities (of all kinds) vary widely, from 2% - 15% of the population (APA, 2000; Mogasale et al., 2012; Cortiella, 2014; Ganapathy & Krishnakumar, 2004), the numbers of students who appeared for the 10th and 12th standard exams as candidates with learning disabilities does not even come close to 1% of the total number of students for the SSC and HSC Board. Students with any of the three types learning disabilities made up just 0.07% of the total number of students who appeared for the exam in 2013. Students with LD that took the CBSE exams made up 0.2% of the population for the 10th standard exam, and 0.1% of the 12th standard exam in 2013. Students who took the ICSE 10th

standard exam made up 4% of the total population, which is more in line with the estimates (see Appendix B and C).

It is extremely difficult to make any conclusions about the current skill level of students with MLD in India at the end of secondary school based on the statistics available from the Boards. In some cases, we only know if these students have passed (at least 35%) the overall exam and not their actual score or their level of understanding of each subject. These data only give us an idea of approximately how many students in Maharashtra are certified and have requested accommodations. The Board exams are the only assessments that all students in the state of Maharashtra are required to take each year. There are no other state-wide or nation-wide assessments. Therefore, the data collected as part of this needs assessment and doctoral dissertation is quite valuable in order to begin to understand the skill level of students with MLD.

Other factors impacting special education and transition in India

Overall, there are some accommodations available for students with learning disabilities through the curricular Boards. However, there are other factors that impact students and families' ability or desire to avail the provisions and transition to higher secondary education, including stigma from society, socio-economic status (SES), limited remedial services, and an ultra-competitive academic environment.

Societal stigma

Gender

More boys are identified and certified as having learning disabilities in Mumbai than girls. In various studies on students with learning disabilities in India, boys outnumbered girls in the sample, around 2:1 (Karande et al., 2007; Karande, Bhosrekar, Kulkarni, & Thakker, 2009;

Karande & Kuril, 2011). The reasons for more boys being diagnosed than girls are multi-faceted.

Masarrat Khan, MDA CEO, explains the cultural connotations around learning disabilities:

On the whole, boys are typically reported more often to MDA than girls. Boys are initially referred to a center like MDA for behavior issues, such as associated ADHD or acting out, or low performance due to lack of interest in studies. Many times, girls go undetected because they are quiet, hard-working, and don't act out. When girls have difficulties in academics, they try to work on their difficulties by putting in more effort. In fact, some families do not want a diagnosis for their child, either a boy or girl. There is a huge stigma against any kind of disability in India. Many families specifically do not want a diagnosis for their daughters. This is for fear that it may hurt her future marriage prospects (in the case of an arranged marriage, which is very common in the Indian context). Many families do not reveal the dyslexia diagnosis outside the immediate family, even if they have a certificate and have availed the provisions. Many families do not come forward for research purposes willingly. They do not want their real names mentioned. For remedial education, families usually focus on the boys. Sometimes their academic problems are coupled with behavior problems. For girls, the families think that it is ok if she doesn't do well in school. They say, "we'll just get her married" (personal communication, May 29, 2013).

Religion

Additionally, gender and caste can intersect within the Indian context. For girls with special needs from low socio-economic status backgrounds and low castes, a "triple jeopardy" exists (Halder, 2009, p. 635; Rousso & Wehmeyer, 2001).

Socio-economic status (SES)

A student's socioeconomic status can also impact his/her transition to secondary and post-secondary education. In India, the financial burden of special services for students with math learning disabilities falls on the family. The state and national governments do not offer any mandatory special education services during the school day or reimbursement for private services. No special education services are required at any level: elementary, secondary, or post-secondary.

Literature in the United States has shown that socioeconomic status (SES) is the most significant predictor of postsecondary transition status (Rojewski & Kim, 2003; Gregg, 2007).

Additionally, parental social class is an important predictor of a child's mathematics performance. Social class is an even greater predictor in a country like India, which has great social inequalities (Dowker, 2005).

SES can also play a factor for typically achieving students in India. In fact, children from wealthier backgrounds are more than twice as likely to be enrolled in secondary education as poor children. Additionally, children in private schools are generally richer, from more educated families, and are less likely to be from a scheduled caste or tribe. All of these variables may affect achievement (World Bank, 2009). Privately managed (aided) and publicly funded (government) colleges admit 50% of their students based on their performance on entrance exams (free seats), while the other 50% of students are admitted based on their willingness to pay extra tuition (payment seats). However, the unaided private colleges set their own fee levels, which are generally extremely high in comparison to the aided private colleges and government colleges. Typically, students must obtain a score between 80% and 99% on their 10th standard exams to get admission in a good (select and competitive) college (Rhines Cheney, 2005).

Kerala, Maharashtra, Tamil Nadu and Karnataka are the states with the highest secondary enrollment rates (World Bank, 2009). However, there is variability within the states, and even within a large city, like Mumbai. Secondary schools are not distributed evenly: "good" neighborhoods have an abundance of schools, but poor neighborhoods or slums hardly have any (World Bank, 2009, p. 19).

Limited remedial services available

Most schools in Maharashtra do not employ special educators as staff members. Schools are not held accountable for student performance. There is no law in India that requires schools to provide remedial education. Children may take extra remedial classes from private

special educators that come to the child's home or have a private practice in their own home/clinic. Also, these private remedial classes can be quite expensive for the Indian context, ranging from Rs. 150-800 (approximately \$2.50 - \$13 USD) a session (Karande, n.d.). There is no government funding for families who are unable to afford these services (Karande, Sholarpurwala, & Kulkarni, 2011). However, MDA does offer discounted rates for low-income families for some services.

There is also a dearth of special educators in the country. According to the Rehabilitation Council of India (RCI), there are 15 special educators with a Master of Education degree in learning disabilities currently registered in Maharashtra (all in Mumbai and its suburbs) and 45 special educators with a Bachelor of Education degree in learning disabilities currently registered in Maharashtra (all but two are from Mumbai and its suburbs) (Rehabilitation Council of India, 2013). There are many individuals and institutes offering short-term post-graduate and certificate courses, which vary in length and quality. The Maharashtra Dyslexia Association only recognizes degrees from Shreemati Nathibai Damodar Thackersey (SNDT) University in their hiring process (M. Khan, personal communication, March 21, 2014). In the entire country of India, only ten institutions offer a B. Ed. degree in LD (two in Mumbai) and two institutions offer a M. Ed. degree in LD (SNDT University in Mumbai and Jamia Millia Islamia in New Delhi) (Rehabilitation Council of India, 2014).

In Indian schools, there is no summary of performance (SOP) passed on from class to class, let alone from secondary to postsecondary (M. Khan, personal communication, October 19, 2012; Madaus, Banerjee, & Hamblet, 2010). In theory, each school should have a school counselor who helps with passing on information from year to year, but in most cases, parents have to explain their child's learning disability to their child's teacher each year (M. Khan, personal communication, October 19, 2012).

Population and competition

Also, due to the massive numbers of students vying for the best colleges, the Indian context is very competitive. Students attend tuition classes, or group tutoring sessions, from a young age to supplement the topics taught in school. Students may even attend coaching classes in order to prepare for entrance exams for degree programs, such as the Common Entrance exam (CET) or Common Management Aptitude Test (CMAT) for MBA programs (Rao, 2013; Kunal¹¹, personal communication, March 13, 2013). Most students in primary and secondary school (from upper and middle class families) sit in classes for 6-8 hours a day during the school day, and then attend a tuition class for around 2 hours in the evening.

Special education services, including meeting the learning needs of students with MLD, in the Indian context are still in the infancy stages. Most of the accommodations for MLD are centered on examinations, as is general instruction in the classroom. There are additional factors that prohibit students from seeking identification and certification of MLD in the first place, such as societal stigma and socio-economic status. Students with MLD have worked extremely hard to finish secondary school; yet the transition to higher secondary education is also difficult and competitive.

Transition to Higher Secondary Education

Once students complete secondary school (10th standard), they can enter higher secondary studies by attending a junior college. In junior college (11th and 12th), students can choose one of the three streams: arts, science, or commerce. The following figure (Figure 17) lists the academic choices Indian students can make from the end of secondary school to a Bachelor's degree. In each stream, I have listed the mathematics courses that are offered as part of the specific degree. Courses in bold are mandatory. All other courses are electives.

¹¹ pseudonym

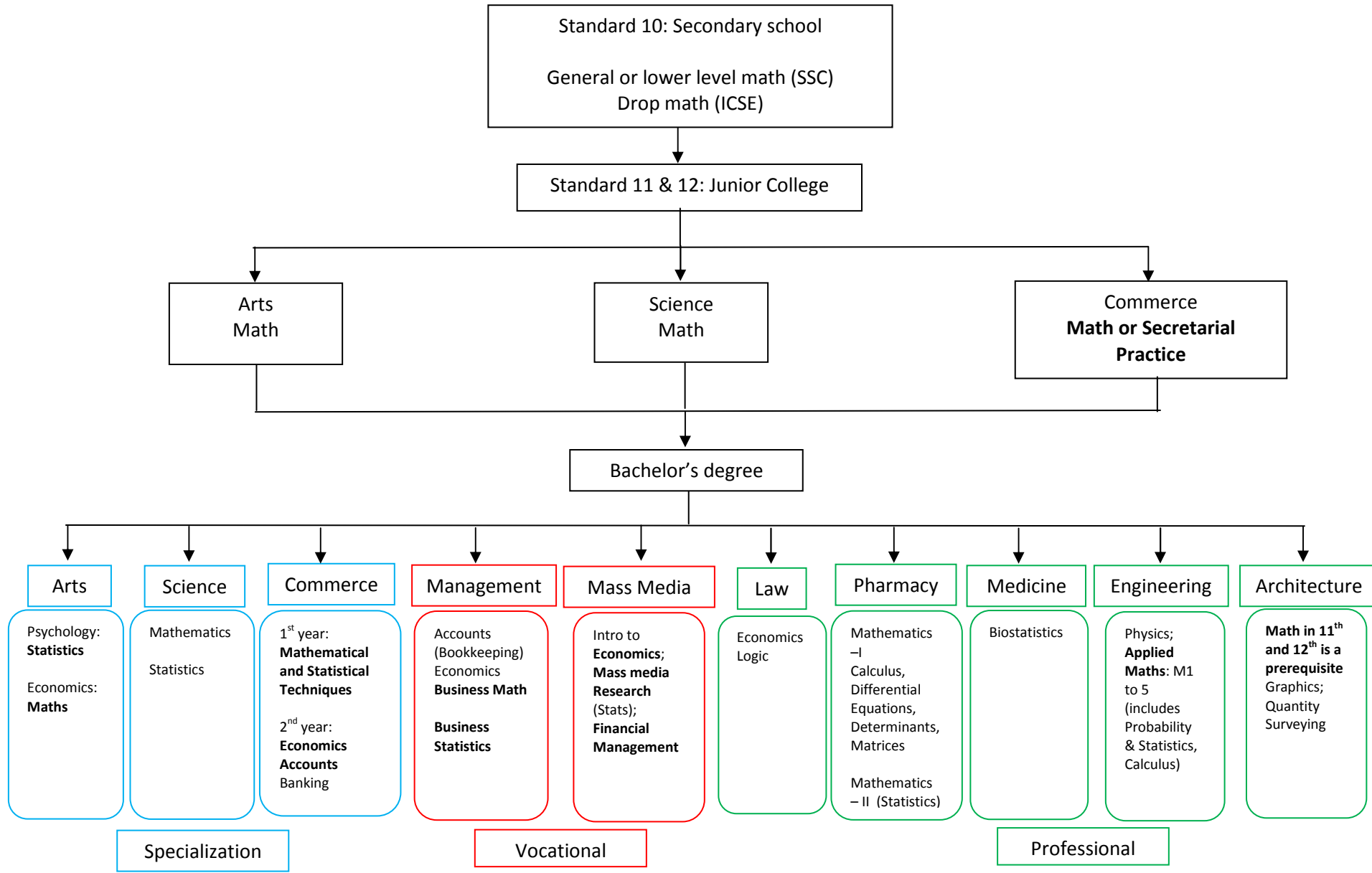


Figure 17. Academic choices for Indian students

The choice of stream is very important to students. For example, students who enter the Arts stream in junior college can only do a Bachelor of Arts (BA) or a Bachelor's in Mass media degree in degree college (M. Bose¹², personal communication, February 18, 2013).

Some students continue in the same school for junior college (if the secondary school has an attached junior college). Students may choose this option because they are guaranteed admission in that junior college. Some students might have to get admission in a junior college because their school does not offer schooling past 10th standard. These students might continue in the same school for junior college and degree college, if there is a degree college attached (K. Kapoor, personal communication, January 21, 2013).

However, many students with MLD have difficulty meeting post-secondary mathematics demands. Students with MLD may have conceptual gaps in understanding, visual-spatial deficits and/or difficulties with word problems. Due to the hierarchical nature of mathematics, students with MLD will not be prepared for post-secondary math demands, if they have fallen behind their peers in primary and secondary school (Strawser & Miller, 2001). The government of Maharashtra and the Higher Secondary Certificate Board have attempted to put some supports in place for students with MLD in the post-secondary setting, such as a quota for students with LD, curricular accommodations, and exam concessions. However, I argue that more supports and services should be provided for students with MLD to succeed in mathematics.

Quota / Reservation

In junior colleges, there is a 3% quota (or reservation) for admission to 11th standard for physically handicapped students, which includes visually impaired students, speech and hearing impaired students, and students with orthopedic disorders and learning disabilities (dyslexia, dysgraphia, and dyscalculia) (Maharashtra Secondary and Higher Secondary State Education

¹² pseudonym

Department, 2001). There is some confusion over the interpretation of this government resolution. The university system has a different interpretation, which demarcates 1% to each of the three categories: visually impaired (known as P1), speech and hearing impaired (known as P2), and orthopedic disorders, learning disabilities, and cerebral palsy (known as P3) (Directorate of Technical Education, 2012; M. Patil, personal communication, September 16, 2013). However, the 11th and 12th standard junior colleges places all of the categories together and offers the 3% to all students with disabilities (P. Patil, personal communication, August 23, 2013).

Syllabi / Curriculum

By the end of 10th standard, typically achieving secondary students have studied arithmetical concepts, number systems, algebra, geometry, trigonometry, statistics, measurement, graphs and coordinate geometry. The core content on the 12th standard exam (covered in 11th and 12th standard) depends on which stream the student chooses (Rhines Cheney, 2005). No learning standards are available for secondary or post-secondary math. In Appendix D, I have listed the curricular content for higher secondary education in mathematics. The math curriculum for 11th and 12th standard is very challenging, and actually contains more difficult concepts than the math required for first year degree college in the Commerce stream (A. Kumar¹³, personal communication, November 27, 2012).

If a student attends a Maharashtra state board junior college (Higher Secondary Certificate, or HSC, Board) once he/she finishes secondary school, the only compulsory subjects are English, Environment Education, and Health and Physical Education. Math is an elective subject. Students have to take four elective subjects (out of the 43 offered) (Maharashtra State Board of Secondary and Higher Secondary Education, 2012b).

¹³ pseudonym

In the Higher Secondary Certificate (HSC) Board, students can substitute math for Secretarial Practice (S.P.) during 11th and 12th standard. However, S.P. requires no mathematical skill. The students need only to understand English (S.P. college lecturer, personal communication, December 19, 2012). S.P. does not serve as a mathematical subject option. It is an entirely unrelated subject.

There are a few junior colleges in Mumbai that follow the Indian School Certificate (ISC) syllabus. For the ISC 12th standard exam, the only compulsory subject is English. Students can choose to take 3-5 additional subjects as electives. Mathematics is one of these elective subjects (Council for the Indian School Certificate Examinations, 2013a).

Students in both HSC and ISC junior colleges can opt out of mathematics. However, once students finish junior college (12th standard) and they pursue a Bachelor's degree, students may need to take a required math course (depending on their degree program). So although SP can be a course substitution in HSC-affiliated colleges, which serves as a program accommodation, students may still have to take a math course later on in their academic career (Madaus, 2010). For instance, if a student pursues a Bachelor's degree in Commerce, a math course is required in the first year.

Accommodations

Most junior colleges in Maharashtra are affiliated with the Higher Secondary Certification Board (HSC). When secondary students with MLD transition to a HSC junior college, they receive half an hour extra time on each exam (two hours in duration) and do not have to draw figures. If the student fails the exam, he/she gets "20 grace marks to pass the exam" (Government of Maharashtra Higher & Technical Educational Department, 2004, p. 1). Students can apply these grace marks to one subject, or spread them across subjects. Students will not be penalized for number reversals (Government of Maharashtra Higher & Technical

Educational Department, 2004). Degree colleges (for Bachelor's and Master's degrees) are affiliated with the University of Mumbai. The same accommodations listed for the junior colleges above are available at the degree college level (MDA, 2014a).

If students have difficulty understanding the math concepts in junior college and degree college, most lecturers will offer extra classes. However, these are open to all students and are not remedial classes. The lecturer might be able to give more attention to students, but he/she does not use alternative teaching methods to explain the concepts. Only a few colleges in south Mumbai offer special "dyslexia cells." These "cells," or programs, are primarily for support services for students with learning disabilities (A. Kumar, personal communication, November 27, 2012; R. Archarya¹⁴, personal communication, February 11, 2013; Getzel & Thoma, 2008). However, some students chose not to self-disclose their learning disability to postsecondary faculty and do not avail the provisions (Getzel, 2008).

Even though they have dropped (or opted out of) math, some students with learning disabilities are able to mask their difficulties in junior college and degree college. Students with LD who have attended English medium schools throughout their primary and secondary schooling have much better English language skills than their peers that attended vernacular medium (Marathi, Urdu, etc.) schools. Nearly all of the degree colleges in Mumbai have English as the medium of instruction (with the exception of Shreemati Nathibai Damodar Thackersey (SNDT) University (M. Bose, personal communication, February 18, 2013). Therefore, students with dyslexia and dyscalculia have better spoken and written English, as well as receptive language skills in English than some of their peers who have limited English proficiency (K. Currawalla, personal communication, January 15, 2013).

¹⁴ pseudonym

In conclusion, due to the current special education policy in Maharashtra (SSC Board), students with MLD are exempt from the math content on the 10th standard exam, as well as from taking algebra and geometry courses. Students with MLD in the ISCE Board have the option of dropping math and/or science after eighth standard, and must take one or two other subjects instead, such as commercial studies or commercial applications (R. Khan, personal communication, October 24, 2012). However, because of these exemptions, students with MLD may lag even further behind their peers in mathematics when they enter college. As evidenced from the tables in Appendix D, students are responsible for understanding advanced math concepts at the end of 12th standard if they have a required math class in the first year of their degree course. Students with MLD may lack the foundational skills needed to begin to understand the required math content on the 12th standard exam. Since students with MLD need continued practice and review with foundational math skills, opting out of math courses in junior college may be a temporary solution, and could lead to more serious deficits in mathematics (Fuchs et al., 2013).

Yet, students with MLD in India aspire to attend degree college and obtain a Bachelor's degree, just like their peers without learning disabilities. They all want the benefits of having a college degree and the positive impact it has on adult outcomes (Webb et al., 2008). Yet, many students with MLD have to face their fear or dislike of mathematics in degree college, perhaps after many years of avoiding math. Students may have to make a decision to drop math at the end of eighth standard, as is the case for the ICSE Board. Students cannot change their decision at any time in the 9th or 10th standard once it has been made. Students may have avoided math for as many as 4 years, depending on the Board, but must take a compulsory math course if they enter a Bachelor's degree program in Commerce, Architecture, Engineering, etc.

Other skills students need for transition

According to the literature, students need skills other than math content knowledge in order to succeed in college (Shaw, Madaus, & Banerjee, 2009). All students need self-determination skills as they transition from secondary to higher secondary education, but this is especially true of students with MLD (Brinckerhoff, McGuire, & Shaw, 2002; Parker, 2004; Parker & Boutelle, 2009; Allen, 2010). Self-determination is a combination of skills, or components, which enable a student to act “purposefully and planfully” (Wehmeyer, 2004, p. 352; Wehmeyer, 1994; Trainor, 2008). These skills include: choice making, decision making, problem solving, goal setting and attainment, self-observation, self-evaluation, self-reinforcement, self-instruction, self-advocacy and leadership, internal locus of control, positive attributions of efficacy and outcome expectancy, self-awareness, and self-knowledge (Wehmeyer et al., 1997; Konrad et al., 2007; Thoma & Wehmeyer, 2005). Overall, self-determination is “being able to advocate for what you need, understanding your disability and how it impacts your learning, having self-confidence, being independent, and adjusting your schedule to make sure things get done” (Getzel & Thoma, 2008), p. 79).

Typically, students with learning disabilities typically have learned helplessness, an external locus of control, and poor problem solving and planning skills (Brinckerhoff et al., 2002). Therefore, it is important that students with learning disabilities receive training in self-determination, so that they can act with a purpose and a plan while making choices (Field & Hoffman, 1994; Wehmeyer, 1994, 2004). Students with learning disabilities may be perceived by their college lecturers as “lazy, attempting to cheat, or using learning disabilities to avoid schoolwork” (Lee, 2011, p. 74). Therefore, these students need self-determination skills to advocate for their educational rights to accommodations (Shaw, Madaus, & Banerjee, 2009).

Self-determination skills have been found to be a “critical factor” in successful transitions for students entering college (Chiba & Low, 2007, p. 41). In fact, there is a strong connection between students’ self-determination skills, academic performance, and post-high school outcomes (Martin, Portley, & Graham, 2010). Students need self-determination skills in order to be aware of their strengths and weaknesses, to be aware of resources available to them (including assistive technology), and to take advantage of and use the resources (Cawthon & Cole, 2010; Chiba & Low, 2007; Martin, Portley, & Graham, 2010; Webb et al., 2008). Students need self-determination skills to recognize the potential barriers that exist and develop strategies to overcome the obstacles (Getzel, 2008). Students need self-determination skills to advocate for their academic needs, including skills to ask for clarification and to express their need for accommodations (Kosine, 2007).

In addition to self-determination skills, students should also have self-knowledge / self-awareness of their level of attention, organizational skills, time management skills, coping/stress-management skills, study skills, note-taking techniques, test-taking skills, and compensatory skills to succeed in higher education (Elksnin & Elksnin, 2010; Credé & Kuncel, 2008; Shaw, 2010). These skills are sometimes referred to as self-management skills and include self-monitoring and self-regulation (Konrad et al., 2007; Getzel, 2008). As students transition to college, they will be exposed to a whole new set of instructional demands; they will be expected to read large volumes of text, read and comprehend information that may not be explicitly discussed during the lecture, and take notes in large lecture halls (Banerjee & Brinckerhoff, 2010; Madaus, 2010). Since there is a significant difference in the expectations between secondary school and college, students with learning disabilities need to develop and exercise their self-determination and postsecondary education strategies to persist in college (Shaw, 2010). In college, students also have less time in class and fewer opportunities for direct contact

with the teacher/lecturer. The class sizes can be significantly larger in college than secondary school, and there is more emphasis placed on out-of-class assignments and preparation (Brinckerhoff, 2007).

In order to facilitate and assist students in the process of moving from secondary to post-secondary education, transitional services may be needed. Transition services are made up of coordinated activities that are focused on improving the academic and functional achievement of a student (Rusch et al., 2009; Individuals with Disabilities Education Act (IDEA), 1990). Educational counseling programs have been a successful model for transitional services. In this model, students meet with a post-secondary counselor during their last year of secondary school and their first year of post-secondary courses to promote self-advocacy and self-management skills (Kosine, 2007; Aune, 1991). These skills can also be taught during a summer orientation program for secondary school graduates with LD (Brinckerhoff, Shaw, & McGuire, 1992). Or, they can be incorporated in a first semester student development course for credit (Turnberger, 2008). Whatever programming option is chosen for transition services for students with MLD entering post-secondary education, self-determination and self-management skills are pivotal in students' persistence in college (Brinckerhoff, Shaw, & McGuire, 1992).

Although self-determination and study skills are important to a successful transition to college for all students, these skills are outside of the scope of my research questions. I will further explore these skills and how they differ between students with MLD and those without MLD in future research.

Students with learning disabilities have critical transition needs when shifting from secondary to postsecondary education. According to a literature review of evidence-based transition practice by Webb et al. (2008), students have needs in five areas: self-determination, social skills, academic preparation and learning strategies, accommodations, and assistive

technology. Educators and service providers must be aware of students' transitional needs and the demands they will face in college, and facilitate students' acquisition of skills, strategies, and accommodations so they can persist in postsecondary education (Webb et al, 2008).

Conclusion

In conclusion, the literature translates into the Indian context in many ways. First of all, there is a great need to conduct more research in the area of MLD, and this is especially true in India. There are varying opinions as to the prevalence rate of MLD and how to diagnose it in India, especially since it is not a recognized disability by the national government. Also, very little information is known about students with MLD as they transition from secondary school to post-secondary education. We do not know how students' choices to opt out of math after 7th standard, or to take a lower level math, affects their future studies or job opportunities. Additionally, students with MLD around the world struggle with similar skills and concepts. Students with MLD in India may also have deficits in conceptual understanding of fractions, decimals, algebra, geometry, and word problems.

Yet, Indian students with MLD are under great pressure, which is not as evident in Western literature. Culturally, Indian students are put under family pressure (including extended family pressure, since many families live in an extended or joint family arrangement). From a very young age, students are expected to be at the top of their class in all subjects. Academics are paramount in India. Sports, extra-curricular, and artistic activities are secondary, and in some situations, considered unnecessary. The awareness of learning disabilities is much less in India as compared to Western countries, and therefore, families and teachers are sometimes unsympathetic towards their child and his/her academic performance. Lack of awareness also exists among students' peers, which results in bullying and strained peer relationships. Teachers and lecturers are also unaware of the multitude of alternative teaching

strategies for helping students with MLD understand math. The Indian system is focused on exams and rote memorization of content, which does not leave much time for developing conceptual understanding of mathematical concepts.

Conceptual framework

Students with MLD enter secondary school without the foundation required for higher-level mathematics, including conceptual understanding of math, mastery and automaticity of basic math combinations and skills, and problem-solving strategies. Yet, their teachers in higher secondary education assume and expect that students have already acquired the needed foundational knowledge and skills in previous classes.

Students with MLD are at a disadvantage in the regular math classes as compared to their peers (Montague & Jitendra, 2006). These academic discrepancies manifest in middle school (or late primary school in India). In the case of algebra, students must integrate and extend skills that they learned previously. Students must have a strong foundation of previously learned concepts and conceptual understanding of core concepts to succeed in algebra, such as: the understanding of variables and constants, decomposing and setting up word problems, symbolic manipulation, and understanding of functions, inductive reasoning, understanding of rational numbers, procedural fluency with computational skills, and advanced problem-solving skills. Students that lack this foundation have a huge disadvantage when studying algebra and other higher-level math concepts (Ketterlin-Geller, Chard & Fien, 2008; Little, 2009).

Proficiency in mathematics is influenced by the continued development and blending of critical component skills. When students with MLD have gaps in these crucial skills, they will struggle with many aspects of grade-level mathematics (Jones & Riccomini, 2007).

This study and data collection was guided by the following conceptual framework (adapted from Witzel, Smith & Brownell's (2001) Arithmetic to Algebraic Gap model), which highlights the cumulative effects of students' difficulties in mathematics (Wolcott, 1994):

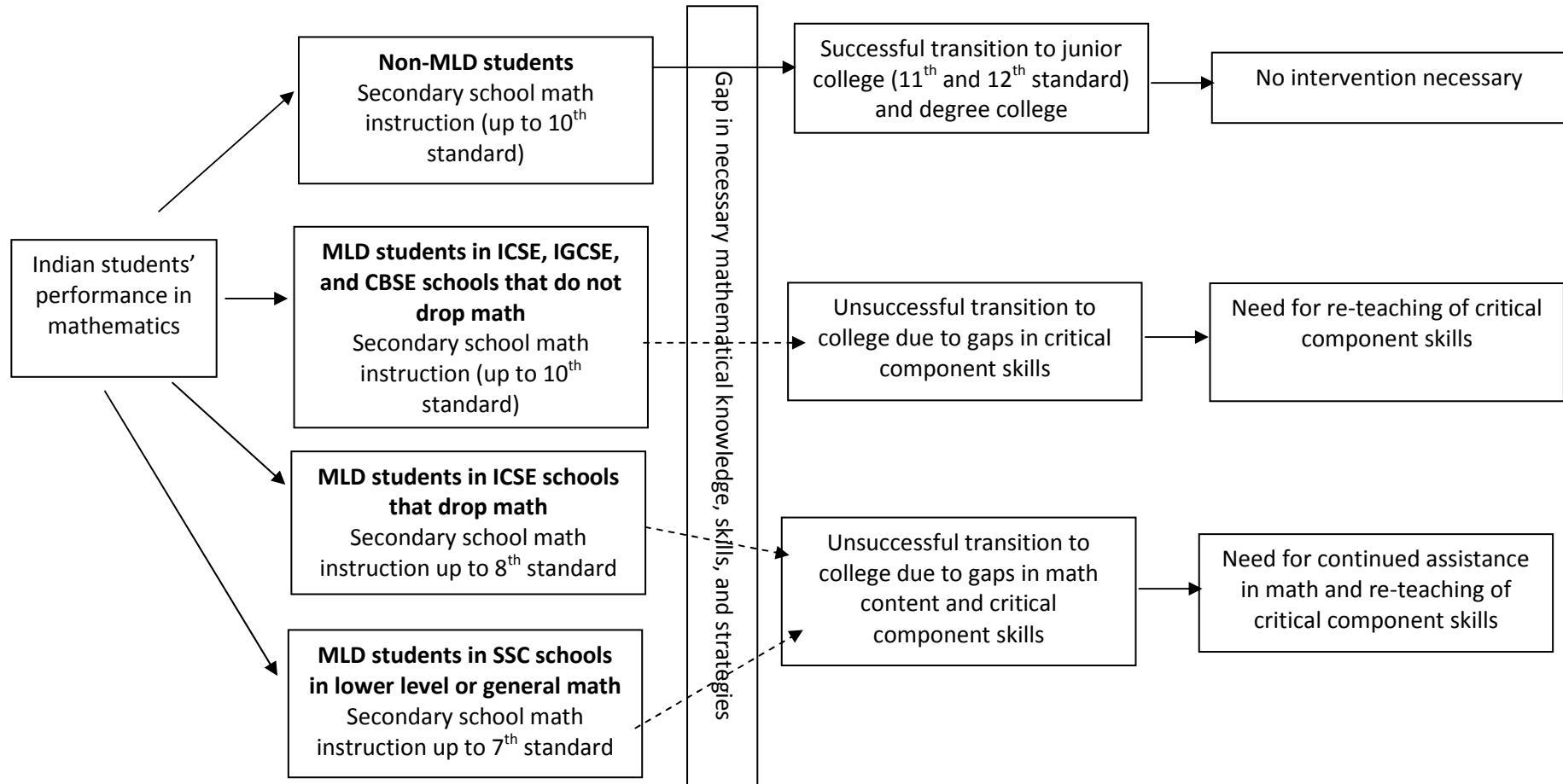


Figure 18. Conceptual framework

Students with MLD have difficulty acquiring and retaining mathematical concepts, including abstract content associated with algebra and other higher-order mathematics (Witzel, Smith & Brownell, 2001). Many research-based instructional interventions have helped students with MLD make progress in mathematics, especially if interventions are implemented in the early stages of learning (Fuchs et al., 2013). However, in most Indian schools, there are no methods in place for early screening of difficulty with mathematics. There is also low awareness among teachers regarding learning disabilities. If students start behind in mathematics, chances are, they will stay behind (Siegler et al., 2012). Adding to this, current special education guidelines with the curricular Boards allow students to either take a lower-level math course without instruction (SSC) or to opt out of math entirely after 8th standard (ICSE). Students can again opt out of mathematics in junior college (HSC and ISC). Therefore, students with MLD, who have struggled with foundational and underlying concepts in mathematics and have not had access to appropriate instructional techniques to meet their learning needs, are expected to understand abstract concepts in algebra and statistical analysis in degree college (if they enter a stream that requires a compulsory mathematics and statistics course).

Data collection was guided with this framework in mind. First of all, I wanted to know if students with MLD really are disadvantaged in mathematics before they exit secondary school in India. And, if so, what are the critical component areas in which they have gaps in conceptual and procedural understanding? And, how are current students with MLD navigating their transition to higher secondary education? How do lecturers and administrators view their transition? How do former students look back on their transition experience in secondary and higher secondary school, and how does math impact them in their lives now? Ultimately,

looking for these answers through the lens of the cumulative effects of gaps in critical component skills framework enabled me to answer my broader research question regarding the goals and content for a transition course for students with MLD.

My data analysis was also guided by this framework. I analyzed the data with an overlapping lens of critical theory or critical pedagogy, to begin to identify processes that segregate and marginalize students with MLD due to gaps in mathematical knowledge (Moore, Klingner, & Harry, 2013; Liasidou, 2012; Gabel, 2005; McDermott, Goldman, & Varenne, 2006; Creswell, 2007). By examining this problem through the lens of critical pedagogy, I argue that current special education policy and practice at the secondary and post-secondary level in Mumbai is performing a gate-keeping role and excluding students, rather than including them with typically achieving peers.

In the analysis, students' voices and experiences throughout the transition process were paramount. I wanted students to be heard, recognized, and valued in this framework, as well as to understand how future students could be more successful in the overall transition into post-secondary education, and if a transition course would be part of the answer (Moore, Klingner, & Harry, 2013; Parker & Lynn, 2002).

CHAPTER 3

DESIGN AND METHODS

This study focused on the following research questions and subquestions:

Research question 1: How prepared are students with MLD to enter post-secondary education?

- a) What math knowledge, skills, and learning strategies do students with MLD currently have?
- b) How do the math knowledge and skills of these students with MLD differ from students without MLD (comparison group)?
- c) What knowledge, skills, learning strategies, and other supports do these students with MLD need, based on their desired program of study in junior college and degree college and the math requirements of the courses in that program?

Research question 2: How do college math policies and procedures affect students with MLD?

Overall approach and rationale

The Maharashtra Dyslexia Association (MDA) asked me to investigate the problems students are currently facing as they transition to post-secondary education, as well as identify some potential solutions for a transition course to help the students bridge the gap. The research problem for this needs assessment was to identify content and procedures in a math transition course that will assist students with learning disabilities as they transition into the postsecondary education (Turnberger, 2008). With this in mind, I needed to know the current abilities of secondary students with MLD and how they differ from their typically achieving peers. Later, these levels were compared with the expectations of post-secondary math courses. For the doctoral dissertation, I added research questions that focused on deeper “how” and “why” questions, as opposed to the “what” questions that were geared towards the

needs assessment, in order to reflect on the role policy plays in a larger theoretical picture of comparative and international education.

I used a mixed methods design for data collection in order to answer my research questions. The mixed methods approach combines both quantitative and qualitative forms of inquiry to provide a comprehensive analysis of the research problem (Creswell, 2009). I employed a convergent mixed methods approach, since I collected both forms of data concurrently. I later integrated the information in my interpretation of my findings (Creswell, 2009, 2014).

Quantitative

I collected quantitative data from a sample of secondary students, their parents, and college lecturers. I wanted a numeric description of the current math proficiency of students with MLD and typically achieving students, so I collected performance data from both types of students using the researcher-constructed screener. I also wanted descriptive statistics of the samples, as well as numerical descriptions of their opinions, so I collected this information using a survey.

Qualitative

I included qualitative research into my design to explore the phenomenon of students with MLD as they transition and the meaning they ascribe to their transitional experience. This part of the study was conducted in a natural setting, either in an educational institution or at home, where the participants experience transitional issues. I collected multiple sources of data, such as interviews, observations, and documents, and reviewed all of them to see if there were themes that existed across data sources. I wanted to highlight the voices of the participants in my data analysis (Creswell, 2007). By using qualitative research methods, I wanted to develop a deep understanding of what it is like to experience MLD in the Indian

education system and to allow students and administrators to share their stories of transition. As a foreigner, I also wanted to try to gain as much of an “insider perspective” as possible (Creswell, 2007, p. 41). Within the qualitative research approach, I chose to compile collective case studies to best illustrate the transition issues for students with MLD in post-secondary education. I gathered data from multiple cases to reflect different perspectives in the transition process, as opposed to focusing on a single case (Creswell, 2007; Merriam, 2009).

I used qualitative research to follow up on the quantitative data and to attempt to capture the complexity of the trend of a widening gap between students with MLD and typically achieving students in mathematics (Creswell, 2007). I wanted an in-depth understanding of the interactions between students with MLD, administrators, lecturers, and policy makers. The in-depth interviews with secondary students, post-college students, and college lecturers also served as member checking activities to clarify points from the surveys (Brantlinger, et al., 2005). Audiotapes from both the large group and individual interviews were transcribed, in the cases that audio recording was allowed.

According to Trainor (2007), focus group interviews of small groups of adolescents with similar characteristics are useful in promoting dynamic discussion on a topic (Vaughn, Schumm, & Sinagub, 1996). I had the opportunity to interact with a group of 11th standard students with learning disabilities and conduct a large group interview. The interview was conducted in their college, with no faculty members present, in a relaxed and natural environment (Krueger, 1998; Getzel & Thoma, 2008). The majority of all interview questions were open-ended and focused on participants’ experiences with secondary math and their goals for the future.

Overall, I used quantitative methods to identify student skills, to understand differences between groups of students with and without MLD, and to establish the needs of the students with MLD with regards to meeting the required standards for college mathematics. In addition,

the qualitative component enabled me to better understand the transition process for Indian students with MLD and without MLD and the various perspectives of the participants involved in the transition process (Merriam, 2002). I used multiple and different data sources and methods to consider various perspectives on the transitional experience to post-secondary education. This is also known as triangulation (Creswell, 2007)

Therefore, the mixed methods approach was most effective, as opposed to only quantitative or qualitative, to help me answer the research questions efficiently and effectively (Dukes, 2010).

Researcher Stance

Personally, I have a strong interest in students with math learning disabilities, as well as extensive experience in India. I have worked with students with learning disabilities since 2002, after receiving my Bachelor's and Master's degrees in Special Education from the University of Tennessee, Knoxville. I worked as a resource teacher and co-teacher in an inclusive classroom in Hartford, Connecticut before moving to India in July 2004. In India, I have worked in Special Education primarily in the states of Maharashtra and Tamil Nadu. I have worked extensively with regular education primary teachers in private schools associated with the various Indian curriculum boards in the area of inclusion of students with learning disabilities. I have been associated with MDA since 2008, when I collaborated with them to offer a series of training workshops on instructional strategies for students with math learning disabilities.

I acknowledge that, as a researcher, I bring my own worldview and beliefs into the research process, which have shaped the methodology, data collection, and analysis (Creswell, 2007). I have viewed this entire study through the lens of critical theory/pedagogy and have sought to investigate the way the current education structure and policy is segregating students and constraining their academic choices due to their learning abilities (Creswell, 2007). Because

I want to ultimately advocate for students with MLD and education reform, I aimed for students' voices to be heard in the case studies and the research process (Creswell, 2007).

Methodology

I collected quantitative data in the form of math scores on a screening tool, as well as surveys from students, parents, and college lecturers. I gathered qualitative data through interview transcripts, classroom observation field notes, and a review of documents regarding educational policy for students with learning disabilities and college math requirements. The data were collected between April 2012 to November 2013.

Sampling

Research Site

This study took place in Mumbai (formerly Bombay), which is India's most populated city, located in the state of Maharashtra. The approximate population of the Mumbai Metropolitan Region (comprising Mumbai, Navi Mumbai, Thane, Vasai-Virar, Bhiwandi and Panvel) is nearly 21 million, according to the 2011 census (Press Information Bureau, Government of India, 2011). The secondary student participants in this study live in a variety of areas of the city and suburbs (see Table 1), and all would be considered from an urban environment.

Sampling design

In many qualitative studies, researchers use purposeful sampling, since the participants are selected on the basis that they can purposefully address the research problem (Creswell, 2007). I employed a snowball, or chain, sampling strategy or procedure within purposeful sampling. This approach identifies cases from people that know people in a certain environment (Creswell, 2007). Because I worked full-time for the Maharashtra Dyslexia Association (MDA) in Mumbai during the course of this study, I obtained access to many

participants from their network. MDA is one of the most popular organizations working for advocacy of students with learning disabilities in India, so many of the students in the case studies had been beneficiaries of MDA's programs. Other students were referred through a lecturer that has strongly supported MDA's programs in the past. Also, MDA was well-known in the schools in which the quantitative research was conducted. MDA had either presented awareness workshops about learning disabilities in the schools, or the school counselors had attended a MDA training program.

Recruitment and enrollment

Secondary school students and parents

During the school summer vacation in April 2012, MDA contacted students in their database that had expressed interest in math remedial classes in the past, to see if they would be interested in the research study as well as a summer intensive remedial program in math. MDA also advertised the study and remedial classes on their website and e-mail list-serv. Eighteen students with MLD (and co-morbid reading and/or writing learning disabilities) and their parents responded and agreed to participate in the study at that time. The students were tested at the MDA centers in Parel, Deonar (Chembur), Dombivli, and Vile Parle. All of the names of students, parents, teachers, and schools in the secondary sample are pseudonyms.

Suburban School #1: Shanti Niketan

Once the school year began in June 2012, MDA's CEO, Masarrat Khan, contacted the administration of a suburban secondary school, Shanti Niketan, to see if they would be willing to participate in the study. Shanti Niketan is affiliated with the SSC Board and has classes from pre-school to 10th standard. A former MDA staff member works at this school, so the administrators were very familiar with MDA (and they are proactive about referring struggling students for LD testing). I accompanied Masarrat to the school for a formal meeting with the administrators in

early July 2012 to work out the details of the project (a sample letter to schools is found in Appendix E). The administrators agreed to try to provide 20 students with MLD and 20 students without MLD, between 7th and 10th standard for the project. The school sent out the formal letter, explaining the project, along with the informed consent form to students with MLD, which the administrators thought would be open to participating in a research project. The administrators also chose students who did not have MLD, either typically achieving (average) students or high-achieving students who would be interested in a research study. Since there are very few research studies completed in private schools, the school administrators chose students and parents that either valued research or had been enrolled in the school for an extended time and trusted the school to make wise and informed decisions, with the students' interests in mind. To compensate the school for their participation, MDA offered a free workshop, which I conducted, to train their teachers in research-based math intervention strategies, once the data collection was completed. From this school, 21 students with MLD and 29 students without MLD completed the screening and surveys, along with their parents. The screening began in late August 2012.

Suburban School #2: Gyanankur School

The MDA President, Kate Currawalla, contacted the administrators at another suburban school, Gyanankur school, in August 2012. MDA had a previous, long-standing relationship with this school, and the administrators were excited about the study and what they would learn about their students' math abilities as a result of the data collection. This school is affiliated with the SSC Board, and has classes from pre-school to 10th standard. The primary section (pre-school to 4th standard) is close by, but the research was conducted at the secondary campus (5th - 10th standard). A teacher that works with students with LD in the secondary section, in addition to teaching math, was assigned to help us find participants during my visit to the school in the

middle of September 2012. She contacted parents of students with MLD, average students, and high achieving students, between 7th to 10th standard. I asked the teacher to try to obtain permission from equal numbers of students in both groups. Eight students with MLD and eight students without MLD agreed to participate. The screening took place in mid-October 2012.

South Mumbai school #1: G.P Somkar School

Because the other two schools were SSC schools, I needed to broaden my sample to include ICSE schools and students without MLD. I began creating a list of ICSE schools across Mumbai to visit, but then my personal friend informed me that she knew the principal at a prominent South Mumbai school, G.P Somkar School. I visited the school in early September 2012 and met with the principal and school counselor, who was very familiar with MDA. The principal was very interested in knowing more about the math abilities of his students, as well as the complementary workshop for his teachers. The counselor was asked to contact 10 students who were average and high-achievers between 7th and 10th standard in order to even out the sample (at this point, I had 20 students from MDA with MLD and I needed to match the non-MLD sample). The parents of this school requested a meeting with me to learn more about the project. I conducted a parent meeting in mid-September 2012. After the meeting, eleven students without MLD participated, but one student's scores were evidence of an outlier and this female student was removed from the sample for data analysis. Instead, I recommended that she be referred for more testing for learning disability. The school also asked students with MLD to participate, and four students and their parents gave their consent. The screening took place in October 2012.

South Mumbai School #2: St. John's School

In early September 2012, I visited another south Mumbai school, St. John's School, on my list of ICSE schools. I visited this school first since the counselor has attended many MDA

programs and frequently refers students to MDA for LD testing and certification. I met with the Vice-Principal, who is in charge of the St. John's secondary school. He agreed to allow us to collect data in school in exchange for a complementary workshop for the teachers. The counselor was asked to contact 15 parents of students without MLD (average and high-achievers) between 7th and 10th standard in order to even out my sample. At this school, I did not screen any children with MLD. Fifteen students and parents agreed to participate.

All secondary schools that participated received a complementary workshop for their teachers, which were conducted between November 2012 and January 2013.

In November 2012, I realized that our sample of typically achieving students was larger than the sample of students with MLD. Since April 2012, more students between 7th and 10th standard, had been certified as having MLD (and reading and/or writing LD) at MDA. I contacted the parents of those students and asked them if they would like to participate in the project. Twelve more students with MLD agreed to participate in November and December 2012 at MDA centers.

Secondary students: collective case studies

From the large sample of students with MLD, I selected five students for in-depth case studies, using the chain approach in purposeful sampling. All of these students had been tested for LD at MDA, so they were familiar with the organization. Three of the students had been participants in my intensive math remedial classes during their summer vacation in April and May 2012, so they were very comfortable with me. The two other students were recently tested at MDA and were recommended by the MDA psychologists that completed their testing. The psychologists chose these students based on their ability to express themselves verbally and the parents' willingness to be involved in research for students with learning disabilities. From

these students' responses, I wanted to learn more about their personal experiences and struggles with math in secondary school.

Secondary school math teachers

I wanted to interview secondary school teachers to obtain their perspective on students' preparedness for junior college. These teachers were selected from two of the four schools in which I collected data: one SSC school (Shanti Niketan) and one ICSE school (G.P. Somkar). These schools were chosen because they were the first school sites for data collection for each board. These teachers were the only ones that came forward willingly for an interview, after the principal of each school gave an open invitation to all of the math teachers.

In Mumbai, and in India in general, it is very difficult to enter a school for educational research. There is not much research going on in schools and many administrators and teachers are hesitant to allow researchers to have access to the classroom environment. Normally, as a foreigner, I am greeted with much suspicion in schools. Therefore, it can be extremely helpful to have a personal contact or reference, as was the case in our secondary school sample, as well as many of the colleges in my sample. All of the secondary schools that we contacted regarding the research study did agree to participate.

College administrators and lecturers

In order to contact college administrators, I employed the snowball or chain approach in purposeful sampling. All names of colleges, lecturers, and administrators are pseudonyms. In October 2012, the MDA President, Kate Currawalla, gave me the contact information for Mr. A. Kumar, a lecturer at Gandhi College of Commerce and Economics, in South Mumbai. Mr. Kumar has been associated with MDA for many years and is very interested in helping students with learning disabilities at the college. On November 27, 2012, I went to Gandhi College to meet with Mr. Kumar. Mr. Kumar introduced me to the administrators, including the Principal, Dr. T.

A. Sharma, and we discussed the research project (the template introduction letter is found in Appendix F). The next day, MDA was granted permission to conduct research at Gandhi, with faculty members and students. Gandhi is affiliated with the Maharashtra HSC Board for junior college and the University of Mumbai for their degree college.

In early December 2012, Mr. Kumar introduced me to Mrs. L. Rajan, Vice Principal of the Junior College and Mr. R. Varma, Head of the math department in the junior college. During this conversation, Mrs. Rajan suggested that I return a week later to conduct a focus group with 11th standard students with learning disabilities, following their final exam.

In mid-January 2013, I visited St. Joseph's High School & Junior College in suburban Mumbai. A staff member at MDA knew the Principal of St. Joseph's High School, Mrs. J. Gole, and introduced me to her via e-mail. The Mrs. Gole and the administrators agreed to allow me to interview the staff, however, they did not have any students with learning disabilities enrolled. Both the high school and junior college are affiliated with the Maharashtra state board (SSC and HSC). During my visit, Mrs. Gole also introduced me to Mrs. U. Jain, a teacher in the junior college.

Also in mid-January 2013, I visited Vijaya High School and Junior College and Vijayalakshmi Education Society's College of Arts, Science & Commerce in suburban Mumbai. The MDA administrator's son had attended school at Vijaya High School and referred me to the Principal, Mrs. B. Gokhale. The Principal then introduced me to the Junior College Vice Principal, Mrs. K. Kapoor, who is in charge of the math department. The High School is affiliated with the SSC Board and the Junior College is affiliated with the HSC Board.

In late January 2013, I visited Shri Ram College. The MDA CEO, Masarrat Khan, suggested that I contact Shri Ram College because we have conducted study skill workshops there over the past few years for their students with learning disabilities. Masarrat and another

MDA staff member told me to contact the Vice-Principal of the Junior College (Mrs. A. Pandey), and the Vice Principal of the Degree College (Dr. L.R. Balan). Both of these ladies gave MDA permission to speak with faculty members and conduct classroom observations.

Next door to Shri Ram College is another reputable college in South Mumbai, Narsee College of Arts, Commerce and Science. MDA did not have any contacts there, but I decided to contact them, along with all of the other prominent South Mumbai colleges. I had attempted to call Narsee College many times, but was unable to introduce myself to the Principal over the phone. Since I was at Shri Ram College in early February 2013, collecting data, I decided to see if I could deliver a letter to the Principal next door, explaining the research project and asking Narsee College to participate. The Principal was not in her office, so her secretary told me to meet one of the Vice-Principals. I went to knock on their doors, and the only Vice Principal in the office was Dr. H. Borde, Professor of Chemistry in the degree college. Dr. Borde agreed to participate in the study and allowed me to give surveys to her lecturers. She also asked me to follow up with the Vice Principal of the Junior College, Mrs. M. A. Gupta, since she had some experience working with students with learning disabilities.

I had some difficulty following up with Dr. Borde and Mrs. Gupta over the phone and e-mail, and went back to Narsee College in person in August 2013. I went to the Principal's office again, and the secretary referred me to Dr. Dalal, Vice Principal and Professor of Chemistry in the Degree College. He then introduced me to Mrs. S. Parikh, chairperson of the Exam Committee and Political Science lecturer. I was also able to speak to Mrs. Gupta in person in August 2013 and obtain more information about the Junior College program at Narsee College. Mrs. Gupta then introduced me to Mrs. Thomas, a math lecturer in the Junior College.

I also visited Ambedkar College, which has Science and Commerce streams, and is another famous college in South Mumbai. MDA did not have any contacts there, so I called the

college and was able to make an appointment with Dr. L. Ghose, Head of Department, Degree College Mathematics. I visited Ambedkar College in early February 2013, and met Dr. Ghose, who introduced me to Ms. M. V. Sen, Head of Department, Junior College Mathematics. Dr. Ghose also introduced me to the Principal of Ambedkar, Dr. A. Wagle. Dr. Wagle knew Mrs. Currawalla, MDA CEO, and granted me permission to conduct research with the faculty members at Ambedkar. On a later visit in February 2013, Dr. Ghose introduced me to Ms. M. Bose, math lecturer in the Degree College.

Since most of the colleges in the sample are in South Mumbai, I spoke with the MDA CEO, Masarrat Khan, to discuss possible other colleges that had links to MDA. She did not know any other college administrators personally, but suggested I contact Singh College because it has a good reputation and is one of the largest junior colleges and degree colleges in suburban Mumbai. After a few phone calls, I secured a meeting with an administrator in early February 2013. Two of the administrators, Dr. S. Kapadia (Commerce College) and Mr. V. Jha (Science College) agreed to allow us to conduct research at their institution.

I attempted to contact another prominent south Mumbai college, St. Xavier's College, but this institution was not included in the sample because they did not offer a Bachelor of Commerce, or any courses in the Commerce stream. In the end, our sample schools included three suburban college and four South Mumbai colleges. All of the junior colleges are affiliated with the Maharashtra HSC State Board, and the degree colleges are all affiliated with Mumbai University in the sample.

Because all degree college programs are affiliated with Mumbai University¹⁵, I wanted to contact them to find out more information about students with MLD in Mumbai. At the end of June 2013, I visited the Mumbai University's Kalina campus to meet Mrs. Vidya Shinde, the

¹⁵ Names in this section are not pseudonyms

Controller of Examinations, to obtain information about the number of students with MLD currently enrolled in Mumbai University's courses. Mrs. Shinde told me to visit the enrollment section at the Kalina campus. The staff at the enrollment section, including Mr. Ashok Farde, told me to visit the Fort campus in south Mumbai for the information that I needed. Mr. Farde encouraged me to visit Mr. Denish Kamble, Deputy Registrar, in the Statistics department of the Fort campus.

In the middle of July 2013, I visited Mumbai University's Fort campus. Mr. Kamble was not available, but I met Mr. N.V. Talawadekar, the deputy registrar for the academic authorities unit. Mr. Talawadekar then introduced me to Dr. M.A. Khan, the registrar of Mumbai University. Dr. Khan introduced me to Mr. Vinod Malale, the Public Relations Officer, and Mrs. Rekha Vaskar, a staff member of the Public Relations Office. The Public Relations Office staff were able to give me some answers regarding my questions about learning disability policy in the Mumbai University system. Mr. Malale informed me that Mumbai University does not currently collect data on students with learning disabilities (personal communication, July 19, 2013).

Post-college students/adults: collective case studies

I interviewed six students who have completed junior college and some/all of degree college. All names of college and post-college participants are pseudonyms. The students were selected through the snowball or chain approach. Kunal was asked to participate in the study because he was a former student of Masarrat Khan, MDA's CEO. Ms. Khan first spoke to Kunal, and then she passed his contact information to me. Rani was also a former student, but of another MDA staff member. Again, the staff member first contacted Rani, and then I contacted her. Malik and Om Prakash were former students of Mr. Kumar's at Gandhi College. First, Mr. Kumar spoke to three of his former students who he felt might be open and willing to participate, and he gave me their contact details. However, I was only able to schedule

interviews with two of the three students. Vinod was chosen because he was a personal friend and had expressed interest in helping me with my project in any way. Lastly, Masarrat posted a call for participants on the Indian Psychological Association list-serv. John was the only student that contacted me following the announcement.

Participants and informed consent

All of the parents and students (under 18 years of age) provided verbal and written informed consent (offered in English and Marathi for parents) (See Appendix G & H). At G.P Somkar School, the parents requested a parent meeting so that I could explain the research project to them in person before giving consent. I conducted the parent meetings at G.P Somkar school on September 17 and October 8, 2012. At all of the schools, the counselor or administrator contacted the parents directly and explained the project to them, in addition to giving them the formal consent letter. Secondary teachers signed a consent form as well (Appendix I).

All of the junior college and degree college faculty members were also given a consent letter before any interview or observation (Appendix J). The lecturers provided verbal consent. The post-college students were over 18 years of age and they provided informed consent before their interview (See Appendix K).

I obtained Internal Review Board (IRB) approval from the University of Massachusetts before beginning any data collection.

Sample size

Secondary student participants

From all four secondary schools and MDA centers in the sample, there were a total of 125 student participants in 7th – 10 standard (ages 11-16). These students were studying in the Maharashtra State Board (SSC), the Indian Certificate of Secondary Education (ICSE) Board, the

International General Certificate of Secondary Education (IGCSE), and the Central Board of Secondary Education (CBSE) Board schools in Mumbai and its suburbs at the time of data collection. All of the students are studying in English-medium, private unaided schools and the mean age of the participants was 13.32 years. The majority of students live in the central suburbs (Sion to Kalyan) of Mumbai. Sixty-three students are certified as having MLD and the other students (n = 62) are not having MLD and are average or high-achieving students. The male/female ratio for all students who participated was 88:37.

The final sample of secondary students consisted of 125 participants with the following characteristics, shown in Table 1 below:

Table 1: Socio-demographic characteristics of secondary student participants (n = 125)

Characteristics	N (%) total: all participants	N (%) for students with MLD	N (%) for non-MLD students
Gender:			
Male	88 (70%)	49 (77.8%)	39 (62.9%)
Female	37 (30%)	14 (22.2%)	23 (37.1%)
Educational Board			
SSC	75 (60%)	38 (60.3%)	37 (59.7%)
ICSE	44 (35%)	19 (30.2%)	25 (40.3%)
IGCSE	5 (4%)	5 (8%)	0
CBSE	1 (<1%)	1 (1.6%)	0
Standard			
7 th	30 (24%)	16 (25.4%)	14 (22.6%)
8 th	27 (21.6%)	11 (17.5%)	16 (25.8%)
9 th	40 (32%)	20 (31.7%)	20 (32.3%)
10 th	28 (22.4%)	16 (25.4%)	12 (19.4%)
Type of family ¹⁶			
Nuclear	73 (61.8%) ¹⁷	41 (67.2%) ¹⁸	32 (56%) ¹⁹
Extended (grandparents)	33 (27.96%)	14 (22.95%)	19 (33.3%)
Joint	12 (10.1%)	6 (9.8%)	6 (10.5%)
Neighborhood			
South Mumbai (Colaba –	19 (15%)	10 (15.9%)	9 (14.5%)

¹⁶ Two students with MLD and five typically achieving students did not turn in a parent survey

¹⁷ Out of 118 respondents

¹⁸ Out of 61 respondents

¹⁹ Out of 57 respondents

Byculla/Worli			
Central Mumbai (Byculla – Sion)	17 (13.5%)	3 (5%)	14 (22.6%)
Central Mumbai suburbs (Sion-Kalyan)	77 (61%)	40 (63.5%)	37 (60%)
Western Mumbai suburbs (Mahim/Bandra – Vasai)	3 (2.4%)	3 (5%)	0
Harbour line suburbs	4 (3%)	2 (3%)	2 (3%)
Navi Mumbai suburbs	5 (4%)	5 (8%)	0
Percentage of income spent on educational expenses²⁰			
50% and above	9 (8.57%)	8 (15%)	1 (2%)
Between 20-49%	44 (42%)	30 (56.6%)	14 (27%)
Below 19%	52 (50%)	15 (28.3%) ²¹	37 (71%) ²²
Language spoken at home²³			
Marathi	39 (33%)	21 (35%)	18 (31.6%)
Hindi	24 (20%)	8 (13%)	16 (28%)
English	19 (16%)	12 (20%)	7 (12.3%)
Gujarati	9 (7%)	5 (8.3%)	4 (7%)
English and Gujarati	6 (5%)	2 (3%)	4 (7%)

Table adapted from Karande et al. (2009, p. 385)

Secondary students with MLD

All students with MLD (n = 63) exhibited the characteristics to reflect the purpose of the study (Merriam, 2009). All of the students with MLD in this study have obtained a government hospital certificate (as required by the SSC and CBSE boards) or a psycho-educational report completed by MDA or another ICSE Board-recognized institution, verifying that they have dyscalculia or specific learning disability in math. All of the students with MLD have a full scale IQ of 90 or above (since the Indian system still certifies students based on the aptitude/achievement model). Of the 63 students with MLD, six had been previously repeated a grade (9.5% of the students with MLD, or 4.8% of the total students).

²⁰ Twenty respondents did not answer this question

²¹ Out of 53 respondents for students with MLD on this particular question

²² Out of 52 respondents for typically achieving students on this question

²³ Top five languages spoken

Thirty-one students with math learning disabilities visited the MDA centers for educational psychological testing and/or remedial services, and were asked to participate in the study, while others (n=32) were previously identified as having MLD and were attending the schools in which the research was completed. Students with MLD (or dyscalculia) (n = 63) were asked to participate, irrespective of the presence or absence of reading and writing disabilities, due to the rare diagnosis of only MLD in Maharashtra (less than 1% of all LD diagnoses). The majority of the students with MLD in the study also have a reading and writing learning disability as well. The male/female ratio of students with MLD was 49: 14.

Reading achievement scores were not used in the classification, because for the tasks used in this study, the same pattern of deficits is evident for children with MD, whether or not they show comorbid RD (e.g., Geary et al., 2000; Jordan et al., 2003; Geary et al., 2004).

Secondary students without MLD

I selected a comparison group of students (n = 62) without learning disabilities (with the help of school administrators and counselors) and attempted to match them with the MLD group based on standard (grade) and sex. The school administrators and counselors selected students who were high achievers or average achievers at the schools. The administrators and counselors were asked to choose students who had no indication of a potential learning disability. However, we were limited by which parents would give permission. In the end, we tried to have equal participants from both the MLD and non-MLD categories. No typically achieving students had previously repeated a grade. The male/female ratio for typically achieving students was 39:23.

In the original design, I anticipated that the sample would consist of only 9th and 10th standard students. However, once I started work at MDA, I realized that it would be difficult to get so many participants from 10th standard. Students and parents are quite serious about

studying for the 10th standard government exam, so they focus only on studying and do not participate in other activities. Many times, they are attending extra coaching classes before and/or after school. Some 9th standard students are preparing for this exam, too, and avoid any activities other than studying. Therefore, MDA suggested that we include 7th – 10th standard students in the sample. I also had originally planned for a more equal male/female ratio in the design. However, boys outnumbered girls with MLD both at MDA and in schools. This may be because more boys are referred in the Indian context. All students with MLD had been certified through a government hospital or by a recognized testing center, such as the Maharashtra Dyslexia Association.

Collective case studies: secondary school students

For the case studies of secondary students, I selected five students. At the time of data collection, one of these students was in the 8th standard, three students were in the 9th standard, and one student was in the 10th standard.

Secondary school students' parents

The majority of the 125 students' parents filled out the survey. However, I was unable to obtain surveys from 7 parents, even after reminders were given. The majority of surveys were filled out by the mothers (79 out of 118 returned surveys). Since Mumbai is a diverse city, the parents speak a combination of 16 different languages (English, Hindi, Marathi, Urdu, Sindhi, Tamil, Tulu, Punjabi, Malayalam, Konkani, Gujarati, Marwari, Bengali, Telugu, Kutchhi, and Kannada). Forty-five percent of students have four members in their household. Most households have between 3 to 6 members. Nearly 70% of the fathers have graduate (Bachelor's) or post-graduate (Master's) degrees, while 73% of the mothers have graduate or post-graduate degrees. Almost 90% of the households have a computer in the home.

Teacher participant sampling

I was able to interview four secondary teachers. Three teachers were from Gyanankur School in suburban Mumbai, while one teacher was from G.P Somkar school in South Mumbai. One teacher taught 8th standard math, one teacher taught 9th standard math, one teacher taught 10th standard math, and the last teacher taught 9th and 10th standard math classes.

College lecturers/administrators sampling

In the seven colleges I visited in Mumbai, I was able to collect 28 surveys from college lecturers. Ten of these lecturers were from the degree college level, and the remaining 18 lecturers teach at the junior college level. The lecturers had taught at the college level for an average of 10 years, and the most frequent number of years taught was five.

I interviewed 18 lecturers and administrators. Eight of these lecturers were from the suburban colleges, while ten of them teach in the South Mumbai colleges. Seven lecturers were affiliated with a junior college and eleven taught at the degree college level.

College student participant sampling

I conducted a large group interview with 19 11th standard students at one of the South Mumbai colleges. The Vice Principal instructed me to meet students after their final first term exam. She knew that they would all be present that day due to the exam, otherwise, students' attendance is poor. The students were given the option to leave the room following the exam, or stay for my interview. One student left because he had to catch a train, but the other students remained. Although the group was large, it was my only opportunity to meet the students. I asked them to leave their phone number with me, following the group discussion, if they wanted to share more information about their experience. All students with MLD had been certified through a government hospital or by a recognized testing center, such as the Maharashtra Dyslexia Association.

Collective case studies: post-college students/adults

I was able to interview six students who have finished junior and degree college. Three of these students completed the Commerce stream, two completed the Arts stream, and one completed the Science stream. All students with MLD had been certified through a government hospital or by a recognized testing center, such as the Maharashtra Dyslexia Association.

Data collection

Typically in Mumbai, the school year begins in June and ends in April. However, from February onwards, the examination season starts. Therefore, I was unable to collect any data from students in schools and colleges from February – April. Then, summer vacation occurs during the months of April and May. Colleges open even later, in July. Therefore, there were gaps in my data collection, due to examination and vacation schedules.

Table 2 below, links my research questions to methods of data collection:

Table 2: Research question and data collection linkages

Research question	Data collection methods
1. How prepared are students with MLD to enter post-secondary education?	Quantitative methods Foundational skill assessment/Screeners Qualitative methods Document review: policy of educational Boards Interview transcripts: collective case studies Interview transcripts: college lecturers Interview transcripts: post-college students/adults
1a. What math knowledge, skills, and learning strategies do the students with MLD currently have?	Quantitative methods Foundational skill assessment/Screeners WJ-III, if possible Survey results: students Survey results: parents Qualitative methods Document review: policy of educational Boards Interview transcripts: collective case studies Interview transcripts: secondary math teachers

<p>1b. How do the math knowledge and skills of these students with MLD differ from students without MLD (comparison group)?</p>	<p>Quantitative methods Foundational skill assessment/ Screener WJ-III (MLD only) Survey results: students Survey results: parents</p> <p>Qualitative methods Interview transcripts: secondary math teachers</p>
<p>1c. What knowledge, skills, learning strategies, and other supports do these students with MLD need, based on their desired program of study in college and the math requirements of the courses in that program?</p>	<p>Quantitative methods Survey results: college lecturers in math Results of students' performance (above) to understand the gap</p> <p>Qualitative methods Interview transcripts: college lecturers Notes from class observations Interview transcripts: post-college students/adults Document review: College course syllabi and government resolutions for students with LD</p>
<p>2. How are students with MLD further affected by college procedures regarding mathematics?</p>	<p>Quantitative methods Survey results: college lecturers in math</p> <p>Qualitative methods Interview transcripts: college lecturers Interview transcripts: post-college students/adults</p>

Measures

Math proficiency

Beginning in April 2012, I tested each secondary student on a researcher-constructed screener for 7th standard prerequisite math skills and content math skills (based on the curriculum map/matrix) to measure discrete skills and number sense. The screener is found in Appendix L. This screening tool had 21 questions that covered curriculum-based content from the end of sixth standard textbooks and below, as well as number sense (questions adapted from Mehra et al. (2007); Aggarwal (2010); Kovas et al. (2007); Vilenius-Tuohimaaa et al. (2008);

Siegler & Opfer (2003); Sigler & Booth (2004); Geary, Hoard, & Bailey (2011); and Kyttälä & Lehto (2008). Please refer to Table 3 for more information on individual question sources.

The screeners were piloted in mid-April 2012, following which small changes were made to the formatting of the documents, but the questions remained the same. During the screener, students were told to complete as many questions as they could and to show all of their work. They were allowed to skip a problem if they did not know how to solve it. Students were given unlimited time to complete the problems on the screener, but time was accounted for each individual student. I gave the students one point for each correct answer, up to 21 points. I did not give partial credit for any item. Due to the exploratory nature of this project, I am unable to comment on the reliability and validity of this researcher-created screener.

Table 3: Screener questions

Question	Source from which the question was adapted
1 & 2	Mehra et al. (2007)
3 & 4	Kovas et al. (2007)
5 – 9	Kaufman & Kaufman (2004)
10	Mehra et al. (2007); Aggarwal (2010)
11	Mehra et al. (2007)
12	Mehra et al. (2007); Vilenius-Tuohimaa et al. (2008)
13 & 14	Siegler & Opfer (2003); Sigler & Booth (2004)
15 & 16	Aggarwal (2010)
17	Mehra et al. (2007); Kyttälä & Lehto (2008)
18	Mehra et al. (2007); Aggarwal (2010)
19	Mehra et al. (2007)
20 & 21	Siegler & Opfer (2003); Sigler & Booth (2004)

Additionally, students were given two more tasks. Students were given a subitizing task, consisting of 20 flashcards, to assess how quickly students could enumerate small groups of dots (0 – 6 dots in a circle, per flashcard). I told the students to complete the task as far as they could, since I would be keeping track of time.

Table 4: Subitizing flashcards

Number of dots	Frequency of flashcards
0	1
1	1
2	4
3	7
4	4
5	2
6	1

In a related task, students were given a variation of the Number Sets Test that assesses the speed with which children process and add sets of objects and Arabic numerals to match a target number (e.g., whether $\bullet\bullet 3 = 5$) (Geary et al., 2012). These two tasks were administered to see if there was a difference in the speed with which students with MLD process sets as compared to their peers and to further gauge their number sense. I obtained the Number Sets Test via e-mail on March 5, 2012 from the author, Dr. David Geary. In the original Number Sets Test, Geary gave the students 60 seconds per page for identifying sets of five and 90 seconds per page for identifying sets of 9. However, I wanted to remove as much anxiety as possible from the testing situation, and I told the students they could take as much time as they needed, but I would be keeping track of the amount of time they took to complete the task. I wanted to explore the length of time students, both with MLD and without MLD, took to complete the same number of items. Example items from the Number Sets Test are presented in Figure 19, below.

Circle all of the sets that add up to 5.
Work as quickly as you can.

5

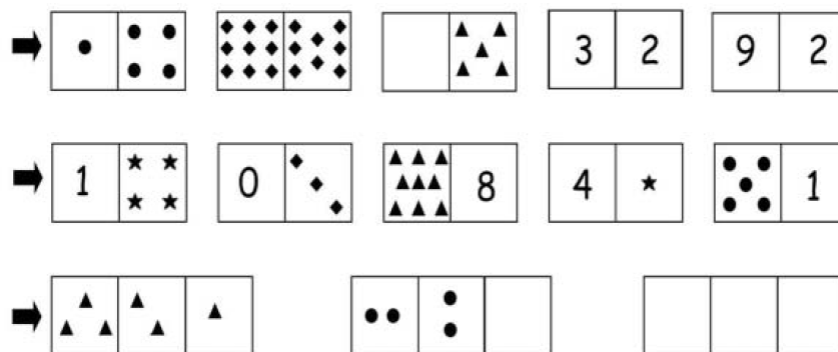


Figure 19: Example items from the Number Sets Test (Geary, Bailey, & Hoard, 2009, p. 268)

I completed most of the screening assessments at the MDA centers (Parel/Lalbaug and Deonar) in April and May 2012. A few of the psychologists at MDA completed the screening assessments for children at the Dombivli and Vile Parle centers in May and June 2012. I met with the psychologists individually and explained how to administer the training tools. During these meetings, they were given written instructions with verbal prompts to ensure uniformity in assessment, as well as a student result sheet for keeping track of scores and observation notes during the screening.

Additionally, for students with MLD that were screened at MDA centers in April and May 2012, we were able to collect additional information on their math abilities through the Woodcock-Johnson III Tests of Achievement (Woodcock, McGrew, & Mather, 2001). The students were tested in the cluster areas of Broad Math (Math Calculation, Math Fluency, and Applied Problems), Basic Math Skills (Math Calculation and Math Fluency), and Math Reasoning (Applied Problems and Quantitative Concepts) by the psychologists at MDA (Mather & Jaffe,

2002). The MDA psychologists administered these tests. Students who came to a MDA center were given the screener, subitizing tasks, survey, and the Woodcock-Johnson III Tests of Achievement individually. In most cases, the students were given the Woodcock-Johnson III Tests of Achievement on a separate day, in conjunction with their psycho-educational assessment testing.

Due to time constraints, we were unable to administer the WJ III to all participants. Some secondary school parents were hesitant to allow their child to miss class for the 20-30 minutes required for the screening, and the WJ III would have taken additional time. Therefore, we did not complete this part of the overall assessment in schools. Therefore, only secondary students with MLD that came to a MDA center were assessed using the WJ III Tests of Achievement in mathematics.

The WJ III is a reliable test. Reliability is used to describe the overall consistency of a test. A test is said to have a high reliability if it produces similar results under consistent conditions. The reliability coefficient is an index of the precision of position in a group, and a high reliability coefficient may be due to good precision of scores (McGrew & Woodcock, 2001). The reliability coefficient for the WJ III should fall at the desired level of .80 or higher. Cluster scores are based on combinations of two or more tests and, therefore, possess consistently higher reliabilities (Schrank, McGrew, & Woodcock, 2001). The median reliability coefficients (Median r_{11}) for the cluster areas and individual subtests are in Table 5 below:

Table 5: WJ III Median Reliability Coefficients

Cluster/Test	Median r_{11}
Broad Math	0.95
Math Calculation Skills	0.91
Math Reasoning	0.95
Test 5: Calculation	0.86
Test 6: Math Fluency	0.90
Test 10: Applied Problems	0.93

Test 18: Quantitative Concepts	0.91
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(Schrank, McGrew, & Woodcock, 2001)

A review of the median reliabilities for each cluster reveals a level of .90 or higher (Schrank, McGrew, & Woodcock, 2001).

To prepare to screen students in the secondary schools, I met with the MDA psychologists at the monthly MDA staff meeting in June 2012. At this meeting, I trained all of the psychologists on administering the screener. The psychologists that had already administered the items also gave advice and feedback at this time.

On August 23, 2012, I went to Shanti Niketan, along with two MDA psychologists to begin screening the 50 secondary school participants. I returned on October 3, 2012, along with another MDA psychologist to complete the data collection. At Shanti Niketan, we conducted the screening assessments in a large room. Each student sat at a large desk with me, or the psychologist, individually. The assessments went on simultaneously. Since the students finished the tasks at different times, each screener administer worked at her own pace since we each had a list of students to be tested. Since Shanti Niketan is quite far from the MDA centers, the testing was completed during the entire school day, whereas the other secondary school screening took place only in the morning.

I went to St. John's School on September 18th and 24th, 2012 to test 15 students. Due to time and scheduling constraints, the testing at St. John's school had to be completed in small groups (no more than 8 in the room). Students were later asked to complete the subitizing activities individually. I conducted all of the testing at St. John's School.

I visited G. P. Somkar school on September 21, 2012 and screened eight students. I returned on October 12, 2012 to complete the assessment of 7 more students. Most of the screening was done individually. However, in two cases, the screeners were administered two

students at a time, due to scheduling constraints. All students completed the subitizing activities individually.

I screened the 16 students at Gyanankur school on October 17, 2012. The teachers and counselors at the school requested that the students be screened during a certain time period. Therefore, the screener was administered in small groups (no more than 6 in the room). Students completed the subitizing activities individually at a later time.

Later, additional screening of students with MLD was completed at the MDA centers in April 2013.

Secondary school students and parents surveys

I gave secondary students a researcher-constructed survey with 16 questions (Appendix M). The students all attended English-medium schools, so there was no need for translation. The students were asked to fill out the survey upon completion of the screening activities. Students were asked if they wanted to complete the survey on their own, or if they wanted the researcher to read the questions aloud and the student respond verbally.

Parents were asked to complete a researcher-constructed survey consisting of 16 questions (Appendix N). The survey was available in English and Marathi (state language of Maharashtra). One of the psychologists at MDA translated the survey into Marathi. Another MDA staff member, fluent in Marathi, checked the translation and made corrections before the final version was handed out. Parents were given the survey, along with the informed consent form. If their child was tested at the MDA center, the parents were asked to fill out the survey while their child was being assessed. However, if the parent was assessed at his/her school, the parents returned the survey along with the informed consent form. All surveys in this study were cross-sectional (collected at one point in time) (Creswell, 2009). All parent surveys were

filled out independently. The purpose of the surveys was to gather additional descriptive information about the participants.

I had originally included survey items about caste and religion, but these items were omitted from the survey before it was distributed, as the MDA CEO thought it was inappropriate to gather this information on a survey. The CEO did not feel that these topics were necessary for educational research.

Interviews with secondary school students

I conducted all interviews in a semi-structured format (sample interview questions in Appendix O). My interviews with Shreya and Deepa were conducted at one of the MDA centers, in a private remedial room. My interviews with Nitin, Vaibhav, and Saihila were conducted over the phone, while they were at home. I had given their parents the option to come to the MDA center, for me to come to their house, or to complete the interview over the phone. All of three parents chose the phone option because of their work schedule or summer vacation schedule. I conducted these interviews between the end of April 2013 and the beginning of May 2013. During the interviews, I took extensive notes and transcribed the interviews immediately after I finished speaking with the participant.

Portraits of the subsample of 5 secondary students (all pseudonyms)

Shreya is a 9th standard female from Navi Mumbai and attends an IGCSE school. She lives with her extended family and speaks Marathi at home. Although she has a diagnosis of dyslexia and dyscalculia, Shreya said that she doesn't think she has a learning disability. "I'm just lazy." She loves to sing, but will pursue either Science or Commerce to become either a doctor or set up a medical manufacturing business (personal communication, April 29, 2013)

Deepa is a 10th standard female from Mumbai's central suburbs and attends a SSC school. She lives with her nuclear family and speaks English at home. Deepa was my math remedial student (one-on-one, following the original screening) for almost one year as she prepared for her 10th standard exam. She wants to pursue Arts in order to become a journalist.

Nitin is an 8th standard male from Mumbai's central suburbs and attends an ICSE school. He lives with his nuclear family and speaks a combination of Hindi, Marathi, English, and Tamil at home. Nitin wants to pursue engineering so that he can create "stuff" for NASA or police purposes (personal communication, May 4, 2013). He is excited to go to college so that he can begin to create his ideas through projects that are required for class.

Vaibhav is a 9th standard male from Mumbai's harbor suburbs and attends an ICSE school. Vaibhav lives with his extended family and speaks Hindi at home. Vaibhav hasn't decided his future goals yet. He is still confused about which stream (Arts, Science, or Commerce) he should pursue. Vaibhav was my math remedial student, following the initial screening, for nearly one year during his 9th standard year.

Saihila is a 9th standard female from Mumbai's central suburbs and attends an ICSE school. She lives with her extended family and speaks English and Urdu at home. Saihila dislikes math, and therefore, is not interested in pursuing Commerce. She finds Arts "fascinating," but she thinks there are fewer jobs and opportunities in this field (personal communication, May 4, 2013). She thinks that she will probably pursue Science, since that is the only other option. After the initial screening, she attended an 8-week intensive summer program in math remedial with me.

Interview with secondary school teachers

I interviewed the Shanti Niketan teachers at the school, in the same room in which the students were assessed. I interviewed the teacher from G. P. Somkar School in the counselor's office. All of the questions were in a semi-structured format (Appendix P). I conducted these interviews on the same days when I visited the school for student assessment (August and October 2012). The three teachers from Shanti Niketan school agreed to audio recording of their interview, while the G.P Somkar teacher did not agree. During the interviews, I took extensive notes and transcribed the interviews immediately after I finished speaking with the participant.

College lecturers surveys

I asked lecturers in four colleges to complete a researcher-constructed survey with 18 questions (Appendix Q). The purpose of the surveys was to gather additional descriptive information about the participants. I distributed surveys to Shri Ram College lecturers on January 30, 2013. I had to give the surveys to Mrs. Pandey and Dr. Balan, the Vice Principals,

who then handed them to the lecturers. I went back to collect the surveys on February 18, 2013. On February 6, 2013, I gave surveys to Singh College's, Ambedkar College's, and Narsee College's Vice Principals to be distributed among lecturers. I went to collect the completed surveys a week later from Singh and Ambedkar. The surveys from Narsee College were ready on February 18, 2013.

Interviews with college lecturers

I conducted all interviews with lecturers in a semi-structured format (sample interview questions in Appendix R). All of the interviews were conducted in the college premises, either in the lecturers' office or in the lecturer staff room. I interviewed Mr. Kumar at Gandhi College on November 27, 2012, and I visited again for a follow-up interview on July 19, 2013. I conducted interviews at St. Joseph's High School & Junior College and Vijaya Junior College on January 21, 2013. I visited Singh Junior College on February 6, 2013. I spoke with lecturers at Ambedkar College on February 6th and 18th, 2013. I visited Shri Ram College and interviewed the Head of Department on February 11, 2013. Later, I visited Narsee College and interviewed lecturers on August 23, 2013. None of the participants agreed to tape recording of interviews.

Observations

I conducted observations of junior college and degree college math courses between January – February 2013. I observed three 11th standard math courses at Shri Ram College on January 30, 2013, and one first-year B.Com math class on February 11, 2013. At Ambedkar, I observed two 11th standard math classes on February 8, 2013. I was unable to observe any more degree college math courses because it was late in the term, and most lecturers had already finished their curriculum.

During the six college classroom observations, I took extensive hand-written field notes. I entered each observations with a few categories, such as classroom environment, pre-requisite knowledge necessary for understanding the lecture, number of students, etc. (see Appendix S for my observation protocol). Basically, I was looking for what students must know and be able to do in order to comprehend and understand what was being taught in the class. I also kept track of the lecturers' actions and speech throughout the class. Following the observation, I returned to the MDA office and typed up my field notes on the same day.

Interviews with post-college students / adults

When I contacted the post-college students over the phone about the research project, I gave them the option of doing the interview over the phone, or choosing a place where we could meet. Because all of the participants in this subsample are pursuing further studies or are working full-time, most of them chose to do the interview over the phone. I conducted one interview in person, with Vinod, on April 25, 2013. The other interviews were conducted over the phone on the following dates: Kunal (March 13, 2013), Rani (May 3, 2013), John (June 10, 2013), Malik (August 25, 2013), and Om Prakash (September 5, 2013). I conducted all interviews with the post-college adults in a semi-structured format (sample interview questions in Appendix T). At the end of each interview, I briefly summarized the participant's responses at the end of each interview and asked for confirmation from the participant, to serve as a member check (Creswell, 2007). During the interviews, I took extensive notes and transcribed the interviews immediately after I finished speaking with the participant.

Portraits of the subsample of 6 post-college students / adults (all pseudonyms)

Kunal is a B.Com. graduate (male) from Mumbai's central suburbs. He is currently preparing for his MBA entrance exam. He hopes to join the family business of steel trading after his MBA and work experience.

Rani is a B.Sc. graduate (female) in jewelry design and manufacturing from Mumbai's central suburbs. She aims to be a jewelry designer. She has dyslexia.

Vinod is a B. Arts (honors, UK) graduate (male) from Mumbai's western suburbs. He is currently a general manager of products and marketing for an entertainment multi-channel network on YouTube. He has been certified as having dyslexia and has difficulty with mathematics.

John is a M.A. (counseling psychology) graduate (male) from Mumbai's harbor suburbs. He hopes to work with children with autism and/or learning disabilities. He has dyslexia, dysgraphia, and dyscalculia.

Malik is a B. Com graduate (male), currently finishing up his MBA and lives in South Mumbai. He has already started his own business in metals and coils retail. He is planning to expand it.

Om Prakash is a B.Com graduate (male) from South Mumbai. He is currently working for his father in the family shipping business and is contemplating whether to pursue further studies.

Document Review

I collected documents and records as part of my data collection. At the colleges, I asked the lecturers about the college math syllabi. I also asked college to provide the number of students with MLD that are enrolled in post-secondary education as well as the math courses and skills that are required for the various degree programs. Additionally, I tried to obtain copies of the government resolution circulars, which outline the exam accommodations and quotas that are required for students with learning disabilities, from the government of Maharashtra. In addition to asking the college lecturers at each of the seven colleges I visited, I also tried to get this information from Mumbai University (Kalina and Fort campuses), NCERT, the Maharashtra State Board of Secondary and Higher Secondary Education (MSBSHSE, Pune), the Maharashtra Education Office (Charni Road), and the Directorate of Higher and Technical Education (Dhobi Talao).

I was able to obtain the junior college math syllabi from on the website of the Maharashtra State Board of Secondary and Higher Secondary Education (MSBSHSE, Pune). The Mumbai University website has the syllabus for the Bachelor of Commerce degree (in which the

Mathematical and Statistical Techniques course is required in the first year). However, trying to obtain the government circulars and acquire further explanation on the policies proved to be much more difficult.

I visited the Maharashtra Education Office (Charni Road) three times (July 19, 2013; August 23, 2013; September 16, 2013). I was unable to obtain a copy of the government resolution, although two staff members told me that policies for an LD quota and exam accommodations did exist (P. Patil, personal communication, August 23, 2013; R.V. Patil, personal communication, September 16, 2013). During my visit to Mumbai University, Fort campus, I was given a copy of the government regulation from the Higher and Technical Education Department, listing concessions for students with learning disabilities (V. Malale, personal communication, July 19, 2013). Please see Appendix U for this resolution.

Also, my quest to try to understand exactly how many students with MLD are currently experiencing the transition to post-secondary education was difficult. For instance, Mumbai University does not keep records of students with learning disabilities. I had to contact each college individually to obtain this information (V. Shinde & A. Farde, personal communication, June 28, 2013; N.V. Talawadekar & V. Malale, personal communication, July 19, 2013).

Summary of data collection methods

I collected both quantitative and qualitative data to answer my research questions. To answer my first research question (*How prepared are students with MLD to enter post-secondary education?*), I collected the following data for my three subquestions:

- a) What math knowledge, skills, and learning strategies do students with MLD currently have?

To answer this question, I collected math proficiency data for students in 7th – 10th standard with MLD. I collected additional proficiency data on students with MLD that visited the MDA

centers in the form of the WJ-III math achievement subtests (calculation, math fluency, applied problems, and quantitative concepts). I gathered more information from secondary students with MLD and their parents through surveys. I probed for additional information through interviews of students (collective case studies) and secondary math teachers. I also completed a document review of current policies of the educational Boards for students with learning disabilities.

- b) How do the math knowledge and skills of these students with MLD differ from students without MLD (comparison group)?

In order to answer this question, I collected math proficiency data for students in 7th – 10th standard without MLD, or typically achieving. I also gathered more information from these students and parents through surveys. I also used the interview responses of the secondary math teachers to answer this question. Additionally, I used the math proficiency data from students with MLD to understand if there is a difference between proficiency levels between typically achieving students and students with MLD in mathematics.

- c) What knowledge, skills, learning strategies, and other supports do these students with MLD need, based on their desired program of study in junior college and degree college and the math requirements of the courses in that program?

To answer this question, I collected survey data from junior college and degree college lecturers in mathematics. I also planned to use the math proficiency data from both students with MLD and typically achieving students to answer this question. I probed for more information to answer this question by interviewing junior college and degree college lecturers in mathematics. I also conducted observations of junior college and degree college math courses. Additionally, I interviewed post-college students/adults with MLD to gather more information for this question. I also completed a document review of policies of educational

Boards, specific junior colleges and degree colleges, and Mumbai University to understand the supports and services that are already in place for students with MLD.

To answer my second research question (*How do college math policies and procedures affect students with MLD?*), I collected the survey and interview data from college lecturers in math. I also collected gathered information from interview with post-college students/adults.

Data Analysis Procedures

Ultimately, data analysis involves making sense of the data by consolidating and interpreting it in order to answer my research questions (Merriam, 2009). In order to prepare and organize the data, I was guided by my research questions, but also by my conceptual framework (Wolcott, 1994). I wanted to relate the themes and categories of my analysis to the framework that was formed by my review of the literature. In my analysis, I was looking for evidence of the gaps in math content and critical component skills that may occur when students with MLD fall behind in primary and secondary math courses, take a lower level math course (SSC Board), or drop math after 8th standard (ICSE Board). My conceptual framework also directed my search for more information about the transition process for students with MLD in post-secondary education mathematics and the amount of support they required in mathematics.

I also analyzed the data through the lens of critical theory/pedagogy, in addition to my conceptual framework. During my analysis, I focused on the context of Indian education and the way educational institutions shape educational practice and the impact it has on students' access to post-secondary math courses (Merriam, 2009). Because I examined the data through the lens of critical pedagogy, I looked for instances of instances of students with MLD being excluded, although the intent of the policy or practice may be to include them with typically

achieving peers. Additionally, I considered the way different participants' views reinforced or differed from the Indian education culture and system, which is structured for one size fits all.

Because I collected both quantitative and qualitative data in my mixed-methods approach, I integrated the qualitative and quantitative pieces to make meaning of the data. For each type of data, I reduced and organized the data by using several methods (Creswell, 2007). For the quantitative data, I managed the data in Excel and SPSS. For qualitative data, I transcribed the data in Word documents or scanned images into computer files.

Data analysis methods

Math proficiency screeners

Once I scored the screeners (out of 21 total points), I analyzed the errors for both students with MLD (Appendix V) and those without MLD (Appendix W) as well as calculated the error frequency and types on each item for all participants. I coded the errors using codes similar to those used in a study by Raghubar et al. (2009). Students' errors were categorized as one of the following: procedural errors (including formulas), arithmetic / fact errors, visual-spatial / visual monitoring errors (number misalignment, miswriting numbers, messy / overcrowding), switch errors (misinterpreting signs), conceptual errors (including fractions, decimals, variables), and did not attempt the problem (Raghubar et al., 2009).

Furthermore, I anticipated that I would perform an independent samples t-test in SPSS to determine if there is a significant difference between the means of two groups (students with MLD and without MLD), or to investigate the difference between two population averages. In this analysis, the independent variable, or grouping variable, (presence of learning disability) has two levels (MLD or non-MLD). The dependent variable, or test variable, is the score on the math screener. However, my data was skewed and therefore, I did not meet the assumptions to run a t-test. Instead, I performed a non-parametric test (Mann-Whitney U test) for scores on the

math proficiency measures, as well as for duration of time to complete each task. Since I conducted so many analyses, I wanted to make sure that I controlled for error and protected my power. In order to do this, I split my subquestion 1b into two parts, grouping all of the score-related questions into one family (with one alpha = 0.05 to distribute across all the p's). Then, I kept time on screening tasks as a separate family (with one alpha = 0.05 for any time-related questions). Controlling the familywise type I error rate in this way is referred to as the Holm's Sequential Procedure.

Surveys: secondary students, parents, and college lecturers

I entered the data into Excel, and later into SPSS (formerly known as Statistical Package for the Social Sciences). I used a separate row for each participant, and I listed each participant by an assigned number (chronologically assigned as the student completed the screener) to ensure anonymity. I defined the names of the variables in each column (one for each survey question), then entered specific values /numeric codes into SPSS, for each participant's response. I labeled each variable by typing in a portion of the survey question to give more detail about what the variable represented. I also labeled each value so that I could remember what each variable represented, especially in the case of discrete quantitative variables or categorical data (such as neighborhood or level of education completed). For some continuous quantitative variables, such as amount of time spent on homework, I entered in specific amounts for each participant's response. For other continuous variables, such as a birth weight, I entered the data in intervals. I also specified whether each variable was string (categorical) or numeric. In order to manage the data, I entered in the survey data every few days, or as I received it. I was constantly reviewing the data to see if there were questions that emerged, and/or I needed to follow up with qualitative data to make more sense of the data.

In some cases, the quantitative data from the surveys were analyzed as totals, percentages, and rates for descriptive statistics across the responses. These averages or percentages told me what proportion of my participants felt a certain way or had similar views on students' transitional issues.

As part of this study, I investigated if the impact of SES was also evident in my sample. In order to gauge SES, I asked parents to report the percentage of income that they spend on educational expenses, with the idea that parents who have more income will spend a smaller percentage on education. I have also considered gender, language group, and ability within the students' profiles (Gregg, 2007).

The table below summarizes the relationship between the research questions, variables, and survey items.

Table 6: Relationship between research questions, variables, and survey items (adapted from Creswell, 2009, p. 151)

Research question	Variable	Item on survey ²⁴
RQ 1: How prepared are students with MLD to enter post-secondary education?	Concessions Level of math College readiness Required math topics	SS #11; PS #16 SS # 14, 15 LS # 3, 4 LS # 15, 16
Descriptive research: RQ 1a: What math knowledge, skills, and learning strategies do students with MLD currently have?	Level of math Concessions	SS #8, 9, 14, 15 SS# 11; PS #16; LS #17,18
Descriptive research: RQ 1b: How do the math knowledge and skills of these students with MLD differ from students without MLD (comparison group)?	Level of math	SS #8, 9, 14, 15
Descriptive research: RQ 1c: What knowledge, skills, learning strategies, and other supports do these	College readiness Current level of math Required math topics Math topics to be	LS #3, 4 LS #5 LS #15, 16

²⁴ SS = student survey, PS = parent survey, LS = lecturer survey

students with MLD need, based on their desired program of study in junior college and degree college and the math requirements of the courses in that program?	strengthened Desire to go to college	LS #6 SS #13
RQ 2: How do college math policies and procedures affect students with MLD?	N/A	N/A
General sample description	Students' age and grade Students' school Language Parents' education level Birth weight Family members Neighborhood SES Students' attendance Students' grade retention Extra time on math Lecturers' experience	SS #1, 2, 3; PS #7 SS #4, 5 SS #6, 7; PS #2, 3 PS #4, 5 PS #6 PS #8, 9, 10 PS #11 PS #12, 14 PS #13 SS #16; PS #15 SS # 10, 12 LS # 1, 2

In chapter four, I present the results of the statistical analysis and the interpretation of the results.

Interviews: secondary students and post-college adults

For each case, I created a portrait of each participant. As I analyzed the data from all of the case studies, I identified issues within each case, then looked for common issues, or themes, which were present across cases to begin to generalize participants' shared issues (Merriam, 2009). In other words, I conducted a "within-case analysis", followed by a "cross-case analysis" (Creswell, 2007, p. 75).

Interviews with secondary math teachers and college lecturers

Since the interviews with teachers and lecturers showed me a different perspective on students' transition, I analyzed these data separately from the students' interviews. I reflected

on the instructors' viewpoints and discovered common themes. Later, I compared these categories to the categories that emerged from the students and adults with MLD above.

College classroom observations

I analyzed my field notes from all of my observations by again developing categories of themes that existed across the observations. I also compared the observation notes to the lecturers' interview transcripts, to see if the themes reinforced each other. While I analyzed the observation data and lecturer interview data, I wanted to clearly describe the college context that students with MLD.

Document review

I reviewed documents and records after I had read and re-read the interview transcripts and observation notes. I compared the information from the colleges with the information from Mumbai University, to understand the way policies are being implemented and the impact these policies have on students and lecturers.

Further qualitative analysis

While analyzing all of the qualitative data (interview transcripts, observation field notes, and documents), I began by reading my research questions. I also printed out my conceptual framework and re-read the text to guide me as I read through the data. I made a list of themes from the literature and my conceptual framework that guided the study, including math content (algebra, geometry), assessment, strategies (specifically addressing memory deficits, attention, and speed), study skills, self-determination skills, etc. Then, I read all of the data several times. I highlighted key phrases and significant statements, and I also wrote key concepts in the margins. During this phase, I tried to pay close attention to the case studies of students, so that I could be sure that their voices were paramount in my analysis. I then made a new list of themes, or patterns, which appeared and emerged from the data (Merriam, 2009). Some of the

new themes were course option factors, assessment, family, peers, coping strategies, attendance, lack of awareness about learning disabilities, etc. Later, I looked for multiple forms of evidence for each new category (Creswell, 2007; 2009).

Therefore, in the process of attempting to describe, classify, and interpret the transitional problems that students with MLD face in post-secondary education, I developed a list of codes, or themes that emerged (Creswell, 2007; Merriam, 2009). From these categories, or themes, I looked for patterns and meaning across the cases and data (Creswell, 2007). I created a table to display the data in a uniform framework, showing cross-case synthesis of relationships and patterns between the cases (Table 7, below). This synthesis presents an in-depth picture of the transition experience for students with MLD (Creswell, 2007). Later, I looked at my research questions along with my list of themes. I went through the data again, specifically looking for answers to each of my research questions. My interpretations of the data is included in chapter four.

Table 7: Cross-case synthesis

Codes/Themes	Interviews	Observations	Document Review
Course options in junior college: Math vs SP	Open enrollment in either class, Limited enrollment based on 10 th std. exam score, Students counseled to avoid math		Students can take either Math or SP as required by the curriculum, most students with MLD take SP in junior college
Enrollment in college courses	120-170 students enrolled in each class, Student attendance is poor	Student attendance is poor	
Style of teaching and assessment in colleges	Exam-focused, Lecturers give students strategies to pass the exam, Memorization, Colleges offer tutorial classes, students'	Memorization	

	desire to understand not memorize		
Students' math abilities	Difficulties with calculation, geometry, and algebra; Take more time; Memory deficits and need tasks broken down		
Students' coping strategies in college	Calculators, peer tutoring / group study, apply 20 grace marks to exams, work hard, practice, go abroad for further studies		Apply 20 grace marks to exams, minimum passing score is 35 – 40%
Students' relationships	Parental pressure, bullying from peers		

Integrating quantitative and qualitative approaches

Since I collected the data convergently, I also analyzed the data using a convergent triangulation approach (Creswell, 2009, 2014). In the convergent triangulation approach, I compared the quantitative and qualitative data to see if there was corroboration or confirmation of the data. More of this mixing approach is found in chapter four, where I present the quantitative statistical results, followed by qualitative quotes that support the quantitative results. I also represent the way I combined both the quantitative and qualitative data analysis in a matrix in the next chapter. Although I tried to give equal weight to both methods, I recognize that priority was given to the qualitative data (Creswell, 2009, 2014). Overall, the quantitative data provides generalized patterns of math proficiency of students with MLD, while the qualitative data provides personal narratives of students with MLD. Both methods contribute to the understanding of the research problem.

Trustworthiness

I have collected and analyzed as accurately as possible, yet I acknowledge that this is my representation of the post-secondary transitional experience for students with MLD in Mumbai. I have spent extensive time in India, including a year and a half working at MDA during data collection. During this time, I engaged in prolonged and persistent observations in Mumbai, conducted multiple in-depth interviews, and inspected a range of relevant documents to study this phenomenon (Creswell, 2007; Brantlinger et al., 2005).

My results are credible and trustworthy because I used data triangulation, or considered several sources of data for this study (Brantlinger et al., 2005). I created an audit trail of my data, in the form of MDA monthly reports, to keep track of interviews I conducted and specific times and dates I spent observing, as well as who was observed on each occasion. In an effort to further demonstrate the credibility of data, I engaged in peer debriefing. In other words, I shared my interpretations and impressions of my interactions with participants with the President and CEO of MDA, while maintaining the confidentiality of participants. I also used thick, detailed description through participants' quotes and field note descriptions to provide evidence for my interpretations and conclusions (Brantlinger et al., 2005; Creswell, 2007). Following each interview, I summarized the participants' responses and asked for their confirmation regarding my interpretation of what I heard during the interview, or member checks (Creswell, 2007). Throughout this study, I maintained a posture of reflexivity. I was continually considering different perspectives to the transitional problems of students with MLD. I wanted to be sure that my personal interpretation of the situation did not get in the way of the participants' views and values (Rallis & Rossman, 2012).

CHAPTER 4

FINDINGS

Introduction: Vignette

Vinod is an outgoing, athletic young man in his late 20's who lives in Mumbai's western suburbs. While he was growing up, he was always interested in pursuing a career in business. Before he took his 10th standard exam, he underwent an assessment for learning disabilities and was certified. He attended Shri Ram College for junior college and took Secretarial Practice in place of math in the Commerce stream. After completing junior college, Vinod enrolled for his Bachelor's degree in Commerce at Shri Ram College. In the first year, he had to take the mandatory Mathematical and Statistical Techniques course. Vinod recounts his transitional experience:

It was a shock for me to take math again. I was weak in math to begin with, and then it was like I wasn't practicing hard enough or something. People said that I wasn't studying and I was not paying attention. But I was. It was frustrating. I started not to care. I left it (math); I was like "screw it." You are stressed when you are behind. No one wants to be behind everyone else.

(Vinod, personal communication, April 25, 2013)

Vinod failed the Mathematical and Statistical Techniques course and eventually moved to Ambedkar College to pursue a Bachelor of Arts degree (which does not require a math course) because Shri Ram College only offers Commerce and Science degrees. Once he finished his Bachelor of Arts degree, he went to London to study media. He is now a general manager of products and marketing for an entertainment multi-channel network on YouTube (Vinod, personal communication, April 25, 2013).

Vinod's case was similar to many other students with learning disabilities in post-secondary education in India. As I analyzed the data, I read account after account of students with MLD having to study harder and longer than their peers, just to scrape by, or in Vinod's case, to have to take another path in order to reach their goal.

Summary of findings

In this chapter, I delve deeper into my findings. I will answer each research question, and present the findings from all data collection methods under each question. I will also mention the way I used my conceptual framework (the cumulative effects of students' difficulties in mathematics in Figure 18), as well as an overlapping lens of critical theory / pedagogy, to inform my findings. As I mentioned in the Methods chapter, I will present quantitative data first, when available, with qualitative data afterwards to give additional meaning to the quantitative data.

Research Questions

Question 1: How prepared are students with MLD to enter post-secondary education?

Since the Maharashtra Dyslexia Association (MDA) was particularly concerned about students with learning disabilities entering a Bachelor's degree program in Commerce (in which math is a required course in the first year), I am limiting my research question answers to the Commerce streams in junior college (11th and 12th standard) and B.Com (degree college).

In order to answer the first question, I had to find out the current math skills and abilities of students with MLD (1a. *What math knowledge, skills, and learning strategies do students with MLD currently have?*), and how that differs from typically achieving students (1b. *How do the math knowledge and skills of these students with MLD differ from students without MLD?*). Once I determined the areas of discrepancy between the two groups, I could compare the current abilities of students with MLD to the level of math that is required for the Mathematical and Statistical Techniques course, as well as other skills students need to pass the degree college course (1c. *What knowledge, skills, learning strategies and other supports do these students with MLD need, based on their desired program of study in junior college and degree college and the math requirements of the courses in that program?*).

In Table 8, I present a summary of the findings, with more detailed explanation for each question below.

Table 8: Summary of findings for research question 1²⁵ and data sources

Source of data	1a. What math knowledge, skills, and learning strategies do students with MLD currently have?	1b. How do students with MLD differ from students without MLD?	1c. What do these students with MLD need for post-secondary transition in mathematics?
Secondary students (screeners, interviews, and surveys)	Relative strengths in basic operations, Misconceptions about fractions, Deficits in geometry	Both groups have a relative strengths in basic operations and relative weakness in geometry, Typically achieving students are faster	Self-determination skills, Listening skills, A strong, supportive peer group, Family support
Secondary teachers (interviews)	Basic operations	Both groups have strong basic concepts and a fear of geometry	
College lecturers (interviews and surveys)	Slow speed		Prerequisite skills (up to 12 th standard math), Reasoning skills, Problem solving skills, algebraic concepts, Daily practice
Observations			Note-taking skills, Memorization of formulas
Post-college adults (interviews)	Deficits in algebra and geometry, Work slowly	Typically achieving students are faster, Students with MLD have to work hard and practice a lot.	Extra practice, Calculator, Strong, supportive peer group
Documents		Students with MLD receive 20 grace marks on end-of-term exams	Twenty grace marks

²⁵ How prepared are students with MLD to enter post-secondary education?

1a: Current math knowledge, skills, and learning strategies of students with MLD

Knowledge and skills

In this sample, students with MLD (n = 63) performed well in the area of basic operations. On the math screener, more than 80% of the students obtained the correct answers on problems involving addition, multiplication, and division (see Appendix V).

Only 27 out of 63 students with MLD in the sample were screened at a MDA center and agreed to also take the WJ-III tests in mathematics. These 27 students, they scored higher (standard score and grade equivalency statistics) on the calculation test, compared to their scores on fluency, applied problems, and quantitative concepts. The average actual grade for this subsample was the middle of 8th grade. The standard scores show how close students with MLD performed to the average mean (100) of same-age peers in the general population, while the grade-equivalent scores indicate the typical grade of students who obtained the same raw score.

Table 9: Standard score results for WJ-III tests and clusters (n=27)

WJ-III	Range (SS) ²⁶	Mean (SS)	Median (SS)	Standard Deviation (SS)
Test 5: Calculation	62 – 124	96.22	97.00	15.290
Test 6: Math Fluency	56 – 106	83.22	82.00	13.325
Test 10: Applied Problems	48 – 106	85.30	87.00	14.325
Test 18: Quantitative Concepts	58 – 105	85.52	86.00	11.175
Cluster: Broad Math	50 – 108	85.93	89.00	15.158
Cluster: Calculation	57 – 113	89.63	91.00	14.262
Cluster: Reasoning	48 – 106	84.07	87.00	13.547

Table 10: Grade equivalent score results for WJ-III tests and clusters (n=27)

WJ-III	Range (GE) ²⁷	Mean (GE)	Median (GE)	Standard Deviation (GE)
Test 5: Calculation	3.2 – 18.0	8.281	7.3	4.1786
Test 6: Math Fluency	2.3 – 12.3	5.711	5.1	2.5996
Test 10: Applied Problems	1.6 – 12.9	5.641	5.1	2.7184
Test 18: Quantitative Concepts	2.4 – 10.5	5.578	5.1	2.0597

²⁶ SS = standard score

²⁷ GE = grade equivalent

Cluster: Broad Math	2.6 – 11.4	6.315	6.0	2.5023
Cluster: Calculation	3.0 – 12.9	6.989	6.2	2.7436
Cluster: Reasoning	2.0 – 9.9	5.519	5.1	2.1993

The WJ-III does not have an Indian adaptation test available, and the current academic achievement battery is standardized on the U.S. and U. K. population. However, MDA uses these results to analyze errors and strategies used to solve the problems (M. Khan, personal communication, March 6, 2014). Although there are problems with using tests that are not standardized on the population, this is the current practice of many organizations in Mumbai (Al-Yagon et al., 2013).

Students with MLD also self-reported through surveys that they think they are good at basic operations (addition, subtraction, multiplication, and division). When asked about which math skills they perform well, 62 percent of students with MLD mentioned basic calculation skills. Secondary teachers also mentioned that students in their classes had good basic concepts and knowledge of basic operations (Shanti Niketan secondary teachers, personal communication, August 23 & October 3, 2013).

According to students in the collective case studies, they claim they are good at commercial arithmetic (simple and compound interest) and solving equations (Vaibhav, personal communication, May 8, 2012; Shreya, personal communication, April 29, 2012; Saihila, personal communication, May 4, 2013). Students and adults with MLD also mentioned that they were good at basic calculation skills (Deepa, personal communication, May 6, 2013; Malik, personal communication, August 25, 2013; Kunal, personal communication, March 13, 2013). John specifically mentioned that his skills improved, in division and multiplication, with the use of a calculator. The calculator was a support, to help him with his attentional difficulties, and he felt more confident completing math problems with it (John, personal communication, June 10, 2013). Thus, both the quantitative and qualitative data show that calculation is a relative strength (compared to other math skills) for students with MLD in this sample.

Although the majority of students with MLD were able to obtain the correct answer on problems involving addition, multiplication, and division, only 62% of students with MLD taking the

screeener correctly answered a three-digit subtraction problem with regrouping. The most common error was sign-switching, and students added instead of subtracting (a complete error analysis for each problem on the math screener is in Appendix V). Other students made procedural and arithmetic/fact errors. Therefore, I hesitate to make a broad claim that students with MLD in this sample have good basic computational skills. The sample is heterogeneous, with students having various areas of strengths and weaknesses, even within the area of calculation.

The students with MLD involved in this study also exhibited poor understanding of fractions from their performance on the math screener. On a subtraction problem involving fractions with common denominators, only half of the students with MLD answered the problem correctly. The most common error ($\frac{4}{7} - \frac{2}{7} = 2$) showed that students have deficits in their conceptual understanding of fractions, and do not truly understand the difference between whole numbers and fractions. Students with MLD performed even more poorly on an addition problem involving fractions with uncommon denominators ($\frac{1}{2} + \frac{1}{3} = ?$). Only 24% of students with MLD gave the correct answer. The most common incorrect answer was $\frac{2}{5}$, indicating both conceptual and procedural misconceptions. Students need to have deep conceptual understanding of math concepts, such as fractions, in order to remember what they have learned. When students have a superficial understanding of math concepts, arithmetic procedures are easily confused with each other, especially in the case of fractions (Fazio & Siegler, 2011).

Students with MLD also performed poorly on a horizontal addition problem with decimals. Thirty-eight percent of students with MLD solved it correctly, while many of the others showed difficulty with visual-spatial skills and monitoring skills, by intertwining the place values in the horizontal format.

Additionally, students with MLD did not perform well on an introductory algebraic word problem, commonly confusing $7 + x$ with $7x$. Only 17% of students with MLD correctly identified the equation with addition.

Students with MLD also self-reported on surveys and in interviews that they have difficulty with geometry and geometric concepts. For example, Vaibhav mentioned that he finds certain geometric terms difficult to understand (personal communication, May 8, 2013). Students also reported having difficulty with properties of circles, theorems, angles, and geometric construction (Shreya, personal communication, April 29, 2013; Saihila, personal communication, May 4, 2013; group interview at Gandhi College, personal communication, December 13, 2013). Kunal reported that he finds theorems very difficult and he is unable to do proofs (personal communication, March 13, 2013).

Other students told me about their difficulties with algebra. Nitin mentioned that he initially understands but then forgets the formulas later (personal communication, May 4, 2013). Kunal admits he gets really confused in algebra. He says, "All of the x 's and y 's - I don't understand how they derive the correct answer. Algebra is very difficult for me" (Kunal, personal communication, March 13, 2013). John reflected on his secondary math experience, reporting that algebra and geometry were very difficult for him, since he was still struggling with multiplication (John, personal communication, June 10, 2013).

Professor A. Kumar offered a potential explanation for students' difficulties. He has noticed that students with MLD have difficulty with abstract thinking and mathematical language that exists in college math classes (A. Kumar, personal communication, November 27, 2012). He adds, "Any abstraction is difficult, and it starts with 8th and 9th standard geometry" (A. Kumar, personal communication, July 19, 2013).

Students with MLD also want to become faster in their math skills, wishing they could be better at mental math and faster with their basic skills (Om Prakash, personal communication, September 5, 2013; John, personal communication, June 10, 2013). A junior college math lecturer also mentioned that students with MLD find it difficult to keep up in class, due to their computation and processing speed (M. Sen, personal communication, February 6, 2013). Saihila also commented that doing math

takes time: “It is difficult and complicated if you don’t understand how and why you are doing things (in math)” (Saihila, personal communication, May 4, 2013). Om Prakash sums it up well: “I get confused often (in mathematics). Unless I understand the whole process and the whole procedure completely, I will be lost” (personal communication, September 5, 2013). Students must have deep conceptual understanding, paired with procedural understanding, to truly be proficient in mathematics. Otherwise, their performance will show weaknesses over time, if they are not constantly reviewing previous concepts.

Overall, students with MLD in this sample have relative strength in basic calculation. However, they lack conceptual and procedural understanding in the areas of fractions, algebra, and geometry. They also require more time to complete math tasks.

Learning strategies

A few of the students with MLD in my case study subsample, including Vaibhav, had visited the Maharashtra Dyslexia Association for a few months of weekly remedial sessions. Vaibhav mentioned that, although he does find geometry challenging, the “tricks” he learned in remedial were helping him (personal communication, May 8, 2013). Additionally, Shreya also mentioned that she keeps a book of formulas to help her study. She said, “I have kept track of all of the formulas I’ve had to memorize since 7th grade. I keep track of everything I am bad at, and I keep adding on to it” (Shreya, personal communication, April 29, 2013). Yet, using a few strategies may not be enough for all students with MLD to keep up in the regular education class.

Malik shared about his experiences in trigonometry. He said, “I used to take longer than the average student. I had a lot of difficulty with diagrams. I took a long time to put my diagrams on paper” (Malik, personal communication, August 25, 2013). John also mentioned that his friends were able to keep up in class and could understand math so much faster than he could (John, personal communication, June 10, 2013).

Students with MLD reported having to practice and work really hard in mathematics. In this sample of secondary students, only half of typically achieving students go for tuition classes, or extra tutoring. On the other hand, only 16% of MLD student do not attend extra classes. For those students who do attend extra classes, typically achieving students attend extra classes for an average of 1.7 hours per week, while students with MLD attend extra classes for an average of 3.75 hours per week.

Also, students with MLD receive 20 grace marks if they fail a math exam (see Appendix U) (A. Kumar, personal communication, November 27, 2012). However, if a typically achieving student fails an exam, they only get 6 grace marks (S. Kapadia, personal communication, February 6, 2013).

Summary of findings on current knowledge, skills and learning strategies of students with MLD

Overall, students with MLD in this sample have a relative strength in basic calculations, but have difficulty with fractions, geometry, and algebra. These findings, in light of my conceptual framework, emphasize the gaps in critical component skills and math content that students with MLD can have as they progress through secondary education. Students with MLD also take more time to complete tasks involving mathematics. Students reported that using a calculator, as well as strategies for memorizing formulas, remedial education, and extra tutoring have helped them in the regular math class. Students also use the 20 grace marks on their math exam to get a passing score.

1b: The differences in math knowledge and skills in students with MLD and typically achieving students

Math proficiency and knowledge as determined by screener scores

To compare the two groups of students, I first analyzed the diagnostic statistics for their performance on the math screener, which consisted of 21 questions. The results, in Table 10, indicate that the comparison group scored significantly higher overall than students with MLD. Because of the moderate skew in scores of typically achieving students, I decided to run a non-parametric analysis

(Mann-Whitney U-test) to determine significant differences between the medians of the groups. Please see Appendix X for a full explanation of the statistical analysis.

Table 11: Screener scores

Group	Range of scores (out of 21 questions)	Mean	Median	Standard Deviation
Students with MLD (n = 63)	1 – 17	9.02	9.00	3.585
Typically achieving students (n = 62)	10 – 20	16.18	16.00*	2.371

* comparison of median scores is significant (U = 199.5, Z = -8.688, p < 0.001)

A median plot, comparing screener score medians for typically achieving and students with MLD is shown below in Figure 20. Also, I included error bars to indicate how closely the means reflect the true values. In this case, the error bars represent standard error, or the standard deviation of the median.

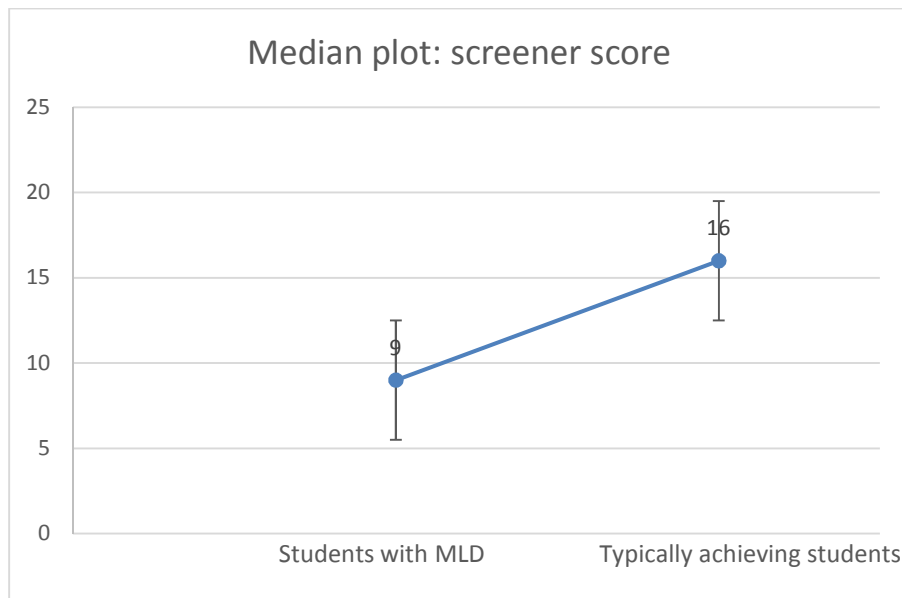


Figure 20: Median plot for screener scores

Neither group performed well on the number sense questions, but more typically achieving students got the correct answers than students with MLD (see Appendix V and W).

Skills determined by time on screener

To compare the time it took for the two groups to complete the screener, I first analyzed the diagnostic statistics. The results, in Table 11 below, indicate that students with MLD needed significantly more time to complete the screener (test) than did the typically achieving students²⁸.

Table 12: Time on screener

Group	Range of time (seconds)	Mean	Median	Standard Deviation
Students with MLD (n = 63)	480 - 3540	1170.05	1040.00	524.246
Typically achieving students (n = 62)	264 - 1420	708.27	702.50*	282.822

*comparison of median time is significant (U = 751.5 seconds, Z = -5.933, p < 0.001)

A median plot, comparing the medians for time on the screener for typically achieving and students with MLD is shown below in Figure 21.

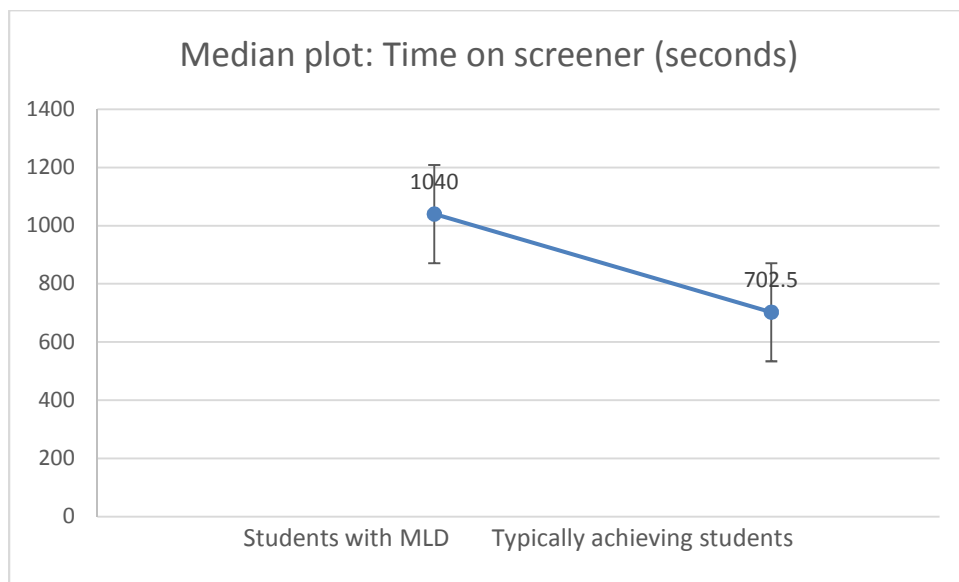


Figure 21: Median plot for time on screener

Skills determined by time on number sense tasks

To continue to analyze the amount of time that students in the two groups took to complete other number sense tasks (subitizing and Number Sets), I examined the diagnostic statistics, and then I

²⁸ As with the screener score results, the skewness in the data indicated a non-parametric test; see Appendix X for a complete description of the analysis.

conducted Mann-Whitney U tests to determine significance (see Appendix X for more explanation, including using Holm’s sequential procedure to control for type-1 error).

Table 13: Time on 20 subitizing flashcards

Group	Range of time (seconds)	Mean	Median	Standard Deviation
Students with MLD (n = 63)	23 – 95	36.73	35.00	12.451
Typically achieving students (n = 62)	21 – 55	29.24	28.00*	6.110

*comparison of median time is significant (U = 1102.00, Z = -4.209, p < 0.001)

Table 14: Time on Number Sets 1 (sets of 5 with symbols)

Group	Range of time (seconds)	Mean	Median	Standard Deviation
Students with MLD (n = 63)	41 – 313	92.25	77.00	46.202
Typically achieving students (n = 62)	33 – 124	57.05	55.00*	16.786

*comparison of median time is significant (U = 624.5, Z = -6.561, p < 0.001)

Table 15: Time on Number Sets 2 (sets of 5 with symbols and numerals)

Group	Range of time (seconds)	Mean	Median	Standard Deviation
Students with MLD (n = 63)	37 – 263	74.29	64.0	37.109
Typically achieving students (n = 62)	28 – 103	47.63	46.0*	13.104

*comparison of median time is significant (U = 690.00, Z = -6.239, p < 0.001)

Table 16: Time on Number Sets 3 (sets of 9 with symbols)

Group	Range of time (seconds)	Mean	Median	Standard Deviation
Students with MLD (n = 63)	88 – 418	149.19	138.0	49.141
Typically achieving students (n = 62)	55 – 173	103.37	102.0*	24.827

*comparison of median time is significant (U = 600.5, Z = -6.679, p < 0.001)

Table 17: Time on Number Sets 4 (sets of 9 with symbols and numerals)

Group	Range of time (seconds)	Mean	Median	Standard Deviation
Students with MLD (n = 63)	56 – 297	104.65	100.0	37.688
Typically achieving students (n = 62)	35 – 128	64.11	64.5*	16.514

*comparison of median time is significant (U = 403.00, Z = -7.655, p < 0.001)

For all of the timed tasks, both exact and asymptotic statistical significance levels were 0.00.

Therefore, students with MLD took significantly longer time to complete all number sense tasks.

Knowledge and skills determined by accuracy on number sense tasks

Additionally, more typically achieving students were more accurate on the Number Sets Test than students with MLD. However, these were not significant differences (when using the Holm’s procedure to control for error). Please refer to Appendix X for additional information.

Table 18: Percentage of completely accurate Number Sets tests

Group	Test 1 (5)	Test 2 (5)	Test 3 (9)	Test 4 (9)
Students with MLD (n = 63)	71.4%	69.8%	44.4%	66.7%
Typically achieving students (n = 62)	80.6%	80.6%	58.1%	77.4%

To earn a completely accurate test, students had to circle all of the sets of 5 or 9. Other students, not included in the above percentages, skipped 1 or more of the sets.

Summary of differences in knowledge and skills

Typically achieving students scored significantly higher on the math screener than students with MLD. Additionally, on all three math proficiency measures (math screener, subitizing flashcards, and the Number Sets test), students with MLD took significantly more time than their peers to complete the mathematical tasks. Students with MLD in this sample needed more time to complete math tasks, even very basic core components of number sense tasks, such as subitizing, which aligns with current research on students with MLD.

Typically achieving students in this sample also self-reported through surveys that their strongest skills were basic calculations, while their area of greatest difficulty is geometry. A junior college math lecturer also reported that many students, not just students with MLD, have a phobia of math. She reported, “Students have a preconceived notion that math is difficult, and they develop a mental block with math” (M. Sen, personal communication, February 6, 2013). Secondary teachers also reported that all students have relative weaknesses in geometry and seem to be fearful of geometric concepts (Shanti Niketan school, personal communication, August 23, 2013; G.P. Somkar school, personal communication, October 12, 2013).

Although both groups in this sample claim to be strong in calculation skills and have difficulty in geometry, students with MLD performed significantly lower on a screener of foundational, or pre-requisite skills than typically achieving students. On average, students with MLD in this sample have fewer foundational math skills and require more time to complete math tasks. Also, students with MLD reported having to work hard and practice a lot, as compared to their peers. This was confirmed by survey data with this sample, in which students with MLD reported attending more extra classes for math tutoring than typically achieving students. Students with MLD can apply as many as 20 grace marks to their math exam score, if they fail the math exam, as an exam accommodation, while typically achieving students can only receive 6 grace marks (S. Kapadia, personal communication, February 6, 2013).

These findings reinforce the gap in necessary mathematical knowledge, skills, strategies between students with MLD and typically achieving peers, as shown in my conceptual framework (Figure 18). Students with MLD, on average, differ from typically achieving peers in their level of critical component skills.

1c: The math knowledge, skills, learning strategies, and other supports students with MLD need for post-secondary success

Since students beginning a Bachelor's degree in Commerce are required to take the Mathematical and Statistical Techniques class during their first year, I am focusing in this study on identifying the necessary skills and knowledge for this course. The amount of prior math knowledge a student has as they enter their first year of B.Com depends on the previous course choices they have made. There are many math skills and strategies that students need in order to pass post-secondary math courses, yet other supports factor into students' success, including family and peer support.

Necessary math knowledge and skills

According to my review of the Mathematical and Statistical Techniques course syllabus and textbooks, students must have pre-requisite understanding of algebraic concepts, such as linear equations and functions. Additionally, there are many formulas that have to be memorized, including mean, median, standard deviation, coefficient of variance, and regression (Welling, Saraph, & Diwanji, 2013; Joshi et al., 2011) (See Appendix Y for a curriculum map of the Mathematical and Statistical Techniques course). Students must complete all of the math by hand in this course. Calculators are permitted in F.Y. B.Com., but statistical software is not available in the colleges in my sample (Shri Ram College, observation, February 11, 2013).

College math lecturers reported through surveys that students lack foundational skills for concepts and simple calculations in their college math classes. The lecturers also reported that the most important skills that students need for their classes are reasoning skills, problem solving skills, and algebraic concepts.

Necessary learning strategies for passing math in FY B.Com.

According to a Shri Ram college math lecturer, the Indian educational system is very exam focused. Therefore, the teaching style is reflective of the exam-centric system (personal

communication, January 30, 2013). In my observations of post-secondary math classes, students copied diagrams, formulas, and equations with no reference to life application problems (Shri Ram College, observation, January 30, 2013, February 11, 2013; Ambedkar College, observation, February 8, 2013). Instead of understanding mathematics, the focus is on practicing and memorizing. Therefore, math lecturers acknowledge the need for daily practice in math (K. Kapoor, personal communication, January 21, 2013; U. Jain, personal communication, January 21, 2013).

Another strategy is to focus on passing the exams. In fact, the head of the math department at Shri Ram College told me that the math lecturers “train students to pass the exam” (R. Archarya, personal communication, February 11, 2013). As part of this strategy, in the first year B. Com Mathematical and Statistical Techniques course, the math lecturers at Shri Ram College tell students with learning disabilities “to focus on sections they find easier, such as Statistics or simple and compound interest, while dropping other sections that they find difficult, such as derivatives” (R. Archarya, personal communication, February 11, 2013). However, the math sections vary for individual students and depends on what they find easier or difficult. Shri Ram College has a special dyslexia cell for students with learning disabilities, including MLD, so students learn the strategies (mentioned above) when this cell meets (R. Archarya, personal communication, February 11, 2013). However, at Ambedkar College, the degree college math lecturers often only find out that a student has a learning disability at the time of an exam, when the student uses accommodations, such as extra time (M. Bose, personal communication, February 18, 2013).

One student, Kunal, reported how he used this strategy—practicing to pass the exam—in the Mathematical and Statistical Techniques course:

I took Secretarial Practice (S.P.) in junior college, so I had a gap of 2 years with no mathematics. Plus, I wasn't really comfortable with math in the first place. During my first year of B. Com, I had a private tutor. He came to my house three days a week and taught me for two hours. Then, he gave me homework and practice problems. For six days a week, I studied math. I had to work really hard at math.

Kunal, personal communication, March 13, 2013

Kunal was solely focused on passing the class: “if you dedicate your time, and study for three hours a day, you can easily get 18 marks on a 50 mark paper (which is 36%, just enough for passing).

A third strategy utilized by college students in Mumbai is attending private tutoring sessions (either individual or group) in order to get a better exam score. By the end of the term, fewer students attend the actual college classes, and instead attend only their private tutoring classes. In my observation at Shri Ram College, out of the 100 students who are enrolled, less than 10 students were present at the beginning (8:40 am) of the Mathematical and Statistical Techniques class, at the end of the semester. Throughout the class, students trickled in; by the end of the 50 minutes, a total of 26 students were present (Shri Ram College, observation, February 11, 2013). When I asked one lecturer at Ambedkar college about students’ current skill level in mathematics, the lecturer responded, “I don’t know. They don’t come to class” (Ambedkar College, survey, February 18, 2013).

Another reason, in addition to prioritizing private tutoring, for poor attendance in degree college attendance may be due to the fact that some B. Com. students are also concurrently enrolled in Chartered Accountant (CA) certificate courses, such as the Institute of Chartered Accountants (ICA) course. A lecturer at Ambedkar College explained:

They take these (certificate) courses much more seriously. They have a better chance to get a job if they have these certificates. To be a certified CA, you do the CA course and have a Bachelor’s degree in something. If they do both courses simultaneously, they will finish everything in 3 years instead of 5-6 years. The syllabus for the CA course is larger than the syllabus for B.Com. These courses start after 10:30 or 11 am. Mathematics and Statistics are a part of these courses. The college fees are much less than the fees for the coaching classes for the CA certificate course (which have very high fees). Typically B.Sc. students come for all lectures. But, with B. Com., only 30 out of 120 students come for lectures. Two out of five of my lectures are at 7:30 am. Some of the students come from very far and find it difficult to make it to 7:30 am classes. All degree college lecturers are over by 11 am.

(M. Bose, personal communication, February 18, 2013).

Students may be juggling several courses and tuition classes all at the same time. Plus, some students live as much as an hour and a half away from the South Mumbai colleges.

To succeed in the Mathematical and Statistical Techniques course during the first year of B.Com, students need pre-requisite reasoning skills, problem solving skills, and algebraic concepts. They also must be able to memorize numerous formulas. Since the Indian education system is exam-centric, students must have strategies for passing the exam. Current students practice mathematics daily, focus on studying easier sections of the syllabus, and attend private tutoring classes.

Necessary non-math knowledge and skills for college courses

Students need many prerequisite skills, other than math knowledge, in all post-secondary math classes. Students are responsible for extensive note-taking and must quickly recall previously memorized formulas during the math lectures (Ambedkar College, observation, February 8, 2013). Students not only must copy notes from the board, but also be able to write notes as the lecturer reads problems out loud (Shri Ram College, observation, January 30, 2013). Several students stressed the importance of good concentration and listening skills:

In college, you have to concentrate and be a good listener. Whatever the teacher says, you have to understand. You cannot be distracted. The teacher will only explain once – not again and again.

(Vaibhav, personal communication, May 8, 2013).

You have to pay attention to your studies. You cannot be distracted by what your college friends are doing.

(Shreya, personal communication, April 29, 2013).

Along with concentration and listening skills, secondary students and post-secondary adults with MLD clearly outlined the importance of self-determination skills, such as having a positive attitude and being confident, that contribute to your success in college (Saihila, personal communication, May 4, 2013). For example, Deepa mentioned that you have to focus a lot in college and work hard. She believes that you need determination in order to focus on your studies (Deepa, personal communication, May 6, 2013). Malik suggested that students with MLD should really try to approach professors and lecturers about their difficulties, although it may be difficult:

Be sure to focus on your studies more. Take the guidance of a teacher. Talk about your disabilities, and they will help you out. Do certain kinds of drills with them. They helped me to get good marks. I got 50-55% on my math exam, not 35%. Students should GO to the professor. They are scared. In 11th and 12th, I was scared to talk to them about it. We are scared, but it has to be removed from our hearts. You can go anytime to the professors.

(Malik, personal communication, August 25, 2013)

John also mentioned certain skills and behaviors that can be broadly described as self-determination skills, including the importance of knowing yourself and your abilities:

Look at your learning disability as an ability. You should know yourself. You have to work for yourself, and you can't expect someone to work for you. You will need help. Take the help and make the best of it. During primary and secondary school, your parents will sit and study with you. But, in college, you have to study on your own. There are a lot of things you have to do on your own. It is up to you in the end.

(John, personal communication, June 10, 2013)

All in all, students with MLD need skills in note-taking, memorization, concentration, and self-determination to succeed in college math courses.

Necessary Supports for College Courses

In addition to the math, academic and self-determination skills students felt necessary for succeeding in post-secondary math courses, students with MLD also felt that support from family and peers was critical to succeeding in college. For example, Rani mentioned that she attributed her success in college to her supportive family, especially her sister who is five years elder. Rani's sister had completed the Science stream and helped explain concepts that were difficult for Rani to understand (Rani, personal communication, May 3, 2013).

However, some students with MLD remarked that their parents and extended families influenced their decisions to enter particular courses. Shreya said that she will enter the Science or Commerce stream, even though she wanted to pursue Arts. She loves to sing and records herself singing, but her parents told her that it is not a promising career (Shreya, personal communication, April 29, 2013). Saihila also thinks that Arts is fascinating, but others have told her that "you don't have so

many jobs open to you, and you don't get so many opportunities" in the arts (Saihila, personal communication, May 4, 2013).

Students in this sample also stressed the importance of peers, both positively and negatively, in relation to college success. Secondary students reported that one must choose one's peer group very carefully when going to college (Nitin, personal communication, May 4, 2013), stressing the importance of a strong and supportive peer group:

If you have a good group of friends, they tell you good things, and it leads you to do good things
(Om Prakash, personal communication, September 5, 2013).

College is not really about studies. You have your friends. Everyone is telling you to do different things – some right and some wrong. But, you have to pay attention to your studies"
(Shreya, personal communication, April 29, 2013).

John and another student with learning disabilities made friends "with the smarter students who were willing to help us. Group study really helped me" (John, personal communication, June 10, 2013).

Potential barriers to success

On the other hand, some students may not be able to interact with peers that are willing to help them study. Peer relationships could hamper students' success. According to Mr. Kumar, lecturer at Ambedkar College:

Most students with LD do not disclose their diagnosis. They get bullied. Other students are very strong and harsh towards students with LD. In fact, many students do not want to meet me during school hours, for fear that their peers might see them getting extra help.
(A. Kumar, personal communication, November 27, 2012).

Vinod did not want to seem different from his peers, so he did not ask for accommodations in college for his learning disabilities:

It is not always so easy to ask for help. If you get provisions, then you have to take your exam in a different room. You will be seated in the roll number order during the exam. People will notice you aren't there and they will ask you, "Why didn't you give your exam?" "Where were you?" No one was aware that I had dyslexia in college.
(Vinod, personal communication, April 25, 2013)

The transition from secondary to post-secondary can be rough. If a student has studied in the same school in primary and secondary school, moving to another environment can be intimidating.

Vinod mentioned that he used accommodations during his 10th standard exam, but then did not disclose his disability in college:

I didn't ask for help in college, but the environment was such that they also did not advertise help. The environment was not helpful. I wasn't sure how I would be perceived. It is easier in secondary school – you know the people and they've known you for years. It is easier to ask for help and people don't judge you.

(Vinod, personal communication, April 25, 2013).

The post-secondary environment, including peer relationships, can influence students with MLD and their success, as well as their ability to ask for assistance from peers and lecturers.

Summary of knowledge, skills, learning strategies, and other supports necessary for college success

To succeed in the Mathematics and Statistical Techniques course, students with MLD need strong pre-requisite skills in algebra, reasoning, and problem solving. Students also need strong note-taking and concentration skills, as well as excellent memory to quickly recall formulas during class. Current students and lecturers suggest that students practice daily, employ specific strategies to pass (such as focusing on the easier sections to score the minimum required points), and attend private tutoring classes in order to succeed in degree college mathematics. Students with MLD also mentioned the importance of self-determination skills, or knowing your abilities and be willing to ask for help when you need it. Having strong and supportive family and peer groups also helped students in the transition to post-secondary mathematics. However, Vinod and Professor Kumar reported on the barriers in post-secondary settings, which can prevent students from asking for help.

Referring back to my conceptual framework (Figure 18), these findings indicate that the more mathematical knowledge, skills, and strategies students have, the more successful their transition to post-secondary education will be. If students lack certain skills and strategies, they can benefit from strong self-determination skills, or peers and family, to find the support they need to pass the math

course in first year B.Com. However, if students do not have access to these supports, or their gaps in math content and critical component skills from secondary school are too vast, then I argue that students will have an unsuccessful transition.

Summary of the preparedness of students with MLD for post-secondary education

Students need strong pre-requisite skills in algebraic reasoning and problem solving to succeed in the Mathematical and Statistical Techniques course. However, students with MLD, in this sample, lack foundational math knowledge before leaving secondary school, as evidenced by their performance on the screener. If these students then take Secretarial Practice in place of math in junior college, they miss daily practice in mathematics for two additional years, as well as important instructional content, such as algebra.

Although students with MLD have passed the Mathematical and Statistical Techniques course because of their academic strategies, self-determination, and strong family and peer supports, I argue that the current special education policies are not preparing students for the math knowledge that they need to succeed in post-secondary mathematics. The current special education policies, including dropping mathematics (ICSE Board), taking a lower-level math exam (SSC Board), or applying 20 grace marks to a student's failed exam to enable them to pass (SSC Board), are not helping them learn important mathematical skills. These policies are focused on helping students pass the 10th standard exams, but are not preparing them for post-secondary education. According to my conceptual framework (Figure 18), the current policies are resulting in students having gaps in critical component skills and math content, as shown by their average performance on the math screener. When I consider my overlapping lens of critical pedagogy, I view the current policies as performing an exclusionary role. In other words, students with MLD are excluded from math content and pre-requisite skills in secondary school that are required for a degree college math course. The current policies for students with MLD

are a temporary fix, but are ignoring the actual root of the problem - gaps in math content and foundational skills.

Therefore, to answer my first research question (*How prepared are students with MLD to enter post-secondary education?*), the data from this sample of students reveals that, on average, students with MLD have less foundational math knowledge than their typically achieving peers in secondary school. However, students may have other skills, strategies, and supports that will greatly enhance their ability to succeed in post-secondary education, but this varies from student to student. Therefore, students with MLD have various preparedness levels, based on their pre-requisite skills in mathematics, as well as the mathematical course options they have chosen.

Participants with MLD are also impacted by the level of support in their home and school environment. Students with MLD in this sample, such as Vaibhav and Kunal, had access to remedial education and private tutoring. Certain colleges, like Shri Ram, offer special programs for students with learning disabilities. Thus, students with MLD can be further supported for post-secondary success and their math abilities, depending on their environment.

During my data collection and analysis, I was very surprised by the range of screener scores for participants with MLD. Participants with MLD scored between 1 and 17 correct answers out of 21 questions. This reflects the heterogeneity of students with MLD. Therefore, it is difficult to generalize my findings regarding the preparedness for post-secondary education for students with MLD, since there are so many factors that can affect their math abilities.

I was also impressed by the hard work and determination of participants with MLD in this sample. For instance, participants with MLD reported that they take more time to study and take more tutoring classes than their typically achieving peers. In general, participants with MLD take significantly more time to complete math tasks than students without MLD. Math can be very difficult and frustrating for these students, yet students with MLD, in this sample, reported how hard they had to

work in order to pass their math courses. However, I was surprised to learn about students with MLD being afraid to ask for help, and even being bullied by peers in the post-secondary environment. The environment in post-secondary education can greatly affect students' with MLD, no matter their level of pre-requisite skills in mathematics.

Question 2: How do college math policies and procedures affect students with MLD?

In the previous section, I identified the ways that students with MLD can struggle with college-level math classes because of inadequate math knowledge, skills and learning strategies, due both to their previous preparation in math and their disability. For example, students with MLD, according to special education policy, may opt out of math in 9th and 10th standard (ICSE Board) or may take a lower level math course (SSC Board) in secondary school, leaving them underprepared for a Bachelor's degree in Commerce. Also, due to their atypical strategies and processing speed, they may have lower math proficiency as compared to their typically achieving peers as they finish secondary school.

However, if students with MLD decide to continue their education in post-secondary settings, they are further affected by the policies and procedures of the junior and degree colleges. In many cases, due to these policies, students are further disempowered and excluded from access to certain degree programs due to their math abilities. Also, because few lecturers and administrators at the post-secondary level are aware of learning disabilities, students with MLD do not receive specialized instruction in mathematics and often have to advocate for accommodations.

In this section, I present data and findings from interviews (post-secondary students and adults with MLD, and college lecturers), surveys (college lecturers), as well as a document review of college policies and syllabi. I found that students with MLD, once in college, are most affected by (1) policies on elective courses and (2) policies on accommodations and support for learning disabilities.

Policies on Elective Courses

According to the syllabus for Standards 11 and 12, college students only have three compulsory subjects: English, Environment Education, and Health and Physical Education. Students can then choose four other electives (42 electives are listed in the syllabus) to complete the required coursework each year (Maharashtra State Board of Secondary and Higher Secondary Education, 2012b). According to a lecturer at Gandhi College, the list of electives is theoretical, since no college will offer all of the courses, such as Botany, Zoology, Child Development (A. Kumar, personal communication, July 19, 2013).

However, in all of the colleges I visited, students must choose, as one of their electives, either mathematics or Secretarial Practice (S.P.). In some colleges, students have an open choice between Math or S.P.; yet other colleges have a cut-off score requirement in order to have access to math courses and all other students must take S.P. At Ambedkar College, only students who have scored 87-88% on their 10th standard exam are eligible to enroll in 11th and 12th standard math classes. All other students take Secretarial Practice (S.P.) at Ambedkar (L. Ghose, personal communication, February 6, 2013). The case is the same at Singh College, except the acceptable passing percentage on the 10th standard exam is a little lower at 83% (or 125 out of 150). Only students who qualify for math based on their 10th standard exam score in math are eligible to enroll in math in 11th standard (V. Jha, personal communication, February 6, 2013). At St. Joseph Junior College, if a student took general math or lower-level math for their 10th standard exam (an accommodation for students with MLD in the SSC Board), they are ineligible to enroll in 11th standard math (U. Jain, personal communication, January 21, 2013).

In this way, some colleges are actually forcing students to take Secretarial Practice (S.P.). One lecturer told me that some colleges force a combination of coursework onto students in order to protect a staffing pattern, or secure jobs for a certain number of lecturers for math and S.P., each year (M.A. Gupta, personal communication, August 23, 2013). The students themselves confirm this policy. For

example, Malik mentioned that he did not have the option to take math in junior college: “I had to take S.P. I did not get the necessary marks on the SSC exam (70%). Gandhi College did not allow me to take math” (Malik, personal communication, August 25, 2013).

The table below shows the division of students with MLD in the Commerce stream taking Math and S.P. during the 2012-2013 academic year for the colleges in this sample.

Table 19: Junior College enrollment for Math and S.P. (2012-2013 academic year)

Junior College	Number of LD students in Math	Number of LD students in S.P.
Gandhi – 11 th std.	2	19
Gandhi – 12 th std.	NA ²⁹	NA
Vijaya – 11 th std.	1	4
Vijaya – 12 th std.	1	2
Shri Ram – 11 th std.	17	28
Shri Ram – 12 th std.	7	35
Singh – 11 th std.	1	2
Singh – 12 th std.	NA	NA
Ambedkar – 11 th std.	1	2
Ambedkar – 12 th std.	2	2
Narsee – 11 th std.	0	6
Narsee – 12 th std.	0	31

In the colleges with the greatest number of students with MLD (Gandhi, Shri Ram, and Narsee), the majority of students are enrolled in S.P., as opposed to Math.

Adding to the complexity of this problem, secondary school counselors have advised students with MLD to drop math or take lower-level math as early as possible (sometimes after 7th standard) (A. Kumar, personal communication, November 27, 2012). Yet, college lecturers (both at the junior college and degree college level) recommend that all students take math throughout their academic career, especially since math is required for competitive entrance exams for furthering their post-secondary education (K. Kapoor, personal communication, January 21, 2013). Thus, there is a disconnect between secondary school counselors’ advice and the recommendations and expectation of math lecturers. Mr.

²⁹ NA = not available

Kumar suggests: “Since we cannot change the syllabus, we can change the way we counsel students about math courses, especially secondary school counselors” (A. Kumar, personal communication, November 27, 2012).

The degree college math lecturers interviewed for this study reported that they expect students to have the prerequisite skills and knowledge from having taken math continuously through 12th standard (K. Kapoor, personal communication, January 21, 2013). A degree college math lecturer adamantly reported that students who take Secretarial Practice, then enroll in the Mathematical and Statistical Techniques course are not prepared for it:

These students have a lot of difficulty, especially with word problems. They have difficulty figuring out what is given, what is asked, applying formulas, like with profit percentage.

(M. Bose, personal communication, February 18, 2013)

A lecturer from Shri Ram College, as well as another lecturer from Ambedkar College also reported that any secondary student that drops math is not prepared to take math at the college level (survey, February 18, 2013).

Therefore, what is a seemingly simple choice between Secretarial Practice and mathematics in junior college, is actually quite complex, and may not be a choice at all. Students who have been counseled to drop math or take a lower level math by secondary school counselors might not know all of the ramifications of their “choice.” While current policies and procedures may raise overall math test scores for the junior colleges on the 12th standard government exam and protect jobs for Secretarial Practice lecturers, they enhance marginalization and exclusion for students not enrolled in mathematics, especially if these students aim to enroll in B. Com. (Arnesen, Mietola, Lahelma, 2007). Referring back to my conceptual framework (Figure 18), students, parents, and secondary school counselors must understand the gap of necessary mathematical knowledge, skills, and strategies that will continue to widen if students take lower level math or drop math, and later on, take Secretarial Practice instead of math. Viewing this gap from my overlapping lens of critical pedagogy, when junior colleges force

students into S.P., they are performing a gate-keeping role by excluding certain students from the opportunity to continue math instruction. Also, by offering a non-math substitute, like S.P., the junior colleges are continuing to marginalize students with MLD in the transition. If enrolled in S.P, students with MLD receive no re-teaching in critical mathematical skills during the two years of junior college.

Policies on Accommodations and Support for Learning Disabilities

As with the data from secondary schools, students with MLD may receive provisions, or accommodations, on exams, but they rarely receive accommodations or individualized instruction on a daily basis. Three colleges in my sample offer extra classes, or tutorial classes, once a week. These classes are open to all students, not just students with MLD. At Shri Ram College, during one of the free periods, four lecturers simultaneously offer classes (30 students each) to review a concept (R. Archarya, personal communication, February 11, 2013). At Ambedkar College, tutorials are also offered, but the students are not willing to do extra assignments (L. Ghose, personal communication, February 6, 2013). At Narsee College, all teachers offer extra lectures, which they call remedial classes (H. Borde, personal communication, February 6, 2013). However, none of the college administrators in my sample mentioned changing their teaching methods to cater to students with MLD's learning needs.

Vinod verified this:

The whole system – how it is dealt with when you come to college and are dyslexic – needs to change. I could go to 50 extra classes, but it won't help unless it is catered to my needs and helps to bridge the gaps in my learning. Teachers need to further understand dyslexia and learning disabilities – they need to understand how to teach me so that I can learn – because I did not learn the way they taught me.

(Vinod, personal communication, April 25, 2013)

Additionally, students from the large group interview at Gandhi College said that they would rather understand the math concepts, instead of just studying for a test. They also reported that they need more time to prepare. They would like less exams and be able to show their knowledge through other means, such as assignments and projects (11th standard students at Gandhi College, personal

communication, December 13, 2012). Yet, as Vinod contrasted his experience in post-secondary education in India and in the U.K., he reported that: “The Indian system can’t cater to individuals. The UK has a different system. It caters more towards individual’s needs. There are various methods of assessment” (Vinod, personal communication, April 25, 2013).

In my interactions with lecturers in the colleges, I found that there are only a few lone lecturers that are aware of MLD and really want to advocate for them, such as Mr. Kumar at Ambedkar. Students, like Vinod, did not feel supported by college lecturers. This may be a result of low awareness of learning disabilities among faculty at the post-secondary level. For instance, when asked about the concessions offered for students with LD at Singh college, one of the Science college principals even questioned the authenticity of the LD certificates:

Most students are applying for dyslexia (and other LD certificates) because they get concessions and benefits. We question the authenticity of the government hospital certificate. We question whether or not the student really has a problem or difficulty. Are parents taking advantage of the system?

(V. Jha, personal communication, February 6, 2013)

Another lecturer at Narcee College also wondered how you could tell if the LD certificate was authentic or not: “Some of these dyslexic students (with certificates) don’t have spelling mistakes, but for others, you can make out their mistakes. How do you know if a student really has a difficulty?” (S. Parikh, personal communication, August 23, 2013). Unless lecturers and administrators understand what MLD involves and the way it affects a student’s ability to complete mathematical tasks, the colleges may continue to question the authenticity of learning disabilities, which could affect the overall support they are willing to offer. Students with MLD admitted to feeling frustrated in college because they knew they were behind their peers and had to work extra hard just to keep up and scrape by on the exams (John, personal communication, June 10, 2013). However, the majority of lecturers and administrators in my sample did not express empathy towards students’ difficulties.

According to Mumbai University's Public Relations Office, parents and students come to their office when colleges and universities (outside of this sample) are not giving students the concessions that are legally required. The Public Relations Office gives the college or university in question the government resolution circular (Appendix U), but no one checks on implementation of the LD policies of the 700 colleges and universities registered with Mumbai University (V. Malale, personal communication, July 19, 2013). Therefore, students with LD may have to advocate to even receive the appropriate accommodations.

In colleges that do offer the accommodations, such as extra time on exams, students may feel uncomfortable with the way the colleges are implementing the policies. For example, Vinod felt uncomfortable taking his exam in a separate room in order to have extra time, so he did not disclose his learning disability to the college (personal communication, April 25, 2013). However, Kunal had a positive experience and reported that Shri Ram college was "cooperative, offered special classes, and kept track of our progress" (personal communication, March 13, 2013). Therefore, it is difficult to generalize the post-secondary support experiences for all students with MLD in this sample, since they vary from college to college, and person to person. Also, since students with MLD are a heterogeneous population, students will require various amounts of support.

Summary of the way college math policies and procedures affect students with MLD

Secondary students who do not take grade level math or score below 85% on their 10th standard exam in math, are ineligible to take math in some junior colleges. In a way, these students are forced to take Secretarial Practice as an elective subject. However, math lecturers believe that students who take S.P. are not prepared to take the Mathematical and Statistical Techniques course required for first-year B.Com. Therefore, by viewing this problem through the lens of critical pedagogy, students who follow the Commerce stream in junior college (11th and 12th standard) and drop math, then continue to pursue

Commerce in their Bachelor's degree, will not be prepared; they are seemingly set up for failure by having to take S.P. instead of Math.

Students with MLD are further affected by colleges' procedures on accommodations and supports, with the majority of lecturers unaware of students' instructional needs. Instead, colleges offer "remedial" courses that are open to all students, with no variation of teaching methods or style. While colleges in this sample offered accommodations to students with MLD, such as extra time on exams and calculator use in 11th and 12th standard math, lecturers and administrators were skeptical of the legitimacy of the students' difficulties. However, students, such as Malik, benefitted from Professor Kumar's teaching in degree college. Because Malik felt that Mr. Kumar understood his difficulties, he was not scared to ask for help (personal communication, August 25, 2013).

Therefore, in order to answer my second research question (*How do college math policies and procedures affect students with MLD?*), the data reveal that students with MLD are most affected by colleges' policy on the elective "choice," between math and Secretarial Practice. When students are excluded from math, they lose additional pre-requisite skills that are required for the Mathematical and Statistical Techniques course in B.Com. If students fail this math course, they have to repeat the entire year of first-year B.Com, and many of them experience similar difficulties in accounts and economics later in the coursework (S. Parikh, personal communication, August 23, 2013). In Vinod's case, he lost his entire first year coursework in B.Com because of math, and he decided to switch to a degree in Arts.

Students with MLD are also affected by the overall environment, which varies from college to college, and lecturer to lecturer. Students with MLD reported that they have to work extremely hard to simply pass the Mathematical and Statistical Techniques exam. Some students found individual lecturers that helped them understand the math content, while others had to work on their own, with a private tutor, or with peers.

While collecting this data, I was shocked with the lack of awareness of learning disabilities in some of the colleges. The various administrators had wide-ranging outlooks on the levels of support that colleges should offer. I was also amazed with the lack of transitional planning for students with MLD. From my interviews, I learned that students are not counseled in high school about the implications of dropping math, or taking a lower level math exam. In fact, one of the high school counselors was very interested in the findings of this study, in order to know how to better counsel students about math provisions. Yet, the B.Com math lecturers were very clear about their view that students need pre-requisite skills in mathematics through 12th standard. I was left wondering why colleges were not changing their policies regarding the Secretarial Practice / math elective choice, so that students are more prepared for the Mathematical and Statistical Techniques course. This policy not only affects students with MLD, but also their typically achieving peers. However, since students with MLD enter post-secondary education underprepared in mathematics, the S.P. policy only pushes them further behind, excluding them of math instruction for an additional two years.

CHAPTER 5

DISCUSSION AND RECOMMENDATIONS

Introduction

The Maharashtra Dyslexia Association approached me with a felt need to correct the discrepancy between students with MLD and their typically achieving peers in post-secondary education, specifically in the Bachelor of Commerce degree program. They originally wanted me to create a transition course for students in the Mathematical and Statistical Techniques course; however, I conducted this study as a needs assessment for such a course. My original over-arching research question was: *What math content and goals should be included in a transition course for students with MLD?* However, as a result of this study, I concluded, based on the data about students' knowledge, skills, learning strategies (or lack thereof), and experiences in transitioning, as well as the requirements for the college math courses, that I cannot endorse the idea that solely offering a transition course would help students to bridge the math achievement gap. Conducting a post-secondary transition course for a few weeks or a semester may help some students strengthen their math skills, but the solution to this problem requires more than a quick fix. For instance, it is very difficult to repair foundational deficits in math understanding once the student reaches post-secondary education. Interventions are most effective when they are conducted early in a student's academic career (Dowker, 2005; Nelson & Sheridan, 2011; VanDerHeyden, 2008). Also, in the Indian educational system, students are not rewarded for understanding the math content or for increasing their mathematical literacy. Instead, the goal is to simply pass the exam or pass the course (usually by memorizing). However, I have included recommendations, in this section, for a pilot model course in order to determine if a variation of a transition course is feasible and effective in the Indian context. Due to the above factors, I revised my research questions to: *How prepared are students with MLD to enter post-secondary education?* *How do college math policies and procedures affect students with MLD?*

This study produced three main findings:

1. Students with MLD in this sample do have gaps in their foundational math skills as compared to their typically achieving peers;
2. Students who take Secretarial Practice, instead of math, in junior college instead of math are not prepared to take the Mathematical and Statistical Techniques course in degree college, so that when they enroll for B.Com they are shocked that they have to take a math course, and they typically have to work extremely hard to pass the course; and
3. Students with MLD in this sample revealed that they do want help with math, but many feel scared to ask for help and are judged by peers and lecturers.

Below, I offer implications for practice, policy, and future research for each of these three findings.

Finding: Gap between students with MLD and typically achieving students

In this study, secondary students with MLD had significantly lower scores on a math proficiency screener than typically achieving students. Students with MLD also took significantly more time than typically achieving students to complete the three mathematical assessments. Secondary students with MLD in this sample also reported attending more math tutoring classes than their peers. Many students with MLD also remarked that they had to work very hard to keep up with their peers on regular assignments, classwork, and exams.

Implications for practice

The gap between students with MLD and typically achieving students emerges before they leave secondary school. Therefore, as mentioned by several respondents, primary teachers should identify students with math learning disabilities and difficulties in mathematics in the early stages of learning--- rather than in 8th standard or later, the stage at which most students are currently identified--- so that the gap between these two groups of students does not widen in later years. For students with MLD

and difficulties in mathematics, early intervention is vital. If students progress through the educational system without a strong foundational base, they will continue to form misconceptions about mathematical content and will have difficulty linking new skills with prior knowledge, since they lack pre-requisite skills. If teachers try to bridge the gap between students with MLD and typically achieving students in junior college or degree college, they will have to re-teach many critical component skills before they can move on to the actual math content in the syllabus. Also, if students have been using time-intensive and immature strategies to solve math problems throughout primary and secondary school, it will be very difficult to change their habits in post-secondary education. Therefore, I suggest two implications for practice: math screening tools and additional pre-service and in-service training for teachers.

Math screening tools

In order to provide early intervention to students who need it most, I recommend that schools begin by screening students for early detection of difficulties with number sense and atypically understandings in mathematics at two points. First, teachers, or designated trained personnel, should screen students for number sense in kindergarten (or, in the case of government schools, at the beginning of first grade, when students first enter formal schooling), since children with proficient number sense are likely to have greater achievement in mathematics in the future (Sood & Jitendra, 2007). Although many number sense screeners exist in the U.S., a screening tool must be developed for the Indian setting, perhaps by NCERT. I recommend that the screener be administered individually, since the administrator of the screener must pay attention to the strategies the student is using to obtain his/her answer, in addition to accuracy. Ideally, the screener should be administered by a trained special educator or school counseling psychologist, but classroom teachers could be trained to administer and interpret the screeners as well. One of the most difficult obstacles to implementing this type of screener would be finding the time to complete it for all students during the school day. If this

type of screener is put into practice, and students are screened before they enter school, the results should not be used to deny children admission to the school, in the case of private schools. Instead, the results can be used to place children with poor number sense in targeted intervention activity classes.

Later, teachers or other trained personnel must screen students for atypical understanding of mathematical concepts by the end of fourth standard, since fractions have been introduced by this point. As with the kindergarten / first grade screener, this second screener should be administered individually, paying close attention to the strategies the student uses to determine the answer. This screener could be given only to students with low math achievement, if the school is unable to screen all students. NCERT can develop this screener, tailored to the Indian environment and curriculum, and use it as one informal assessment to determine the need for additional testing for a math learning disability. The results of this screener can also inform special educators or tutors about the math concepts and skills that the child needs to strengthen, either through remedial classes or private classes.

Pre-service and in-service training for teachers

In addition to earlier detection and diagnosis of students with MLD through screening, the finding from my study indicates that MLD students need more remediation as part of their regular primary and secondary math courses, so that they don't fall so far behind their typically achieving peers. In order for such remediation to happen, however, math teachers in formal schools need additional pre-service and in-service training on identifying math difficulties and on strategies for teaching students so they better understand math concepts throughout primary and secondary school. Math remediation that continues to focus on traditional methods of repetition and drill have not been previously effective for students with LD in the U.S. (Bottge, Rueda, Grant, Stephens, & LaRoque, 2010; Levin & Calcagno, 2008; Koski & Levin, 1998). Teachers should have multiple strategies for teaching foundational math skills, such as fractions, geometry, and algebra. Since lecturers surveyed for this study reported that post-secondary students have a phobia about math, primary and secondary teachers must have access

to a curriculum and teaching strategies that not only foster mathematical conceptual understanding, especially of critically component skills, but also help students see math as fun, relevant, and necessary for both daily life and further study. One way to do this is to integrate math into and across other subjects, such as history, language, and science. For example, the most effective math remedial courses at the higher secondary level in the United States have linked basic skill acquisition in mathematics and critical thinking to course content (Koski & Levin, 1998).

In order to improve math classroom instruction, teachers need explicit training in math remediation. I recommend that NCERT offer more professional development for teacher trainers in the universities, as well as for current teachers. Teacher educators and teachers need access to teacher guides that accompany the textbook and outline specific strategies and ways to adapt the curriculum to teaching students with misconceptions and atypical understandings in mathematics, as well as ways to modify the curriculum (Gagnon & Bottge, 2006). In-service training and professional development should include video examples of math remediation (since there are few experts in this area in India) in one-to-one, small group, and large group settings, so teachers can observe methods of math remediation (that address number sense and working memory deficits) and snapshots of engagement with students with MLD, and then practice these remediation techniques (Frey & Knackendoffel, 2012; Brownell, Leko, Kamman, & King, 2008; Halaas Lyster & Wormnaes, 2008). NCERT has the capability to offer math remedial training and modeling through satellite and video conferencing to regional education institutes. They can also upload the videos to their website so that private school teachers can also view them. Later, teachers will need follow-up support for implementation (Morris Deyoe, Newman, & Asaro-Saddler, 2014).

Implications for policy

The gap between the two groups of students in this study indicates that curriculum content and requirements must be responsive to the particular needs of MLD students in both primary and

secondary school. Currently in India, it is truly a one-size fits all system, with only one math class per standard offered. Yet, research studies have shown that students with MLD have slower growth in mathematics than typically achieving peers, especially in adolescence (Cawley & Miller, 1989; Warner et al., 1980; Calhoun et al., 2007; Geary, Hoard, Nugent, & Bailey, 2012). Students with MLD need more curricular options in regard to math instruction so that they have continued practice and review of foundational math skills, as well as access to the grade-level curriculum.

Curriculum boards (SSC and ICSE) should examine the current curricular offerings for secondary mathematics and re-examine their accommodations for students certified with MLD. MLD students currently receive extra time on exams. However, these students take more time to complete math tasks in general. So, they will require a more flexible time frame for completing the same amount of content on the syllabus. The current system is very rigid and does not cater to individual students' needs, perhaps an artifact of an education system that must educate, uniformly, such a huge population.

However, I recognize that the implications of the gap between students with MLD and typically achieving students may be greatly impacted by Parliament's decision to include or omit learning disability in national legislation (Al-Yagon et al., 2013). For instance, the Persons with Disability (PWD) Act, 1995, currently has a 2011 draft amendment pending in Parliament that would add specific learning disabilities to a list of disabilities that are included in The Right of Children to Free and Compulsory Education (RTE) Act, 2009 (Department of School Education and Literacy, 2014; Unni, 2012). If MLD is included in this list of disabilities, then government funds could become available for services that could help close the gap in math performance between students with MLD and typically achieving student. Such services may include pre-service and in-service teacher training for remedial math teaching strategies, including differentiation of the curriculum based on students' needs, as well as for national centers for early detection, intervention, remediation of LD (Al-Yagon et al., 2013; Unni, 2012; Brownell, Leko, Kamman, & King, 2008).

Implications for research

The gap between students with MLD and typically achieving students in this sample leads to research questions about how best to minimize the gap between these students with MLD or for MLD students in other parts of India. Specific research questions that derive directly from this study and from this finding are:

- Does the gap between MLD and typically achieving private, English-speaking school students exist across multiple time samples, or longitudinally?
- Does the gap between MLD and typically achieving private, English-speaking school students uncovered in this study also emerge between MLD and typically achieving students in public, government schools?
- Do national educational legislation changes lead or contribute to narrowing the gap in math knowledge, skills and strategies between MLD and typically achieving students?

Such research, based on the greater numbers of students with MLD in the metropolitan areas, could first begin in New Delhi, Kolkata, or Chennai (MDA, 2014b; Unni, 2012). In these urban areas, there are more assessment centers that certify students as having MLD. Also, the majority of registered special educators live in these cities (Rehabilitation Council of India, 2013). If future studies collect additional information on students with MLD in India, then researchers and practitioners will have a greater knowledge and awareness of patterns of mathematical understanding and qualitative differences of students with MLD, as compared to their typically achieving peers (Lewis, 2011).

Finding: Students who take Secretarial Practice are not prepared to take degree college mathematics

Lecturers in this sample reported that students who take Secretarial Practice instead of math during 11th and 12th standard are not prepared for the required math course for the first year of a

Bachelor's degree in Commerce. Students with MLD that took S.P. in junior college, then opted for B.Com., felt shocked and had to work extremely hard during that first year. Some students pass, but others fail and have to repeat the entire year. Lecturers for the degree college math course assume that students have taken math throughout their academic career and have the pre-requisite skills through 12th standard mathematics.

Implications for practice

Secondary school students with MLD receive little guidance about their post-secondary options (Gregg, 2007; Sparks & Lovett, 2009a). Secondary school teachers and counselors should advise students about the potential repercussions of dropping math. I suggest that secondary school counselors attend professional development workshops, targeting the process of transition to post-secondary options. In this way, counselors would have knowledge of the potential routes students could pursue and the way their choices could impact their future course of study. Counselors could then guide students and parents in the decisions regarding secondary mathematics courses and LD provisions, since educational counseling has been a successful transitional service for students with LD in the U.S. (Kosine, 2007; Aune, 1991).

Students who take Secretarial Practice in place of mathematics in junior college are not prepared for the Mathematical and Statistical Techniques course in the first year of B.Com. Allowing students to take S.P. in place of mathematics is a barrier to degree college mathematics. Therefore, as respondents mentioned, junior colleges ought to examine their procedure of allowing students to opt out of junior college math classes entirely. If students with MLD are already behind their typically achieving peers in secondary school, and they receive less degree college preparation, they will have less math content knowledge and fewer skills to succeed in the Mathematical and Statistical Techniques course. I suggest that the Higher Secondary Certificate (HSC) Board evaluate the junior college practice of forcing students to enroll in S.P. since their 10th standard math scores do not allow them to qualify

for the 11th standard math course. This practice should be re-evaluated so that students who want to take math will have an opportunity to do so. If math and S.P. are truly elective courses, then students cannot be forced into taking one or the other. I suggest that the HSC Board investigate if this practice is widespread in college across Mumbai and Maharashtra, and consider the implications the current practice has on students' transition to B.Com.

In addition, current secondary and post-secondary students need a program now that will repair foundational math skill deficits and prepare them for degree college mathematics.

Pilot course for business math

Based on the findings of this study, I recommend that MDA implement a pilot model course for business math, rather than a remedial transition course for current secondary and post-secondary students with MLD. This "Math for Business" course should be embedded in a realistic context of the way these students will use math in their future careers. The course will motivate students to complete math problems, using fractions and algebra, by applying math to commerce-related situations and multi-media based problems. The goal of this pilot course would be to improve students' foundational math skills required for post-secondary mathematics and their overall perception towards the subject.

This pilot model course can be implemented through a summer program. I suggest that the course be held during the month of May, when students are on school vacation. The course can be held at the MDA center in Parel, or MDA can rent out a classroom at a local college in a central location. Students who have completed 10th standard and plan to enter junior college or the first year of their Bachelor's degree in the next academic year will be eligible to enroll in the pilot course. I suggest that this pilot course enroll 20 students. At least half should be certified as having MLD, while other students may not have a LD certificate, but may be struggling with mathematics. The class should then be split into smaller groups of 3-4 students who form collaborative teams (Bottge et al., 2004). For this pilot

model course, the duration should be at least 20 instructional days (four hours per day) (Bottge et al., 2007).

Since extra effort is required to teach mathematics so that students with MLD can understand, this pilot course will require significant preparation (Bottge et al., 2007). The course should be co-taught by a college math lecturer from the Commerce stream, with strong math ability who also advocates for students with LD, as well as a special educator (Maccini & Gagnon, 2006). The special educator can create and implement learning strategies and accommodations for students with MLD (Gagnon & Bottge, 2006). The course content/curriculum should be written by a Commerce lecturer in mathematics, not a Science lecturer, and should be centered on improving conceptual understanding of mathematics. The lecturer should also consult local businesses to obtain input regarding math skills that are needed in current jobs in the technology-based marketplace. The special educator can contribute skill development and remediation content in the foundational skills of number sense, fractions, algebra, and word problem strategies. (Gagnon & Bottge, 2006).

The content must address students' previous misconceptions, especially in regards to fractions (Bottge & Cho, 2013). I suggest the course be aligned with the six general instructional principles by Fuchs et al. (2013), including: instructional explicitness, instructional design that minimizes learning challenges, strong conceptual basis for procedures, drill and practice, cumulative review, and motivators to regulate attention and behavior. These instructional practices accompanied by technology (a computer-based learning model), will be most effective (Bottge et al., 2010). This course will be based on enhanced anchored instruction (EAI) courses that have been implemented in the U.S., along with a combination of explicit instruction using the CRA method for hands-on application. These courses have greatly improved the problem solving performance of average- and low-achieving students (Bottge & Cho, 2013). All algebra content and word problems will be applied to a business situation. During the course, students will have access to calculators and extra time to complete projects and tests.

The EAI model will have at least two multi-media based problems that students will engage with over the 20-day period. MDA should apply for a grant in order to have necessary funds for the pilot course, including the technology needed for the course (laptops and tablet computers for students to use in small groups) (Evmenova & Behrman, 2012). Also, MDA will need funds to create video-based or multi-media based problems, based on the Indian curriculum and context. MDA will pay the college lecturer and special educator for their services. Depending on the content of the multi-media based problems, MDA may need to purchase raw materials so that students can build models of the problems. MDA can see if corporate sponsors are willing to donate money or materials for course use. MDA can also charge an enrollment fee for students, to encourage daily participation during the vacation period. Parents will ensure their child attends if they have paid for the service.

Making use of MDA's network of adults with LD who are successfully running their own companies, guest speakers can also present ways they are using math in their daily work life throughout the course. If possible, students can visit these businessmen and women at their actual place of work. Collaboration with local business can ensure that this pilot course is embedded in the real world context.

In the Math for Business model pilot course, MDA can help students begin to address misconceptions and improve their critical component skills needed for post-secondary mathematics. Also, by embedding mathematics in a realistic and motivating context catered to their needs, students with MLD may foster an appreciation for math, instead of feelings of anxiety.

Implications for policy

Since students who enroll in S.P. are not prepared for the degree college math course in B.Com, I recommend that the HSC Board evaluate their current policy of not requiring a mathematics course for 11th and 12th standard in the Commerce stream, while it is required in the first year of B. Com. Secretarial Practice is not a satisfactory alternative for the regular mathematics course, since it does not

require any mathematics skill. Also, only one math course per grade level is offered, not allowing for different math levels and abilities. In this study, lecturers repeatedly underscored the importance of practicing math, yet if a student takes S.P. for two years of junior college, they are not practicing math on a daily basis, and perhaps not at all.

Students need additional options for junior college mathematics. I suggest that the HSC Board consider new mathematics courses and syllabi (such as Math for Business) that could be added to the junior college curriculum in Commerce junior colleges to better prepare students for the transition to degree college and for mathematical literacy they will need for life after college. I suggest that a task team from the HSC Board and Mumbai University together examine the issues of junior college and degree college mathematics in the Commerce stream. Perhaps, as a respondent suggested, math could be compulsory in the 11th and 12th and optional after 12th standard.

The HSC must examine their policy, as well as colleges' implementation of the policy, in order to provide more options for students to continue to learn new math skills and maintain their foundational skills in mathematics. If B. Com. students need the pre-requisite skills in math through 12th standard, and the degree college syllabus has been created assuming students have continuously taken math classes, then students who take S.P. are missing two years of skills needed for B. Com. Policy changes by the HSC Board that allow an alternative math course in junior college would support a pilot Math for Business course in 11th and 12th standard.

Implications for research

The finding that students in Mumbai that take S.P. are not prepared to take the Mathematical and Statistical Techniques course in degree college leads to research questions about the preparation of junior college students all over India. Specific research questions that derive directly from this study and from this finding are:

- Does the gap of preparation between students who take S.P. instead of math exist in other junior colleges across Maharashtra?
- How do other states in India prepare students for post-secondary mathematics?
- Does the preparation for post-secondary mathematics differ between students with MLD and typically achieving students in other states?

MDA would also need to conduct further research on the proposed pilot model course, Math for Business. Since the goal of the course is to improve foundational skills in fractions, algebra, and word problem reasoning, as well as overall perceptions towards math, MDA would collect data on students' current levels of performance in these areas. I suggest that students complete a pre-test, or screener, to determine foundational skills, strategies used, and attitude toward mathematics before the course begins. MDA and the Commerce math lecturer would develop this screener, based on pre-requisite skills necessary for the Mathematical and Statistical Techniques course. During the course, MDA can collect additional data based on formative assessment, at the end of each week, as well as through individual and small group (collaborative team) interviews. The course instructors will also maintain reflective journals for each day of the course, noting key teaching and learning strategies, as well as course adjustments and revisions that should be considered for a full-length course.

At the conclusion of the course, students will complete a summative post-test (same assessment used for the pre-test) to assess their use of new skills and strategies, as well as perceptions towards math. In order to gather rich qualitative data about students' strategies and reasoning on individual test questions, I suggest that both the pre-test and post-test be administered individually by the special education co-instructor at the MDA Center in Parel (and later analyzed by both the Commerce lecturer and special educator together).

Specific research questions that the pilot Math for Business course could investigate are:

- Does an enhanced-anchored instruction (EAI)-based course lead or contribute to improved foundational math skills in post-secondary students with MLD in Mumbai (Bottge et al., 2007)?
- What do course instructors identify as key teaching and learning strategies and factors that may have impacted students' performance and perceptions (Bottge et al., 2007)?
- Does the performance on the formative and summative assessment tasks differ for students with MLD and low achievers without MLD in Mumbai?

The findings from the implementation of this pilot course can be presented to the Higher Secondary Certificate (HSC) Board and can inform course design for an alternative 11th and 12th standard course, Math for Business, which could be offered in place of Secretarial Practice.

Finding: Students with MLD want assistance in math, but feel scared and judged

Post-college adults remarked that they felt scared to ask lecturers for help during college. Some of these students overcame their fears during degree college due to strong self-determinations skills, yet others reported feelings of being judged by lecturers and afraid of what their peers might think if they found out the students had learning disabilities. One lecturer even mentioned that students in his college are scared to meet him for extra help during school hours, for fear that their peers might see them and later bully them.

Implications for practice

Students with MLD are scared to approach friends and/or lecturers for help. I suggest that secondary schools and colleges increase awareness of learning disabilities among teachers, lecturers, and college administration to improve understanding of the way MLD impacts students and their learning (Karande, Sholapurwala, & Kulkarni, 2011). Teachers and lectures in Mumbai can attend professional development workshops, developed by the Maharashtra Dyslexia Association, to understand the areas of strengths and struggles for students with MLD. MDA could also train college

lecturers to make their “remedial” or extra classes different from their original lecture, by incorporating specific strategies to cater towards students with MLD (Karande, Sholapurwala, & Kulkarni, 2011). I suggest that at least one lecturer from each college be designated for special training in remedial mathematics.

Also, the general population should better understand learning disabilities, especially students’ peers. I suggest that colleges have special programs, organized around diversity awareness. Learning disabilities could be one of the featured topics. This could be held in conjunction with the United Nations’ (UN) International Day of Persons with Disabilities, every December 3rd. Additionally, students could conduct research on learning disabilities as part of one of their classes, such as English, and then write a report or give an oral presentation based on their findings. In this way, teachers and lecturers can help typically achieving students be more aware of the rationale behind the provisions and accommodations for students with learning disabilities (Karande, Mahajan, & Kulkarni, 2009).

Implications for policy

Students with MLD experience difficulty asking for help. Yet, lecturers and administrators should expect to have students with various needs and abilities in their courses since there is a 3% quota in junior colleges and degree colleges in Maharashtra for learning disabilities and other special needs (Appendix Y, in Marathi, dated June 13, 2001, from the Maharashtra Secondary and Higher Secondary State Education Department education subdirector, to the principals of all junior colleges). I suggest that college administrators consider ways to make their college more inclusive, and their lecturers and student populations more aware of various abilities, including students who have MLD. For example, all colleges should have a “special cell” or program for students with learning disabilities, with an appointed faculty member, to whom students can go to with concerns and questions, and who will serve as an advocate for them. This is currently the situation at Shri Ram college and Gandhi (degree) college, and respondents mentioned that they felt supported by these individuals and programs. I also recommend

that Mumbai University monitor the implementation of the Government of Maharashtra resolution that outlines the accommodations for students with MLD (Appendix U). The government, HSC Board, and Mumbai University should consider exploring the implementation of anti-bullying legislation in schools and colleges.

Implications for research

The finding that students with MLD in Mumbai want help in mathematics, but feel judged and scared leads to research questions about the experiences of students with MLD all over India. Specific research questions that derive directly from this study and from this finding are:

- How are the current provisions for students with MLD across Maharashtra being implemented? For instance, do all students with MLD have to take their exam in a separate room in order to receive extra time?
- Do students with learning disabilities in other parts of India have similar experiences of being scared or bullied?
- How do typically achieving students and college lecturers across India view students with various abilities, including MLD?

More phenomenological case studies across India could delve deeper into understanding why and how students feel judged and scared, and if there are patterns among students' experiences.

Conclusion

Math learning disabilities do not disappear with time, and students with MLD will continue to face difficulties as they enter secondary school and higher secondary education (Mazzocco, Devlin, & McKinney, 2008; Vogel, Fresko, & Wertheim, 2007; Shalev, Manor, & Gross-Tsur, 2005). Students with MLD also need continued practice and review of foundational math skills (Fuchs et al., 2013). This indicates the need for continued instruction of critical component skills and math content in secondary

and post-secondary education. However, the results of this exploratory study suggest that current special education policies and practices in Mumbai are not preparing students with MLD for the math knowledge that they need to succeed in post-secondary mathematics. For instance, students with MLD, once they complete secondary school, are already significantly behind their peers in foundational math skills. This gap will only widen if typically achieving students continue taking math in junior college and students with MLD take Secretarial Practice. Also, students with MLD reported that they feel scared to ask for help from lecturers and peers in college.

In order to help MLD students learn the math knowledge, skills and learning strategies to pass the college math course that typically achieving students have, there are three major systemic changes that can be instituted in the Indian education system so that students are better prepared for secondary and post-secondary mathematics. These systemic changes should include: (1) professional development for primary teachers, (2) multiple math course options in secondary and post-secondary education, and (3) awareness training for teachers and lecturers at the secondary and post-secondary level.

First, primary school teachers should be provided with continued professional development that prepares them to identify students who are struggling with math early on and to use varied teaching methods to help students understand math concepts. Teachers need math screening tools, understanding of multiple strategies to teach conceptual and procedural math skills, and knowledge and experience in math remediation. Since the national government does not yet recognize learning disabilities, this information is not included in the B.Ed. syllabus at this time.

Second, students with MLD need multiple math course options throughout their secondary and post-secondary education. Current curriculum Board policies allow students with MLD to drop math in secondary school (ICSE) or take a lower-level math exam without targeted instruction (SSC). However, secondary students with MLD need continued practice and review of foundational math skills, as well as access to the grade-level curriculum, to be prepared for post-secondary math demands (Strawser and

Miller, 2001). Only one math class per standard, or year, is presently offered. However, students with MLD need more flexibility in math course options, including more time to complete all math tasks. Course options continue to be an issue for students with MLD in junior college. Students with MLD are not prepared for degree college mathematics because junior colleges are performing a gate-keeping role and excluding students, by enforcing an eligibility score for mathematics courses in junior college, based on students' performance on the 10th standard exam. When students are excluded from math in junior college, they lose additional pre-requisite skills that are required for the Mathematical and Statistical Techniques course in B.Com. The Higher Secondary Certificate (HSC) Board should examine the exclusive practices of Mumbai junior colleges and consider offering additional math courses, such as Math for Business, to include students with various math abilities.

Third, secondary school teachers and college lecturers should be aware of learning disabilities as well, since the difficulties students with MLD have in math will not disappear as they transition from primary to secondary and on to post-secondary education. When teachers gain knowledge of learning disabilities and the students' need for accommodations, they may form more positive attitudes towards these students (Karande, Sholapurwala, & Kulkarni, 2011; Saravanabhavan & Saravanabhavan, 2001). In turn, students may find the lecturers more approachable for help.

By making math meaningful, as well as supporting students in foundational skills and basic algebraic concepts, the proposed pilot Math in Business course could give students with MLD more motivation and confidence in mathematics. By addressing conceptual and procedural understanding and previous misconceptions, the pilot course will begin to address the transitional issues that current MLD students face in post-secondary education and mathematics. Other recommendations, such as math screening and professional development for teacher educators and teachers, will contribute to closing the gap in math achievement between students with MLD and typically achieving students in the future. Future students will also benefit from various math course options in junior college, possibly

including a business math course, to maintain basic math skills during the two-year period in which current students drop math altogether.

Finally, much more research needs to be done in the area of MLD and the transition from secondary to post-secondary education in India. Through this study, I have begun to fill in some of the knowledge gap regarding students in Mumbai with MLD and the way policy is impacting their transition to post-secondary education. However, researchers need to find out how students with MLD in other parts of the country or world are coping with the transition to post-secondary education, as well as how the special education policy in other Indian states is affecting students' transition. For instance, policy makers and practitioners in India would benefit from research on other policies and programs that have minimized the gap between students with MLD and typically achieving peers, prepared students with MLD for post-secondary education, and improved the post-secondary experience for students with MLD through faculty awareness training.

Overall, students need math to be competitive in the technology-based job market. Students also need to be math literate in order to keep track of their personal accounts and make sound financial decisions. If the education system allows students with MLD to fall behind early on, and enables them to stay behind by not providing math remediation or courses to fit their learning needs, the Indian education system is doing a great disservice to these students. Also, if students find it difficult to approach lecturers and peers for help, then their journey through post-secondary education can be isolating and frustrating. If we want all students to have equal opportunity to obtain educational qualifications, then the current policies, practices, and procedures for mathematics must be re-examined.

APPENDICES

APPENDIX A

MATH CONTENT ACROSS BOARDS

Table 20: 7th and 8th standard common content across SSC, ICSE, and CBSE Boards

Class VII	Class VIII
Integers Fractions (multiplication and division) Exponents	Rational numbers Cubes and cubed roots Square roots
Algebra Algebraic expressions (1-2 variables) Grouping like terms Addition and subtraction of expressions Word problems	Algebra Multiplication and division of expressions Factorization Word problems Linear equations Quadratic equations
Ratio and proportion Ratio Proportion Fractions, Decimals, Percentages Profit and Loss Simple interest	Ratio and proportion Percentages Profit and loss Overhead expenses Discount Tax Simple and compound interest Time and work Speed, distance, and time Word problems
Geometry Pairs of angles Properties of parallel lines Properties of triangles Symmetry Representing 3D in 2D	Geometry Properties of quadrilaterals, parallelograms, square, triangles, rhombus, circles Representing 3D in 2D Construction of Quadrilaterals Symmetry, reflection, rotation
Measurement Area: square, rectangle, triangle, parallelogram and circle	Measurement Perimeter of a plane figure Area of a trapezium and a polygon Volume: cube, cuboid and cylinder Capacity Surface area of a cube, cuboid, cylinder.
Data handling Mean, median, mode Bar graphs Probability experiments	Data handling /Statistics Bar graphs Pie charts
	Graphs Axes (Same units), Cartesian Plane Plotting points Distance/time graphs

(NCERT, 2011; Das Gupta & Kumar, 2012; Maharashtra State Bureau of Textbook Production and Curriculum Research, 2011, 2012; Mukherjea & Sharma, 2010; Thergaonkar, 2012)

Table 21: 9th and 10th standard common content across SSC³⁰, ICSE, and CBSE Boards

Class IX	Class X
Number Systems Irrational Numbers Real Numbers and their Decimal Expansions Representing Real Numbers on the Number Line Operations on Real Numbers Laws of Exponents for Real Numbers	Algebra Linear equations Graphical and Algebraic Methods of Solution of a Pair of Linear Equations Quadratic equations Solution of a Quadratic Equation by Factorization and Completing the Square Arithmetic Progression (A.P.) Geometric Progression (G.P.)
Algebra / Polynomials Polynomials in One Variable Zeroes of a Polynomial Remainder Theorem Factorization of Polynomials Algebraic Identities Linear Equations Solution of a Linear Equation Graph of a Linear Equation in Two Variables Equations of Lines Parallel to x-axis and y-axis Ratio, proportion and variation	Geometry Triangles (Similarity) Circles Tangent Construction
Geometry Lines and angles Triangles (congruence) Circles Quadrilaterals Theorems (Euclid's, mid-point, Pythagoras) Construction	Coordinate Geometry Distance Formula Section Formula Area of a Triangle
Coordinate Geometry Cartesian System Plotting Coordinate points in a plane Distance formula Section formula Area of a triangle	Trigonometry Trigonometric Ratios Trigonometric Identities Heights and distances
Trigonometry Trigonometric ratios Trigonometric identities	Mensuration Surface area Volume
Mensuration Area of triangle (Heron's Formula) Area of regular hexagon, polygon Area of quadrilaterals Perimeter of triangle and quadrilateral	Statistics and Probability Events Outcomes Normal distribution Measures of central tendency (grouped)

³⁰ Algebra and Geometry, not lower-level General Mathematics

Area of circle	Data) Graphical Representation of Cumulative Frequency Distribution
Statistics and probability Collection of data Classification and tabulation of data Diagrammatic representation of data Graphical representation of data Mean, median, mode of ungrouped data	Proofs Introduction
Proofs Introduction	Mathematical Modeling Introduction
Mathematical Modeling Introduction	

(Aggarwal, 2011, 2012; Aswathanarayana, 2010; Bansal, 2013; Maharashtra State Board of Secondary and Higher Secondary Education, 2012a; NCERT, 2006a, 2006b, 2011)

APPENDIX B

NUMBER OF STUDENTS WITH EXAM MODIFICATION BY BOARD (10TH STANDARD)

SSC: 10th standard

Table 22: Number of **students with LD³¹** in **Maharashtra** for the SSC Board Exam

Maharashtra	Year	Appeared	Passed	Overall passed ³² %
10 th std. SSC	2008	458	427	93%
	2009	517	483	93%
	2010	529	498	94%
	2011	744	678	91%
	2012	825	762	92%
	2013	1,086	937	86%

(Maharashtra State Board of Secondary and Higher Secondary Education (MSBSHSE), Pune, personal communication, July 27, 2012; September 17, 2013)

Table 23: **Total** number of students in **Maharashtra** for the SSC Board Exam

Maharashtra	Year	Appeared	Passed	Overall passed %
10 th std. SSC	2009	1,435,875	1,209,154	84%
	2010	1,439,180	1,203,463	84%
	2011	1,460,947	1,111,241	76%
	2012	1,485,700	1,208,170	81%
	2013	1,499,276	1,251,528	83%

(MSBSHSE, Pune, personal communication, September 17, 2013)

Table 24: Number of students **with LD in Mumbai** for the SSC Board Exam

Mumbai only	Year	Appeared	Passed	Overall passed %
10 th std. SSC	2008	355	351	99%
	2009	408	406	99%
	2010	417	412	99%
	2011	614	601	98%
	2012	676	669	99%
	2013	NA ³³	NA	NA

(Mumbai Divisional Board, MSBSHSE, personal communication, July 18, 2012; January 23, 2013)

³¹ any learning disability: dyslexia, dyscalculia, and dysgraphia

³² Passing is score of 35% or above

³³ NA = not available

Information on students with **only** MLD was not available from the SSC Board. I was also unable to find out how many students took the lower level math exams as an accommodation. The above information only reveals that most students passed the 10th standard exam overall, not the individual subjects.

ICSE: 10th standard

For the ICSE Board, I was only able to obtain the number of students with LD that took the 10th standard ICSE exams, not the number that actually passed the exam, with the exception of 2013.

Table 25: Number of students with LD³⁴ in Maharashtra for the ICSE Board Exam

Maharashtra	Year	Appeared	Passed	Overall passed %
10 th std. ICSE	2008	185	NA	NA
	2009	210	NA	NA
	2010	48	NA	NA
	2011	324	NA	NA
	2012	385	NA	NA
	2013	501	501	100%

(Council for the Indian School Certificate Examinations, personal communication, October 5, 2012; October 9, 2013)

Table 26: Number of students with math LD in Maharashtra for the ICSE Board Exam

Maharashtra	Year	Appeared	Passed	Overall passed %
10 th std. ICSE	2008	93	NA	NA
	2009	130	NA	NA
	2010	27	NA	NA
	2011	228	NA	NA
	2012	307	NA	NA
	2013	406	406	100%

(Council for the Indian School Certificate Examinations, personal communication, October 5, 2012; October 9, 2013)

Table 27: Total number of students in Maharashtra for the ICSE Board Exam

Maharashtra	Year	Appeared	Passed	Overall passed %
10 th std. ICSE	2008	6,851	NA	NA
	2009	7,487	NA	NA
	2010	8,289	NA	NA
	2011	9,602	NA	NA
	2012	10,754	NA	NA
	2013	11,828	11,798	99.7%

(Council for the Indian School Certificate Examinations, personal communication, October 9, 2013)

In 2010, the numbers of learning disabled students decreased sharply as compared to the previous years and the subsequent years. I inquired as to why the numbers for 2010 were so low. Lancelot J. Fuller, a Deputy Secretary, replied in writing that they were “unable to provide...any further information other than what we have furnished vide our letter dated 5 October 2012 as we are not

³⁴ all types

aware of the reason for the query raised” (Council for the Indian School Certificate Examinations (CISCE), personal communication, March 1, 2013).

According to Poonam Sodhi, CISCE Deputy Secretary, the CISCE office does not keep state-specific data on students with learning disabilities since the numbers are so few (personal communication, June 4, 2013). Therefore, the information regarding students with learning disabilities in the last five years was not available. Only the results from the most recent examination (2013) were available.

CBSE: 10th standard

After contacting the National CBSE Board in New Delhi several times by mail, email, and phone, I was finally told that they do not keep record of how many students with LD take their 10th standard exam (personal communication, May 28, 2013). However, when I contacted the regional office in Chennai, I was able to obtain the number of LD students who appeared and passed the CBSE exams for the past three years, but only the previous year for the total number of students.

Table 28: Number of students **with LD** in Maharashtra for the CBSE Board Exam

Maharashtra	Year	Appeared	Overall passed %
10 th std. CBSE	2011	31	100%
	2012	56	100%
	2013	67	98.5%

(S. Rao, personal communication, July 17, 2013)

Table 29: **Total** number of students in Maharashtra for the CBSE Board Exam

Maharashtra	Year	Appeared	Overall passed %
10 th std. CBSE	2013	29,565	99.82%

(V. Santhanam, personal communication, October 31, 2013)

IGCSE: 10th standard

For schools associated with the IGCSE (Cambridge International Examination (CIE)) Board, I was unable to obtain information specifically on students with math learning disabilities since CIE only records the number of requests for access arrangements, such as extra time, readers, word processors, and scribes for students with all disabilities. The following table lists the number of requests for the accommodation or provision of extra time (since this would be the only accommodation for which students with MLD would be eligible) for students in Maharashtra appearing for the IGCSE and A-level exams. The CIE Board reported that they have no internal requirement to record learning disabilities by type, but they had some information on definite cases of MLD and/or dyspraxia (although there may be more cases than are recorded here).

Table 30: Number of students in Maharashtra with disabilities for the IGCSE Board Exam

Maharashtra	Year	Requested extra time	Granted extra time	Definite cases of MLD/dyspraxia
IGCSE and A-levels: CIE	2009	321	310	28
	2010	505	490	30
	2011	252	252	19
	2012	50	48	6
	2013	37	37	NA

(Cambridge International Examination Board, personal communication, April 10, 2013)

APPENDIX C

NUMBER OF STUDENTS WITH EXAM MODIFICATION BY BOARD (12TH STANDARD)

HSC: 12th standard

Table 31: Number of **students with LD in Maharashtra** the HSC Board Exam

Maharashtra	Year	Appeared	Passed	Overall passed %
12 th std. HSC	2008	286	249	87%
	2009	352	320	91%
	2010	460	425	92%
	2011	537	469	87%
	2012	554	487	88%
	2013	753	658	87%

(MSBSHSE, Pune, personal communication, July 27, 2012; September 17, 2013)

Table 32: **Total** number of students **in Maharashtra** for the HSC Board Exam

Maharashtra	Year	Appeared	Passed	Overall passed %
12 th std. HSC	2009	1,059,261	867,735	82%
	2010	1,146,899	845,801	76%
	2011	1,159,369	859,702	71%
	2012	1,143,135	851,206	74%
	2013	1,088,753	870,430	80%

(MSBSHSE, Pune, personal communication, September 17, 2013)

Table 33: Number of students **with LD in Mumbai** for the HSC Board Exam

Mumbai only	Year	Appeared	Passed	Overall passed %
12 th std. HSC	2008	240	219	91%
	2009	313	290	93%
	2010	404	377	93%
	2011	489	437	89%
	2012	493	445	90%
	2013	NA	NA	NA

(Mumbai Divisional Board, MSBSHSE, personal communication, July 18, 2012; January 23, 2013)

ISC: 12th standard

I was only able to obtain the results for the 12th standard examinations for the most recent year, 2013, from the Council for the Indian School Certificate Examinations (CISCE).

Table 34: Number of students with LD in Maharashtra for the ISC Board Exam

Maharashtra	Year	Appeared	Passed	Overall passed %
12 th std. ISC	2013	28	28	100

(Council for the Indian School Certificate Examinations, personal communication, June 4, 2013)

Out of these 28 students, only 13 opted to study Mathematics at the ISC level. All 13 students passed. Students with learning disabilities are provided with 45 minutes extra time. All students (including those without learning disabilities) are permitted to use a Casio Fx-82 MS Scientific calculator for the ISC examination (P. Sodhi, personal communication, June 4, 2013).

CBSE: 12th standard

Table 35: Number of students **with LD in Maharashtra** for the CBSE Board Exam

Maharashtra	Year	Appeared	Overall passed %
12 th std. CBSE	2011	11	100%
	2012	8	98.5%
	2013	13	98.5%

(S. Rao, personal communication, July 17, 2013)

Table 36: **Total** number of students **in Maharashtra** for the CBSE Board Exam

Maharashtra	Year	Appeared	Overall passed %
12 th std. CBSE	2013	11,117	93.92%

(V. Santhanam, personal communication, October 31, 2013)

APPENDIX D

CURRICULUM / SYLLABI FOR HIGHER SECONDARY EDUCATION IN MATHEMATICS

The following table shows the mathematical proficiency needed for programs of study in degree college, should students opt to take mathematics in junior college (Patton et al., 1997).

Table 37: **HSC Board Math** syllabus for 11th and 12th standard

Math for Science and Art : Mathematics and Statistics	Math for Commerce : Mathematics and Statistics
11th Standard: Part one Measurement of Angles Trigonometric functions Trigonometric functions of compound Angles Factorization Formulae Locus Straight Line (Slope and equation of a line) Circle and Conics Vectors Linear Inequations Determinants Matrices	11th Standard: Part one Sets, Relations and Functions Complex Number Sequences and Series Angle and its measurement Trigonometric Functions Plane Co-ordinate Geometry (Locus) Circle and Conics Equations Determinants Limits Differentiation
11th Standard: Part two Sets, Relations and Functions Logarithms Complex Numbers Sequences & Series Permutations & combinations Mathematical Induction and Binomial Theorem Limits Differentiation Integration Statistics Probability	11th Standard: Part two Logarithms Theory of Attributes Partition Values Measures of Dispersion Moments Skewness and Kurtosis Permutations and Combinations Probability Index Numbers Time Series
12th Standard: Part one Mathematical Logic Matrices Trigonometric functions Pair of straight lines Circle Conics Vectors Three dimensional geometry Line	12th Standard: Part one Mathematical logic Matrices Continuity Differentiation Applications of Derivative Indefinite Integration Definite Integrals

Plane Linear programming problems	
12th Standard: Part two Continuity Differentiation Applications of derivative Integration Applications of definite integral Differential equation Statistics Probability distribution Bernoulli trials and Binomial Distribution	12th Standard: Part two Ratio, Proportion and Partnership Commission, Brokerage and Discount Insurance and Annuity Demography Bivariate Data and Correlation Regression Analysis Introduction Random Variable and Probability Distribution Management Mathematics (Linear programming problems)

(Maharashtra State Board of Secondary and Higher Secondary Education, 2012b, 2012c, 2012d; Chitale et al., 2012a, 2012b)

Table 38: **HSC Board Secretarial Practice** syllabus for 11th and 12th standard

11 th standard	12 th standard
Secretary Joint stock company Machinery monitoring Joint stock Company Structural Organization of a Joint stock company Company Meetings Business Correspondence Secretarial correspondence	Business Finance Sources of Business Finance Role of a Secretary in the Capital Formation Part I Role of a Secretary in the Capital Formation Part II Declaration and payment of dividend Correspondence of company secretary with members, debenture holders and depositors Financial markets

(Maharashtra State Board of Secondary and Higher Secondary Education, 2012b)

Table 39: **ISC Board Math** syllabus for Class XI and XII

Class XI	Class XII
Section A (compulsory) 80%	Section A (compulsory) 80%
Math Reasoning Algebra Complex numbers Quadratic equations Finite and infinite sequences Permutations Combinations Mathematical induction Binomial theorem Properties of Binomial Coefficients Trigonometry Angles and arc lengths Trigonometric functions Compound and multiple angles	Determinants and Matrices Boolean Algebra Conics Parabola Ellipse Hyperbola Inverse Trigonometric Function Calculus Differential calculus Integral calculus Correlation and Regression Probability Complex numbers

Trigonometric Equations Calculus Basic Concepts of Relations and Functions Differential calculus Integral calculus Coordinate geometry Statistics	Differential equations
Section B (choice of B or C) 20 %	Section B (choice of B or C)
Vectors Co-ordinate geometry in 3-Dimensions	Vectors Co-ordinate geometry in 3-Dimensions Probability
Section C (choice of B or C) 20%	Section C (choice of B or C)
Statistics Average Due Date	Discount Annuities Linear Programming Application of derivatives in Commerce and Economics Index numbers and moving averages

(Council for the Indian School Certificate Examinations, 2013b)

NCERT has also developed a syllabus for Class XI and Class XII, which includes the following units:

Table 40: **NCERT** Math syllabus for Class XI and Class XII

Class XI	Class XII
Sets and Functions Sets Relations and Functions Trigonometric Functions	Relations and Functions Relations and Functions Inverse Trigonometric Functions
Algebra Principle of Mathematical Induction Complex Numbers and Quadratic Equations Linear Equations Permutations and Combinations Binomial Theorem Sequence and Series	Algebra Matrices Determinants
Coordinate Geometry Straight Lines Conic Sections Introduction to Three-dimensional Geometry	Calculus Continuity and Differentiability Applications of Derivatives Integrals Applications of Integrals Differential Equations
Calculus Limits and Derivatives	Vectors and Three-dimensional Geometry Vectors Three-dimensional Geometry
Mathematical Reasoning	Linear Programming
Statistics and Probability	Probability
Infinite Series	Proofs

Mathematical Modeling	Mathematical Modeling
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(NCERT, 2006d)

The syllabus for the Mathematics and Statistical Techniques course is as follows:

Table 41: **First year B. Com.** syllabus for Mathematics and Statistical Techniques

Semester one	Semester two
Shares and Mutual Funds Permutation, Combination and Linear Programming Problems Summarization Measures Elementary Probability Theory Decision Theory	Functions, Derivatives and Their Applications Interest and Annuity Bivariate Linear Correlation and Regression Time series and Index Numbers Elementary Probability Distributions; Decision Theory

(Joshi et al., 2011; Welling, Saraph, & Diwanji, 2013; University of Mumbai, 2012; Shri Ram college, personal communication, February 11, 2013)

APPENDIX E

SAMPLE LETTER FOR SECONDARY SCHOOLS

The Principal
School address

Subject: Permission to Conduct Research

Dear Principal,

We would like to inform you of an exciting research study that is being conducted by the Maharashtra Dyslexia Association.

MDA wants to provide secondary students with Math Learning Disability (MLD/Dyscalculia) an opportunity to tackle their difficulties in Math, while they prepare to transition to college by creating a Math Transition course in 2013. MDA is currently gathering reliable and targeted information about what a Math Transition course should look like for students with learning disabilities in Maharashtra as they transition to college. We are comparing the learning profiles of secondary students with Math Learning Disability in Mumbai with an inventory of needed skills to enroll in higher secondary Math courses. We are also comparing the learning profiles of typically achieving secondary students (non-MLD students) with students with MLD to see how wide the gap is between these students.

We need your help in the next phase of our data collection. We are currently in need of **“typically achieving students”** from ICSE and SSC schools (these students **DO NOT** have MLD/Dyscalculia or are **not** suspected to have MLD or any other kind of Learning Disability, including Dyslexia). These students need to be in the 7th- 10th standard. We would need approximately **15 students** from your school to:

- complete a survey (10 minutes)
- take a short math quiz and participate in 2 math activities (total of 20 minutes)
- allow us to see their math notebooks

The parents of these students would be asked to complete a survey (10 minutes). MDA would also like to interview the **Math teachers for std. 7 – 10** (30 minutes) from your school in order to gather information about the instructional practices in secondary Math classes. Potential interview questions can be provided upon request.

Please let us know if your school is interested in participating in this research study. If you have any questions regarding the study, please feel free to contact Mindy Eichhorn at mda@dyslexiaindia.com or [mindyeichhorn@gmail.com](mailto:mindyeychhorn@gmail.com) or call +91-022- 2556 5754.

Looking forward to your continuing support to the cause of Learning Disability.

Sincerely,

Masarrat Khan
CEO

16 August 2012

APPENDIX F

SAMPLE LETTER FOR COLLEGES

Principal
College of Commerce and Economics
Mumbai

Subject: Permission to Conduct Research

Dear Principal,

We would like to inform you of an exciting research study that is being conducted by the Maharashtra Dyslexia Association.

MDA wants to provide secondary students with Math Learning Disability (MLD/Dyscalculia) an opportunity to tackle their difficulties in Math, while they prepare to transition to college by creating a Math Transition course in 2013. MDA is currently gathering reliable and targeted information about what a Math Transition course should look like for students with learning disabilities in Maharashtra as they transition to college. We are comparing the learning profiles of secondary students with Math Learning Disability in Mumbai with an inventory of needed skills to enroll in higher secondary Math courses. We are also comparing the learning profiles of typically achieving secondary students (non-MLD students) with students with MLD to see how wide the gap is between these students.

We need your help in the next phase of our data collection. We are currently in need of **college lecturers in math**.

- We would like to ask that **all** of your math lecturers complete **a survey** (attached).
- Also, we would like to **interview six** of your math lecturers (2 from each stream). Potential interview questions can be provided upon request.
- Mindy would like to **observe** the six math lecturers during one math class each.

We also need **documents** for a document analysis of Indian curricula requirements and college math course syllabi. All of the above information will be used to determine which skills students need in post-secondary math courses.

Please let us know if your school is interested in participating in this research study. If you have any questions regarding the study, please feel free to contact Mindy Eichhorn at [mindyeichhorn@gmail.com](mailto:mindyeychhorn@gmail.com) or call +91-022- 2556 5754.

Looking forward to your continuing support to the cause of Learning Disability.

Sincerely,

Mindy Eichhorn
Consultant

27 November 2012

APPENDIX G

INFORMED CONSENT FORM: STUDENTS

April 2012

Dear Participant,

I am a doctoral candidate at the University of Massachusetts (USA) School of Education. I am asking that you to participate in a research study for my thesis/dissertation. If you are willing to participate in my study, please review the following:

What is this study about?

- The purpose of this research is to gather information about what a math transition course should be like for students as they transition from high school to college. Based on this information, Mindy will make recommendations to the Maharashtra Dyslexia Association for a transition course.
- The information collected will be used for Mindy's dissertation.

What will I be asked to do?

If I volunteer to participate in this study, I understand that:

- I will be asked to complete a **short survey**.
- I give Mindy permission to give me a **short math test** to understand what I already know about math. The test will be given individually (not in a group setting).
- I may also be **interviewed** by Mindy. The questions I will be answering address Mindy's interest in learning more about Indian students' transition from secondary school to college.
- By signing this form, I give Mindy permission to read my **academic files** at the Maharashtra Dyslexia Association (if this applies to you).

What are my rights?

- I am free to participate or not to participate; it is my decision.
- I may stop participating in this study at any time.
- I have the right to review the data / material at any time.

- I can skip any question on the survey, test, or in the interview
- If I feel uncomfortable about any of the questions or tests, I can speak with a psychologist at MDA.
- I can choose to have my parents with me during the survey and interview, or I can request that they be in a separate room.

Will anyone know I am a part of this study?

Mindy will take the following steps so that people will not know you are in this study:

- My name will not be used, nor will I be identified personally, in any way or at any time. My name will be replaced by a fake name.
- If I give my permission, Mindy may record the interviews; but the audio file will be erased and all files will be deleted after collecting the data. All survey data will be destroyed once the dissertation has been completed.

By signing this form, I agree to:

- Complete a survey
- Take a short math test
- Allow Mindy to see my academic files
- Complete an interview (not compulsory)

If you have any questions regarding this study, please contact Mindy Eichhorn at mindyeychhorn@gmail.com or call +91-022- 2556 5754. You may also contact Mindy Eichhorn’s chairperson, Dr. Cristine Smith at cristine@educ.umass.edu.

Participant’s Signature

Participant’s Guardian’s initials (if participant is under 18 years of age)

Date

Date

Researcher’s Signature

Date

APPENDIX H

INFORMED CONSENT FORM: PARENTS (ENGLISH AND MARATHI)

March 2013

Dear Participant,

I am a doctoral candidate at the University of Massachusetts (USA) School of Education. I am asking that you to participate in a research study titled “A discrepancy analysis comparing the learning profiles of secondary students with math learning disabilities in Mumbai, India with an inventory of needed skills to enroll in higher secondary math courses.” If you are willing to participate in my study, please review the following:

I volunteer to participate in this study and understand that:

- The primary purpose of this research is to gather reliable and targeted information about what a math transition course should look like for students as they transition from high school to college. Based on this information, Mindy will make recommendations for the Maharashtra Dyslexia Association transition course design.
- I will be asked to complete a **short survey**. I may also be interviewed by Mindy (interview is not compulsory). The questions I will be answering address Mindy’s interest in learning more about Indian students’ transition from secondary school to college.
- By signing this form, I give Mindy permission to look at my child’s math **notebook**.
- I also give Mindy permission to **administer an informal test** to my child, in order to assess students’ proficiency level in math
- My name (and my child’s name) will not be used, nor will I be identified personally, in any way or at any time. My name will be replaced by a pseudonym.
- If I give my permission, Mindy may record the interviews; the audio file will be erased and all files will be deleted after transcription
- I am free to participate or not to participate; it is my decision.
- I may withdraw from part or all of this study at any time.
- I have the right to discuss this material with Masarrat Khan, head psychologist at MDA. I have the right to receive counseling from MDA should any problem arise.
- I have the right to review material prior to the dissertation due date or other presentation.
- I understand that remarks made in these interviews may be included in Mindy’s Doctoral Dissertation, scholarly articles, and conference presentations.
- Because of the small number of participants, I understand there is some risk that I may be identified as a participant of this study by any quotes used in the dissertation, articles, or presentations.

If you have any questions regarding this study, please contact Mindy Eichhorn at mindyeychhorn@gmail.com or call +91-022- 2556 5754. You may also contact Mindy Eichhorn’s chairperson, Dr. Cristine Smith at cristine@educ.umass.edu.

Participant's Signature

Date

Researcher's Signature

Date

परवानगी पत्रिका

जुलै 2012

प्रिय पालक,

महाराष्ट्र डिस्ट्रिक्टिसय्या असोसिएशन 'गणित अध्ययन अक्षमता' असलेल्या आणि शाळेतून महाविद्यालयात जाणार्या विद्यार्थ्यांवर एक संशोधन करते आहे.

पी या संशोधनात स्वेच्छेने सहभागी होत असून मला खालील गोष्टीची जाणीव आहे :

- पी दिलेली उल्लेखित मिंडीला हायस्कूल मधून महाविद्यालयात जाणार्या विद्यार्थ्यांबाबत जाणून घेण्यास उपयोगी पडतील. यासाठी मला एक संवेक्षण पत्रिका भरावी लागेल अथवा मला मिंडीला एक मुलाखत द्यावी लागेल.
- पी मिंडीला माझ्या पाल्याचे गणित विषयातील प्राविण्य तसेच आजपर्यंत गणितात झालेल्या प्रगतीचे मुख्यमाधान करिण्याकरिता 'Informal Test' करायची परवानगी देते / देतो.
- माझे नाव कुठल्याही परिस्थितीत जाहीर केले जाणार नाही.
- सहभागी होणे अथवा ना होणे पाड्यावर अवलंबून आहे.
- पी कुठल्याही वेळेला या संशोधनातून नाव मागे घेऊ शकते / शकतो.
- माझी परवानगी असल्यास मिंडी आमच्यात होणारे संभाषण नोंद करू शकते मात्र संशोधन संपल्यावर त्या नोंदी पूर्णपणे नष्ट केल्या जातील.
- महाराष्ट्र डिस्ट्रिक्टिसय्या असोसिएशन मधील मुख्य मनोवैज्ञानिक मसूरत खान यांसोबत या संशोधनातील साहित्याबाबत चर्चा करण्याचा मला अधिकार आहे तसेच एखादी समस्या आल्यास महाराष्ट्र डिस्ट्रिक्टिसय्या असोसिएशन मधून मार्गदर्शन अथवा सल्ला घेण्याचा मला अधिकार आहे.
- मला संशोधनातील साहित्याची माहिती करायचा अधिकार आहे.
- या संशोधनात सहभागी झालेल्यांची संख्या कमी असल्यास पाल्याच्या सहभागाचा उल्लेख केला जाऊ शकतो.

इतर प्रश्न असल्यास मिंडी आयकॉनला खालील दुरध्वनी क्रमांकावर संपर्क साधू शकता.

+91 - 022 - 25565754

दिनांक:

पालकांची सही:

APPENDIX I

INFORMED CONSENT FORM: SECONDARY TEACHERS

August 2012

Dear Participant,

I am a doctoral candidate at the University of Massachusetts (USA) School of Education. I am asking that you to participate in a research study titled "A discrepancy analysis comparing the learning profiles of secondary students with math learning disabilities in Mumbai, India with an inventory of needed skills to enroll in higher secondary math courses." If you are willing to participate in my study, please review the following:

I volunteer to participate in this study and understand that:

- The primary purpose of this research is to gather reliable and targeted information about what a math transition course should look like for students as they transition from high school to college. Based on this information, Mindy will make recommendations for the Maharashtra Dyslexia Association transition course design.
- I will be interviewed by Mindy. The questions I will be answering address Mindy's interest in learning more about Indian students' transition from secondary school to college.
- If I give my permission, Mindy may record the interviews; the audio file will be erased and all files will be deleted after transcription.
- My name will not be used, nor will I be identified personally, in any way or at any time. My name will be replaced by a pseudonym.
- I am free to participate or not to participate; it is my decision.
- I may withdraw from part or all of this study at any time.
- I have the right to discuss this material with Masarrat Khan, head psychologist at MDA. I have the right to receive counseling from MDA should any problem arise.
- I have the right to review material prior to the dissertation due date or other presentation.
- I understand that remarks made in these interviews may be included in Mindy's Doctoral Dissertation, scholarly articles, and conference presentations.
- Because of the small number of participants, I understand there is some risk that I may be identified as a participant of this study by any quotes used in the dissertation, articles, or presentations.

If you have any questions regarding this study, please contact Mindy Eichhorn at mindyeichhorn@gmail.com or call +91-022- 2556 5754. You may also contact Mindy Eichhorn's chairperson, Dr. Cristine Smith at cristine@educ.umass.edu.

Participant's Signature

Date

Researcher's Signature

Date

APPENDIX J

INFORMED CONSENT FORM: COLLEGE LECTURERS

November 2012

Dear Participant,

I am a doctoral candidate at the University of Massachusetts (USA) School of Education. I am asking that you to participate in a research study titled “A discrepancy analysis comparing the learning profiles of secondary students with math learning disabilities in Mumbai, India with an inventory of needed skills to enroll in higher secondary math courses.” If you are willing to participate in my study, please review the following:

I volunteer to participate in this study and understand that:

- The primary purpose of this research is to gather reliable and targeted information about what a math transition course should look like for students as they transition from high school to college. Based on this information, Mindy will make recommendations for the Maharashtra Dyslexia Association transition course design.
- I will be asked to complete a **survey**. The questions I will be answering address Mindy’s interest in learning more about Indian students’ transition from secondary school to college.
- I may be **interviewed** by Mindy (not compulsory). The interview questions will help Mindy obtain more in-depth information, following the survey.
- If I give my permission, Mindy may record the interviews; the audio file will be erased and all files will be deleted after transcription.
- If I am interviewed, Mindy would also come to one of my math classes and **observe** my teaching. The purpose of the observation is to gather information about what is expected of students in college classes. Observation is not compulsory.
- My name will not be used, nor will I be identified personally, in any way or at any time. My name will be replaced by a pseudonym.
- I am free to participate or not to participate; it is my decision.
- I may withdraw from part or all of this study at any time.
- I have the right to discuss this material with Masarrat Khan, head psychologist at MDA. I have the right to receive counseling from MDA should any problem arise.
- I have the right to review material prior to the dissertation due date or other presentation.
- I understand that remarks made in these interviews may be included in Mindy’s Doctoral Dissertation, scholarly articles, and conference presentations.
- Because of the small number of participants, I understand there is some risk that I may be identified as a participant of this study by any quotes used in the dissertation, articles, or presentations.

If you have any questions regarding this study, please contact Mindy Eichhorn at mindyeichhorn@gmail.com or call +91-022- 2556 5754. You may also contact Mindy Eichhorn's chairperson, Dr. Cristine Smith at cristine@educ.umass.edu.

Participant's Signature

Date

Researcher's Signature

Date

APPENDIX K

INFORMED CONSENT FORM: POST-COLLEGE ADULTS

December 2012

Dear Participant,

I am a doctoral candidate at the University of Massachusetts (USA) School of Education. I am asking that you to participate in a research study for my thesis/dissertation. If you are willing to participate in my study, please review the following:

What is this study about?

- The purpose of this research is to gather information about what a math transition course should be like for students as they transition from high school to college. Based on this information, Mindy will make recommendations to the Maharashtra Dyslexia Association for a transition course.
- The information collected will be used for Mindy's dissertation.

What will I be asked to do?

If I volunteer to participate in this study, I understand that:

- I will be **interviewed** by Mindy. The questions I will be answering address Mindy's interest in learning more about Indian students' transition from secondary school to college.

What are my rights?

- I am free to participate or not to participate; it is my decision.
- I may stop participating in this study at any time.
- I have the right to review the data / material at any time.
- I can skip any question in the interview.
- If I feel uncomfortable about any of the questions or tests, I can speak with a psychologist at MDA.

Will anyone know I am a part of this study?

Mindy will take the following steps so that people will not know you are in this study:

- My name will not be used, nor will I be identified personally, in any way or at any time. My name will be replaced by a fake name.
- If I give my permission, Mindy may record the interviews; but the audio file will be erased and all files will be deleted after collecting the data. All survey data will be destroyed once the dissertation has been completed.

By signing this form, I agree to:

- Complete an interview, either in a group setting or individually.

If you have any questions regarding this study, please contact Mindy Eichhorn at [mindyeichhorn@gmail.com](mailto:mindyeychhorn@gmail.com) or call +91-022- 2556 5754. You may also contact Mindy Eichhorn’s chairperson, Dr. Cristine Smith at cristine@educ.umass.edu.

Participant’s Signature

Date

Researcher’s Signature

Date

APPENDIX L
MATH SCREENER

Name: _____

Date: _____

Please complete the following problems. Read each one carefully. Take as much time as you need. Show your work.

$$\begin{array}{r} 1. \quad 399 \\ + \quad 53 \\ \hline \end{array}$$

$$\begin{array}{r} 2. \quad 727 \\ - \quad 548 \\ \hline \end{array}$$

3. Look at the number 6,085. Change the order of the figures around to make the biggest number possible.

4. Write the missing number on the line:

$$27 + 27 + 27 + 27 + 27 = 27 \times \underline{\quad}.$$

$$\begin{array}{r} 5. \quad 35 \\ \times 16 \\ \hline \end{array}$$

$$6. \quad 4 \overline{)56}$$

$$7. \quad 12 \overline{)372}$$

$$8. \quad 8.6 + 5.42 = \underline{\hspace{2cm}}$$

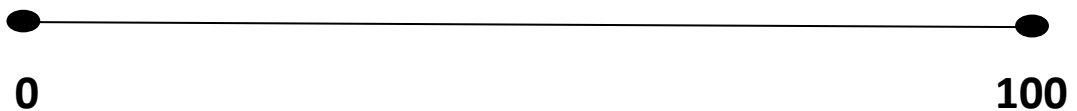
$$9. \quad \frac{4}{7} - \frac{2}{7} = \underline{\hspace{2cm}}$$

$$10. \quad \frac{1}{2} + \frac{1}{3} = \underline{\hspace{2cm}}$$

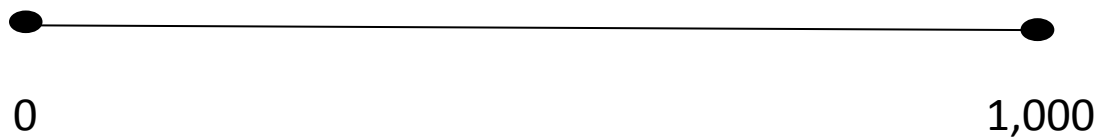
11. A bottle filled with oil weighs 2.56 kg. The empty bottle weighs 0.69 kg. What is the weight of the oil in the bottle?

12. There are 7 girls in the class. x girls join in. So, now the total number of girls is _____.

13. Make a large dot to show where **38** should appear on this number line:



14. Make a large dot to show where **783** should appear on this number line:

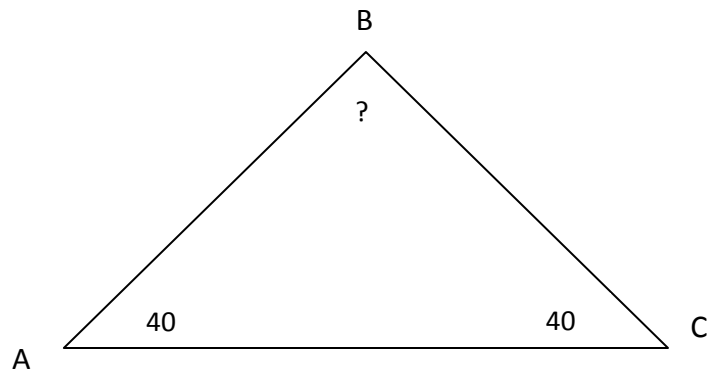


15. The perimeter of a rectangle is 360 cm. If its length is 100 cm, find its breadth.

16. A woman earns Rs. 18,000 in 5 months. How much does she earn in 7 months?

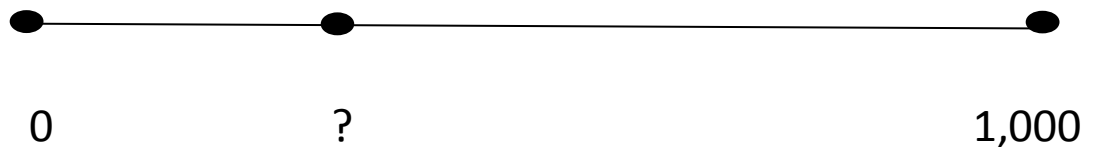
17. If two metres of fabric costs Rs. 175, how much does three metres of the same fabric cost?

18. What is angle ABC? _____



19. Round 4,283 to the nearest 100. _____

20. What could this number be?



21. Put the fractions on the number line:

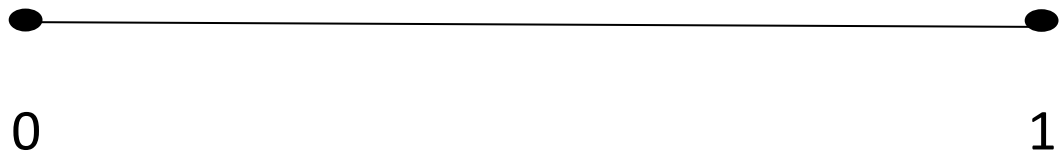
$$\frac{1}{2}$$

$$\frac{2}{3}$$

$$\frac{3}{4}$$

$$\frac{1}{3}$$

$$\frac{1}{4}$$



APPENDIX M

SURVEY FOR SECONDARY STUDENTS

1. What is your age?

2. What is your date of birth?

3. In which grade/standard are you currently studying?

4. Which school do you attend?

5. What board is your school a part of?

6. What languages do you speak (please tick **all** that apply)?

Hindi Marathi English Urdu Other: _____

7. What is the language of instruction at your school?

8. What was the last math class you passed?

9. What was your last percentage in math?

10. How long do you spend on math homework per week?

11. When you take a math test / exam, which of the following concessions do you use (please tick all that apply):

extra time calculator test questions are read to me

graph paper is provided math subject dropped

other (list): _____

12. Do you attend tuition class for math? If so, how many hours per week?

13. Do you want to go to college (11th and 12th standard)? **Why or why not?**

14. Which math skills can you perform well?

15. Which math skills are difficult for you?

16. Have you ever repeated a class/standard? **If so, which class (es)?**

APPENDIX N

SURVEY FOR PARENTS / GUARDIANS

1. What is your relationship to the student?

Mother Father Other: _____

2. What languages do you speak (please tick **all** that apply)?

Hindi Marathi English Urdu Other: _____

3. What language do you use **the most** at home with your child (ren)?

Hindi Marathi English Urdu Other: _____

4. What is the highest level of education completed by the child's **father**?

Secondary completed (10th) Higher secondary completed (12th)
 Graduation Post-graduation Other: _____

5. What is the highest level of education completed by the child's **mother**?

Secondary completed (10th) Higher secondary completed (12th)
 Graduation Post-graduation Other: _____

6. What was the child's weight at birth?

7. What is the child's age **and** date of birth?

8. How many people are living in your household?

9. Describe your family:

Nuclear

Extended (grandparents)

Joint

10. Which members of your family work outside of the home?

11. What is the name of the neighborhood / area in which you live?

12. Do you have a computer at home? Tick one box.

Yes

No

13. About how many days has your child been absent from school in the past one year?
Please list reasons.

14. What **percentage** of your household income goes towards educational expenses (school fees, tuition fees, outside services, etc.) for your children?

15. Has your child ever repeated a class/standard? If so, which class(es)?

16. When your child takes a math test / exam, which of the following concessions does he/she use (please tick all that apply):

extra time

calculator

test questions are read aloud

graph paper is provided

math subject dropped

other (list): _____

पालकांसाठी सर्वेक्षण पत्रिका

1. विद्यार्थ्यांशी तुमचे नाते काय आहे?

आई

वडील

अन्य

2. तुम्हाला कोण-कोणत्या भाषा बोलता घेतात?

3. पाल्याशी कुठल्या भाषेत संवाद सादला जातो?

4. आई - वडीलांचे शिक्षण काय?

5. जन्माच्या वेळी पाल्याचे वजन किती होते?

6. पाल्याचे वय आणि जन्मतारीख काय आहे?

7. घरात किती माणसे राहातात? त्यांचे विद्यार्थ्यांशी नाते काय आहे?

क्रमांक	नातं

8. घरातील कुठल्या व्यक्त रोजगारासाठी घराबाहेर पडतात?

9. तुम्ही कुठल्या परिसरात राहाता?

10.तुमच्या घरात संगणक आहे का?

हो नाही

11.गेल्या एक वर्षात तुमचे पाल्य शाळेत किती दिवस गिरहजर होते? कारणे सांगा

12.तुमच्या उत्पन्नातील किती टक्के उत्पन्न तुम्ही पाल्यच्या शिक्षणावर खर्च करता?
(शाळेची फी, शिकवणी फी इत्यादी)

13.तुमचे पाल्य एखादया इयत्तेत अथवा वर्षात नापास झाले आहे का?

14.गणिताचा पेपर देताना, परीक्षेच्या वेळेस तुमच्या घात्याला खालील पैकी कुठल्या सुविधा मिळतात?

- अतिरिक्त वेळ
- कॅलकुलेटर
- प्रश्न वाचून दाखवली जाणे
- आलेखाचा कागद उपलब्ध असणे
- दहावीच्या परीक्षेच्या वेळेस इयत्ता सातवीचे गणित सोडवणे
- वा व्यतिरिक्त अजून काही

APPENDIX O

INTERVIEW QUESTIONS FOR SECONDARY SCHOOL STUDENTS WITH MLD

1. What class do you attend at MDA?
2. About how many days have you been absent from school in the past one year? Reasons?
3. What stream are you interested in for college?
4. Which colleges are you considering applying for admission?
5. Tell me about a typical day in your current math class.
6. What are you good at in math? What do you like about math?
7. In which math skills do you need to become stronger?
8. How do you get help when you have difficulty in math?
9. What are some questions that you want to ask your teacher about the current math topic?
10. What do you do when you have a math exam coming up? How do you study?
11. During a math test, do you have any accommodations / concessions? (extra time, test read aloud, etc.). Which concessions help you the most?
12. What do you want to learn about math in the future?
13. Tell me about your future goals.
14. Have you thought about college? If so, what do you think about it?
15. How do you feel about college?
16. Suppose your friend is considering whether or not to go to college. What would you tell him/her?
17. What skills do you think someone needs in order to be successful (enroll and pass) in college?
18. Do you tell others that you have a math LD? If so, what do you tell them?
19. What else would you like to share about math?

APPENDIX P

INTERVIEW QUESTIONS FOR SECONDARY SCHOOL TEACHERS

1. Do you feel that secondary students are prepared to enter college when they leave your classroom?
2. Overall, what skills do they have when they leave, and what skills do students need to improve on?
3. What are the minimum criteria to pass (actual test score, etc.)?
4. What math skills do students need in order to pass?
5. How many students are enrolled in your class?
6. On a typical day, how many students come to class?
7. Tell me about a typical day in your math class.
8. What methods of math instruction do you use in your class on a weekly basis?
 - a. Lecture
 - b. Group work
 - c. Solving sums during class
 - d. Other, list here: _____
9. Do you give homework following your class? If so, how much do you give per week?
10. Do you allow students to use calculators in your class? Why or why not?

APPENDIX Q

SURVEY FOR COLLEGE LECTURERS

1. Which classes do you teach (include level)?

2. For how long have you been teaching at the college level?

3. Do you feel that secondary students are prepared to enter college?

Yes

No

4. Why or why not?

5. Overall, what skills do students have?

6. What skills do students need to improve on?

7. How many students are enrolled in your class?

8. On a typical day, how many students come to class?

9. What are the minimum criteria to pass in your college (actual test score, etc.)?

10. What methods of math instruction do you use in your class on a weekly basis (please tick all that apply)?

- Lecture Group work Solving sums during class
- Other, list here: _____

11. Do you give homework following your class?

- Yes No

12. If so, how much do you give per week?

13. What is your opinion about students' success:

- The student is responsible for his/her own success
- The college supports students in their academic success

14. Explain your choice above

15. Please rank the following math skills as low (L), medium (M), or high (H) – depending on which skills are most important in your field of study:

- | | | | |
|----------------|---|---|---|
| • Algebra | L | M | H |
| • Geometry | L | M | H |
| • Statistics | L | M | H |
| • Trigonometry | L | M | H |
| • Calculus | L | M | H |

16. Please rank the following cognitive skills as low (L), medium (M), or high (H) – depending on which skills are most important in your field of study:

- | | | | |
|-------------------------------|---|---|---|
| • analytical skills | L | M | H |
| • interpretation | L | M | H |
| • precision and accuracy | L | M | H |
| • problem solving | L | M | H |
| • reasoning | L | M | H |
| • time management | L | M | H |
| • strategic study skills | L | M | H |
| • persistence | L | M | H |
| • ability to use study groups | L | M | H |

17. Do you allow students to use calculators in your class?

Yes

No

18. Why or why not?

APPENDIX R

INTERVIEW QUESTIONS FOR COLLEGE LECTURERS

1. Tell me about the requirements (prerequisites) for all incoming students in regards to math at your college.
2. Approximately how many students are enrolled in math vs. secretarial practice at your college?
3. Do you feel that students are prepared to enter college? Overall, what skills do they have, and what skills do students need to improve on?
4. Tell me about a typical day in your math class.
5. What math skills do students need in order to pass?
6. What are your institution's vision and mission statements? What are your objectives for students enrolled in your math courses? (What should students be able to know and do when they complete your math course?)
7. What is your opinion about students' success? Is the student responsible for his/her own success or should the college support students in their academic success?
8. Tell me about specific programs that your college offers to students (Levin & Calcagno, 2008).

9. Tell me about the “special cell” for LD students at your college.

10. Tell me about what you know of learning disabilities.

11. How would you feel if a student with a learning disability enrolled in your class?

12. What concessions could you offer to a student with LD in your course?

13. Have you had students with LD in your course previously?

14. What else would you like to share about college math courses?

15. What are your standards for college readiness (Educational Policy Improvement Center, 2011)?

APPENDIX S

OBSERVATION PROTOCOL: COLLEGES

Location:

Date:

Time:

Descriptive notes	Reflective notes
General classroom set-up Number of students present:	
Interaction between lecturer and students	
Pre-requisite knowledge needed to understand this lecture Vocabulary:	
Skills needed during this class (i.e. note-taking, memorized formulas, etc.)	
Would anything about this setting be distracting if I were a student with MLD?	
Other notes	

APPENDIX T

INTERVIEW QUESTIONS FOR POST-COLLEGE ADULTS

1. Where do you stay?
2. What degree have you completed?
3. Which college did you attend?
4. Which stream were you in?
5. What math class did you take in junior college?
6. Tell me about your junior college math class. What was a typical day like?
7. Which degree college did you attend?
8. What did you study? Which course?
9. What math class did you take in degree college?
10. What were/are you good at in math? What did/do you like about math?
11. In which math skills do you need to become stronger?
12. How did/do you get help when you have difficulty in math in junior college? In degree college?
13. What do you did/do when you have a math exam coming up? How did/do you study?
14. During a math test, did/do you have any accommodations / concessions? (extra time, test read aloud, etc.). Which concessions help(ed) you the most?
15. What do you want to learn about math in the future?
16. Tell me about your future goals.
17. How do you feel about your overall college experience?
18. Suppose your friend is considering whether or not to go to college. What would you tell him/her?
19. What skills do you think someone needs in order to be successful (enroll and pass) in college?

20. Do you tell others that you have a math LD? If so, what do you tell them?

21. What else would you like to share about math?

APPENDIX U

MAHARASHTRA GOVERNMENT RESOLUTION REGARDING LEARNING DISABILITIES

Government and Government Aided / Professional & Non Professional Non Agricultural, Universities Colleges/Technical Institute Training College etc. Learning Disabled Students Facilities GIVEN

Govt. of Maharashtra,
Higher & Technical Educational Department,
Circular No. 2004/86/04-4,
Mantralaya Annexure Bhavan, Mumbai-32.
Dated : 7th August, 2004.

1. Govt. Resolution Education SSC 1099/15199 Ed. – 2
Date 28/Nov/2000
2. Govt. Resolution School Education Dept. Miscellaneous 1021/(1501)/Pr. Ed-5
Date 13th /Nov/ 2001
3. Govt. Circular School Education Dept. Miscellaneous 1021/(1501)/Pr Ed.-5, Date 23/
Sep./2003.

Intorduction : As per the reference Govt. Resolutions different facilities are given to Learning Disabled students till std. XII Schools. It was also in view of taking into the mainstream of colleges/ Engineering (degree/post) Learning Disabled students giving them (Teachers Education, Science etc) facilities was a proposal being considered by the Govt.

GOVT. Resolution : A decision has been taken to given facilities to Learning Disabled students from Govt. & Non Govt./Professional Non Agricultural Universities/Colleges/ Engineering/Technical Institute Teachers College etc. as follows. Accordingly all relevant are informed that LEARNING DISABLED students who have Dyslexia, Dysgraphia and Dyscalculia are included and such students will be given the following facilities/concessions.

Facilities for Learning Disabled Students :

1. L.D. students oral exams should be taken by relevant subject teachers at unit tests and term exams. These marks should be noted down and at the end of the year take an average. On this average promotion of the std. will be decided.
2. At the time of written exam all L.D. students should have permission to use a writer. Also these students should get half an hour more than the fixed time for each exams.
3. L.D. students should get the exam centre near to their house.
4. These students should be given concession for not attempting the question of drawing figures, maps, draft etc. where necessary in the written exams. These questions/sub question mark should be converted in the facility provided.
5. They will have the permission to bring certificates from relevant Institutions authorized for work experience, Technical subjects (practical).
6. L.D. students who have failed gats 20 grace marks to pass the exam. These marks will be given for one subject or more subject.
7. Sandents with Dyslexia and Dusgraphia will be given permission to choose work experience subjects instead of the total optional language (only one language) or (only one subject)
8. Concession will be given for spelling mistake or maths number(b/d-3/5)
9. In the final exam for one hour paper 25% more i.e. (15 mins) and for two hours or more maximum of 30 mins. Additional time will be given.

Official Work Procedure Followed By Officer For L.D. Students.

1. Each academic year a meeting with college professors/directors/ principals in the area of authority to provide them with information regarding the facilities/concession for L.D. students. For the meeting if possible call people post at M.D.A.
2. As per Govt./Govt. Recognized Medical Officers certificates to be provided to L.D. students their Learning Disability.
3. Once such certificate is provided to the colleges they should not again and again ask for these certificate.
4. Those students with L.D. while giving exams their list should be provided with their certificates of Disability be relevant colleges and directorates.
5. Syllabus should be provided to students and their parents by the authorized people (universities/exam boards).
6. Utmost care should be taken that L.D. students are not deprived of these facilities and concession given to them by the Govt.
7. Responsibility should be taken by all Non Agricultural Universities. Chancellors for Higher and Technical Education Dept.

In the name and order of Govt. of Maharashtra

(V.G. Dalvi)
Sect. Maharashtra Govt.

APPENDIX V

ERROR ANALYSIS OF STUDENTS WITH MLD

Table 42: Analysis of students' responses (with MLD; n = 63)

Item	Correct answer	Percentage of students with MLD with correct answer	Most common incorrect answer (type of error) (number of students)	Other answers
$399 + 53$	452	94%	None (arithmetic/fact errors)	462, 1.452, 652, 442, 552
$727 - 548$	179	62%	1275 (switch – signs) (6)	189, 279, 479, 289, 331, 181, 171, 262, 139, 478, 170, 239, 221
Re-arrange the digits	8,650	75%	8,065 (conceptual) (4)	DNA ³⁵ ; 8,605; 8,560; 8,075; 8,506; 6,085,000; 6,850
$27 + 27 + 27 + 27 + 27 = 27 \times \underline{\quad}$	5	59%	27 (conceptual) (8)	135, 4, DNA, 162, 28, 3543, 25, 27 ⁴ , 113, 27 ⁵
35×16	560	82.5%	60 (2)	830, 70, 37.360, 565, 500, 550, 410, 330, 400, 540
$56 \div 4$	14	90%	13 (arithmetic/fact errors)	DNA, 95, 11, 104
$372 \div 12$	31	89%	DNA (3)	2, 210.10, 29.2, 24, unfinished with 2 in the tens place
$8.6 + 5.42$	14.02	38%	13.48 (visual spatial / monitoring) (10)	6.28, 1.402, 3,22, 12.02, 0.1402, 14.2, 1402, 0.628, 14.12, 62.8, 16.102, 13.102, 3.18, 628, 12.02, DNA
$\frac{4}{7} - \frac{2}{7}$	$\frac{2}{7}$	52%	2 (conceptual) (14)	$\frac{2}{0}$, DNA, 1, 6, 67, -14, 14, $\frac{5}{3}$, 1428
$\frac{1}{2} + \frac{1}{3}$	$\frac{5}{6}$	24%	$\frac{2}{5}$ (procedural and conceptual) (27)	$\frac{1}{5}$, DNA, $\frac{2}{6}$, $\frac{1}{3}$, $\frac{2}{3}$, $\frac{6}{6}$, 5, 6, 42, $\frac{4}{3}$, $1\frac{1}{3}$
Subtraction word problem	1.87 kg	52%	3.25 (procedural) (6)	0.87, DNA, 1.7664, 1.9, 2.56, 1.97, 2.92, 1.31, 1.85, 2.13, 8.13, 1.37, 3.45, 1.86

³⁵ DNA = did not attempt

Introductory algebraic word problem	$7 + x$	17%	DNA (19); 7x (procedural) (19)	8, 7, 17, 10, 49, 80
Number line: 0-100	38	19%		
Number line: 0-1,000	783	14%		
Perimeter word problem (breadth)	80 cm	16%	260 (procedural) (20)	DNA, 460, 3.6, 3600, 36000, 200, $400, \frac{18}{5}, 100, \frac{5}{9}, \frac{360}{200}, \frac{36}{10}, \frac{360}{50}, \frac{360}{10}, 36, 120, 50, 13, 130,$
Proportional word problem	Rs. 25,200	24%	DNA (11); 126,000 (procedural) (11)	22,000; 63,000; 100,000; 2,900; 16,200; 7,200; 24,500; 90,007; $\frac{18000}{31}$; 630,000; 125,000; 66,000; 226,500; 14,300; 22,000; 24,200; $\frac{18000}{5}$; 36,000; 3,600; 21,000; 84,000; 124,000; 35,000
Proportional word problem	Rs. 262.5	24%	DNA (13) 525 (procedural) (8)	87.5, 178, 172, 340, 2625, 255.5, 261, 244.5, 185, 256, 210, 105, 555, 242.115, 260, 350, 227.5, 200, 262.2, 264.2
Angles in a triangle	100	44%	40 (procedural) (12) 80 (procedural) (10)	DNA, 10, 120, 90, 180, 1600, 280
Round 4,283 to the nearest hundred	4,300	11%	DNA (41)	4,183; 430; 2,348; 4.283; 4,083; 83; 428,300; 42.83; 4,324; 238; 293; 4,200
Number sense: 0-1,000	Between 250 and 300	25%		
Number sense: benchmark fractions	$\frac{1}{4}, \frac{1}{3}, \frac{1}{2}, \frac{2}{3}, \frac{3}{4}$	0%	Conceptual (50)	

APPENDIX W

ERROR ANALYSIS OF STUDENTS WITHOUT MLD

Table 43: Analysis of students' responses (typically achieving; n = 62)

Item	Correct answer	Percentage of typically achieving students with correct answer	Most common incorrect answer and type of error	Other answers
399 + 53	452	98%	346 (switch-sign) (1)	
727 – 548	179	87%	1,275 (switch-sign) (2) 169 (arithmetic/facts) (2) 189 (arithmetic/facts) (2)	279, 178
Re-arrange the digits	8,650	100%	None	
27 + 27 + 27 +27 +27 = 27 x _____	5	84%	4 (visual spatial / monitoring) (5)	27 ⁴ , 135, 27, DNA
35 x 16	560	84%	245 (procedural) (2) 550 (procedural) (2)	530, 525, 570, 860, 565
56 ÷ 4	14	97%	9 (arithmetic/facts) (1) 16 (arithmetic/facts) (1)	
372 ÷ 12	31	95%	DNA (1) 11 (arithmetic/facts) (1) 211 (procedural) (1)	
8.6 + 5.42	14.02	92%	13.02 (arithmetic/facts) (2)	14.2, 15.02, 13.48
$\frac{4}{7} - \frac{2}{7}$	$\frac{2}{7}$	97%	2 (conceptual) (1) $\frac{8}{7}$ (procedural) (1)	
$\frac{1}{2} + \frac{1}{3}$	$\frac{5}{6}$	92%	$\frac{2}{6}$ (procedural) (2)	$\frac{1}{3}, \frac{2}{5}, \frac{1}{5}$
Subtraction word problem	1.87 kg	92%	3.24 (procedural) (2)	1.88, 1.97, 1.60
Introductory algebraic word problem	7 + x	90%	7x (procedural) (5)	7-x
Number line: 0-100	38	31%		
Number line: 0-1,000	783	24%		
Perimeter word problem	80 cm	79%	160 (procedural) (5)	260, 130, 3.5, $\frac{18}{5}$
Proportional word problem	Rs. 25,200	82%	39,200 (arithmetic/facts) (2)	25,300; 32,000; 514.28; DNA; 26,800; 252,300; 36,000; 23,800; 2,520
Proportional word problem	Rs. 262.5	81%	DNA (3) 253.5 (arithmetic/fact) (2)	252.5; 262.3; 2,625; 26.25; 188; 2,512.5
Angles in a triangle	100	92%	None	90, 40, 120, 80

Round the number to the nearest hundred	4,300	56%	DNA (14)	42.83; 4,238; 4,383; 2,348; 3,842; 4,000; 4.28; 4,28; 428; 43
Number sense: 0-1,000	Between 250 and 300	61%		
Number sense: benchmark fractions	$\frac{1}{4}, \frac{1}{3}, \frac{1}{2}, \frac{2}{3}, \frac{3}{4}$	1%	visual spatial / monitoring (43)	

APPENDIX X

DESCRIPTION OF STATISTICAL ANALYSIS

Screeener scores

While comparing the screener scores of the two groups of students, I first analyzed the diagnostic statistics for their performance on the math screener. Next, I looked at the screener score results for both groups of students in a histogram in order to see if I had a normal, or near normal, distribution. The skewness for all of the screener scores is -0.437. Since the skewness is less than -0.5, the scores are approximately symmetric overall. However, the distribution for typically achieving students is moderately skewed (between -1 and -0.5; the skewness for typically achieving students is -0.699 whereas the skewness for students with MLD is -0.111), as shown in the histograms (Figures 20 and 21 below).

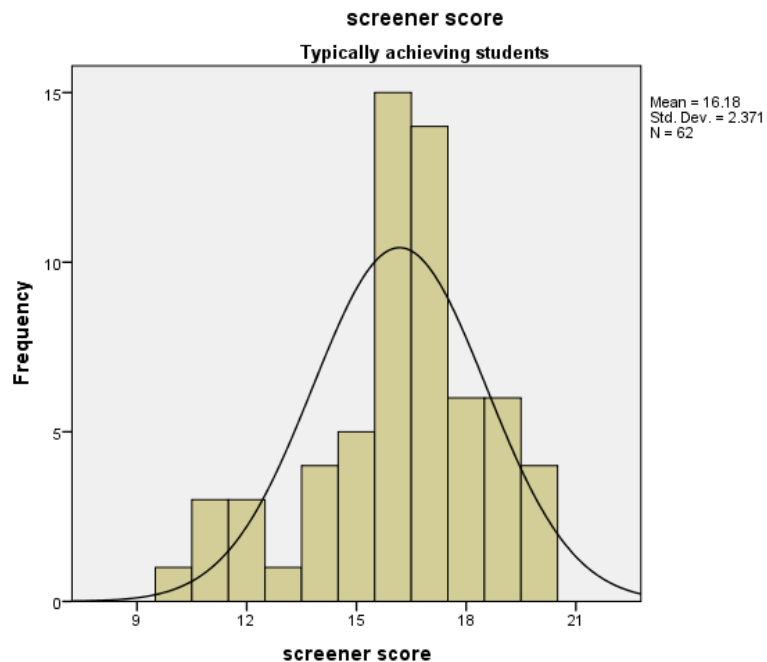


Figure 22: Histogram of typically achieving students' screener scores (n = 62)

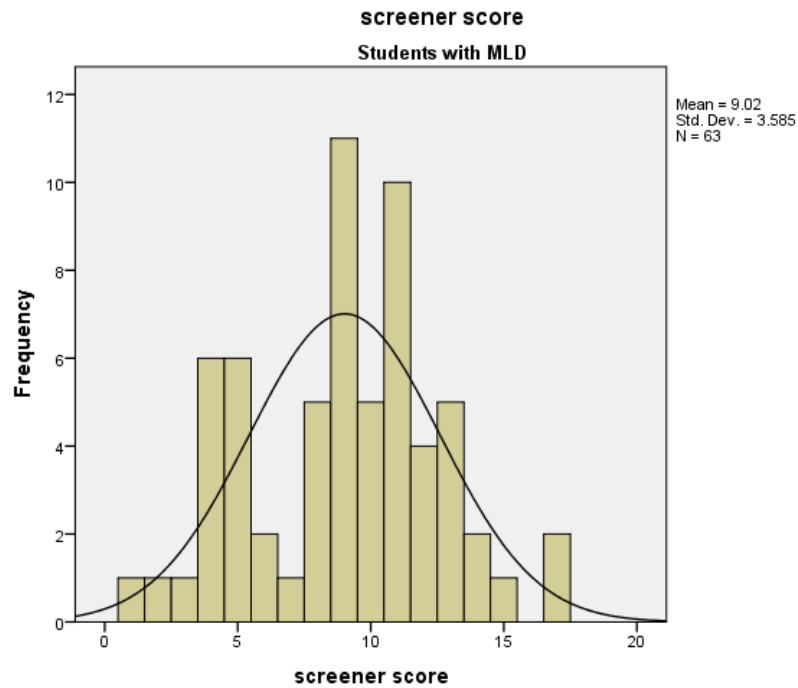


Figure 23: Histogram of screener scores for students with MLD (n = 63)

These results violate the normality assumption for an independent samples t-test. Therefore, in order to analyze my data, I did not want to make any assumptions about the distribution in my data. Because the screener score distributions were moderately skewed (between -1 and -0.5) for typically achieving students, I needed to do transform my data or conduct a non-parametric test. A transformation, such as natural log or square root, would yield results that not easy to interpret. However, a non-parametric test (such as the Mann-Whitney U test) does not rely on the data belonging to a particular distribution; it is a distribution-free test and the results are easy to interpret. In the end, I decided that the non-parametric test was preferable because my results are in the original scale (score, or number correct) and are easier to interpret.

In order to conduct a Mann-Whitney U-test, I made sure I met the four assumptions. First, I have one dependent variable, which in this case, is continuous (screener score). Second, I have one independent variable that consists of two, independent and categorical groups, such

as students with MLD and typically achieving students. Third, I have independence of observations, which means that each participant is in one of the two groups, but not in both of the groups. Fourth, the distribution for the scores for each group has the same shape, which means that the Mann-Whitney U-test will be used to determine whether there are difference in the medians of the two groups. Once I ran the analysis, I found that the difference between the two groups was significant ($U = 199.5$, $Z = -8.688$, $p < 0.001$).

Time on screeners

As with the screener score results, I first analyzed the diagnostic statistics for their time on the math screener. Then, I looked at the screener time results for each group of students in a histogram (figures 23 and 24 below) in order to see if I had a normal, or near normal, distribution. The skewness for all of the screener scores is 1.993. This distribution is highly skewed. When I separately the two groups, the skewness for typically achieving students is 0.579 and for students with MLD the skewness is 2.064. The skewness for typically achieving students is moderately skewed, but the skewness for students with MLD is highly skewed. The skewness for both groups is evident in the histograms below, since both have longer right tails.

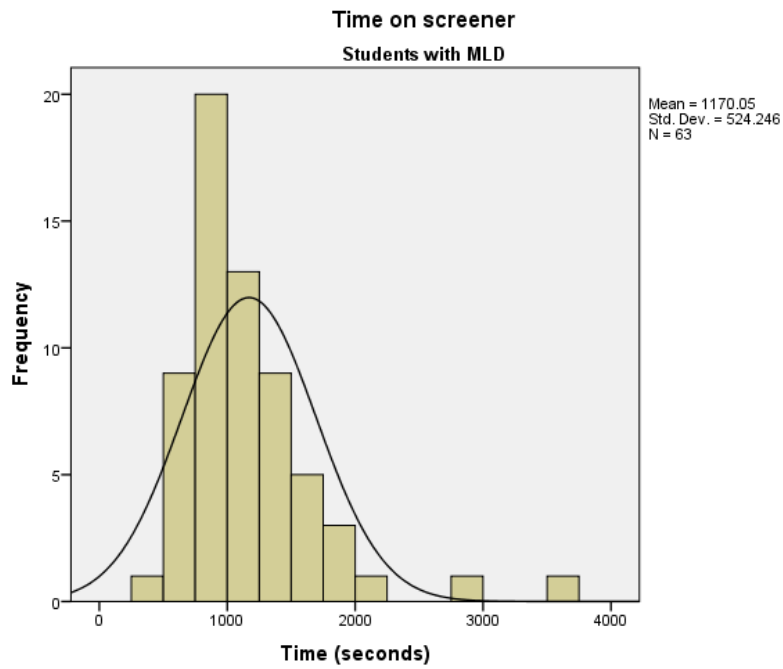


Figure 24: Histogram of time taken to complete screener (students with MLD)

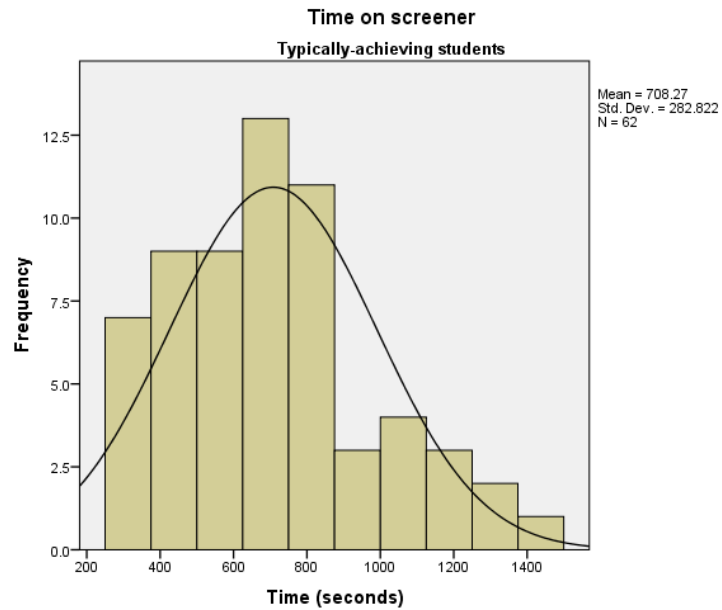


Figure 25: Histogram of time taken to complete screener (typically achieving students)

Because the screener time distributions were highly skewed (more than 1.0 or less than -1.0), I needed to do transform my data or conduct a non-parametric test. In the end, I decided that the non-parametric test was preferable because my results are in the original scale

(seconds) and are easier to interpret. Based on my data, when I conducted the Mann-Whitney U non-parametric test, I found that students with MLD had a higher median (1040.0 seconds, or 17 minutes and 18 seconds) than typically achieving students (702.5 seconds, or 11 minutes and 42 seconds), and the difference of the median time on the screener between the two groups is significant ($U = 751.5$ seconds, $Z = -5.933$, $p < 0.001$).

Time on number sense tasks

I first analyzed the diagnostic statistics for their time on the math screener. Next, I checked for skewness of the time on subitizing and Number Sets tests, and all of the histograms were highly skewed. The distributions for students with MLD, in particular, were highly positively skewed.

Table 44: Skewness for time on subitizing and Number Sets tests

Test	Skewness (MLD)	Skewness (TA)
Subitizing	2.145	1.966
Number Sets 1	2.776	1.333
Number Sets 2	2.828	1.525
Number Sets 3	2.970	0.318
Number Sets 4	2.463	1.032

This was also evident from the histograms for each number sense task. Below, Figures 26 and 27, show the positive skewness visually, for the time on subitizing tasks. The histograms for both groups for the Number Sets tests looked similar, with the tail longer on the right, but I have not included the figures here.

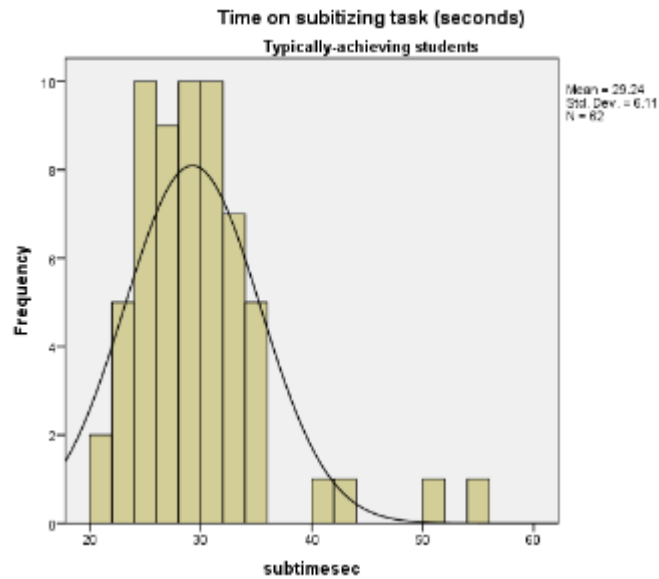


Figure 26: Histogram of time taken to complete subitizing task (typically achieving students)

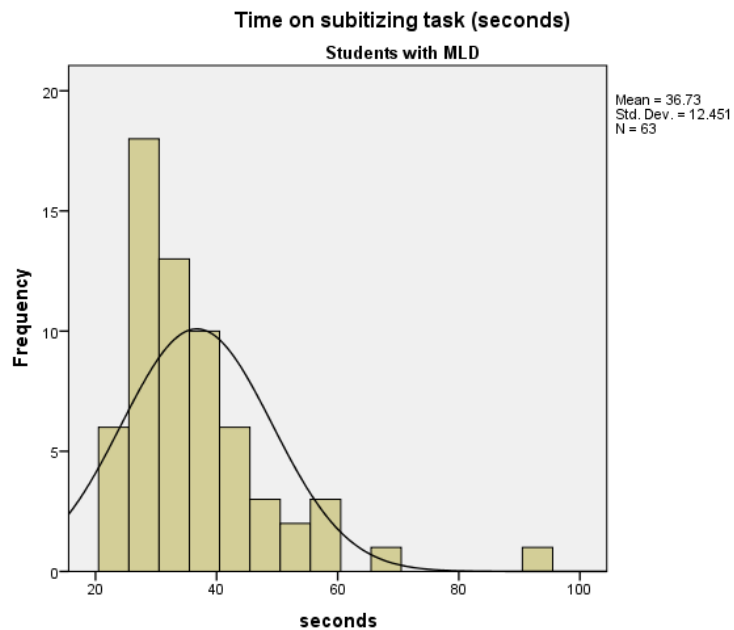


Figure 27: Histogram of time taken to complete subitizing task (students with MLD)

Because my data was not normally distributed, I again violated the assumptions for a t-test.

Therefore, since I had non-normally distributed data, I conducted the Mann-Whitney U test for the subitizing and Number Sets timed tasks. For my sample, I can conclude that students with MLD took significantly longer than typically achieving students on all of the timed

tasks. The results of the Mann-Whitney U tests for the subitizing and Number Sets test are below.

Table 45: Mann-Whitney U test results for subitizing and Number Sets tests

Test	Median (MLD)	Median (TA ³⁶)	U value	Z value	P value
Subitizing	35 sec ³⁷	28 sec	1102.00	-4.209	0.000
Number Sets 1	77 sec	55 sec	624.5	-6.561	0.000
Number Sets 2	64 sec	46 sec	690.00	-6.239	0.000
Number Sets 3	138 sec	102 sec	600.5	-6.679	0.000
Number Sets 4	100 sec	64.5 sec	403.00	-7.655	0.000

Controlling for error

Since all of the time-related questions were grouped in one family, I used the Holm's procedure to control for familywise type-I error, because I was conducting multiple statistical analyses. In this procedure, the alpha level of 0.05 is distributed across all of the time tasks. In total, I have six timed tasks (screener time, subitizing time, and four Number Sets subtests times). Therefore, using the Holm's procedure for my data, I take 0.05 (threshold p value) and divide it by 6. The most significant p value must be 0.0083 in order to be significant, the second most significant p value would have to be 0.01 (0.05÷5). In other words, the adjusted p value for paired comparisons is $\frac{\text{Target p value}}{n}$, then $\frac{\text{Target p value}}{n - 1}$. In the Holm's Sequential Procedure, the p-values should be sorted from smallest to largest, and compared to the smallest to largest revised p-values. However, with my data, all of the p-values were the same. See Table 12, below, for the p-values for each timed task.

Table 46: Significance of time difference using the Holm's Sequential Procedure

Timed item	P-value	Compare to	Decision
Time on screener	0.000	0.05/6 = 0.0083	Significant
Time on subitizing	0.000	0.05/5 = 0.01	Significant
Time on Number Sets (1)	0.000	0.05/4 = 0.0125	Significant
Time on Number Sets (2)	0.000	0.05/3 = 0.0167	Significant

³⁶ TA = typically achieving

³⁷ Sec = seconds

Time on Number Sets (3)	0.000	$0.05/2 = 0.025$	Significant
Time on Number Sets (4)	0.000	$0.05/1 = 0.05$	Significant

Accuracy on Number Sets

I compared the percentages of students with MLD and typically achieving students by conducting a one-sample t-test. I grouped all of the Number Sets questions into one family to control for family-wise type-I error. After conducting the test, I sorted the p-values from smallest to largest, and compared them to the smallest to largest revised p-values. None of the values were significant.

Table 47: Significance of accuracy difference on the Number Sets Tests

Test	MLD (n=63)	TA (n=62)	p value	Holm's p value	Decision
Number Sets 1	71.4%	80.6%	0.038	$0.05/4 = 0.0125$	Not significant
Number Sets 2	69.8%	80.6%	0.046	$0.05/3 = 0.0167$	Not significant
Number Sets 4	66.7%	77.4%	0.047	$0.05/2 = 0.025$	Not significant
Number Sets 3	44.4%	58.1%	0.085	$0.05/1 = 0.05$	Not significant

APPENDIX Y

GOVERNMENT RESOLUTION: QUOTA FOR ADMISSION TO JUNIOR COLLEGE

MAHARASHTRA DYSLLEXIA ASSOCIATION

क्र. २-१३/उमाशि-६.११वी प्रवेश/११७६८ -
मिशन उपस्थालक, बृहन्मुंबई पांचे कापलिय,
जवाहर बालभवन, नेताजी सुभाष मार्ग,
चर्नी रोड (५), मुंबई ४००-०९९.

दिनांक :- १३ जून २००१

Reg 3%
Quota
for admission

प्रति,
प्राचार्य/मुख्याध्यापक,
वरिष्ठ महाविद्यालयाना जोडलेली कनिष्ठ महा.
तसेच माध्यमिक शाळांना जोडलेली उच्च माध्यमिके वर्ग,
२. ए.एन. कनिष्ठ महाविद्यालय,
बृहन्मुंबई.

विषय :- इयत्ता ११वी प्रवेश सन २००१-२००२.

संदर्भ :- १) शासन निर्णय क्र. एचएससी-१०९७/(१६०३/९७)/
उमाशि-१ दि. २५ जून १९९८.
२) शासन निर्णय क्र. एचएससी-१०९७/(१४४८-९७)/उमाशि-१
दि. २६ जून १९९७.
३) शासन पत्र क्र. एचएससी १०९७/(१६०३-९७)/उमाशि-१
दिनांक ४/५/१९९८.
४) या कावनिधाचे परिपत्रक क्र. ए-१३/उमाशि-६.११वी
प्रवेश ९८-९९/२००१ स.३० दि. २६/६/१९९८.
५) शासन निर्णय क्र. एचएससी १०९७/(२४९/९९)/उमाशि-१
दि. २३ जून १९९९.

महोदय/महोदया,
सन १९९७-९८ या शैक्षणिक वर्षापासून इ. ११वी च्या वर्गात प्रवेश देण्यासाठी
अपवादकाच्या कार्यपद्धतीबाबतची वरील संदर्भित शासन निर्णय/शासन पत्र वा
या कावनिधाची परिपत्रके वहावीत.

मा. उच्च न्यायालय, मुंबई यांनी याचिका क्र. ९०२/९८ या संदर्भात
दि. २२/६/९८ रोजी दिलेल्या अंतरिम आदेशाद्वारे दि. ६ मे १९९८ रोजी
शासन निर्णय दि. २६/६/९७ व शासन पत्र दि. ४/४/९८ ला दिलेली स्थिती
उठविली आहे. त्यामुळे सन २००१-२००२ मधील इ. ११वी प्रवेश करणाऱ्या
शासन निर्णय दि. २६/६/९७ नुसार दिलेले आदेश लागू राहतील याची नोंद
घ्यावी. अल्पसंख्य (धार्मिक/भाषिक) संस्थांनी करावयाच्या प्रवेशाबाबत
मा. उच्च न्यायालयाने दिलेल्या आदेशानुसार कार्यवाही करण्याबाबत शासनाने
सुधारित आदेश शासन निर्णय दि. २५/६/९८ नुसार निर्मित केले आहेत त्याचे
काटेकोर पालन करावे. याबाबत मा. उच्च न्यायालयाच्या आदेशाचा अंमल
होणार नाही याची नोंद घ्यावी. तसेच मा. उच्च न्यायालयाच्या सूचना,
सूचना फाळावर प्रदर्शित कराव्यात.

११३०

मा. उच्च न्यायालय, मुंबई यांनी याचिका क्र. १३०१/९८ वर दि. १०/७/९८ रोजी दिलेल्या अंतर्गम आदेशानुसार संस्थेची माध्यमिक शाळा असल्यास इ. ११वी प्रवेशासाठी त्यांना २०% जागा आपल्या संस्थेच्या माध्यमिक शाळेतील विद्यार्थ्यांना देता येतील. याप्रमाणे कार्यवाही करणे आवश्यक आहे. शासन निर्णय दि. २३ जून १९९९ नुसार इ. ११वीच्या प्रवेशाकरिता शासन निर्णय दि. २६ जून १९९७ मध्ये नमूद करण्यात आलेल्या अर्जा या प्रकारात अध्ययन अक्षमता [डिस्लेक्सिया, डिस्कॅल्कुलीय, डिस्ग्राफीया, स्पॅटीक] असलेल्या विद्यार्थ्यांचा विशेषीत समावेश करण्यात आलेला आहे. शासन निर्णय दि. २७/४/२००१ नुसार अर्जा मुलांना प्रवेशासाठी उपलब्ध असलेल्या किमान ३% जागा राखीव ठेवण्यात याव्यात. प्रवेश देण्याच्या अंकरच्या दिवसापर्यंत प्रवेश घेवू इच्छिणा-या अर्जा मुलांना प्रवेश दिल्यानंतर ३% आरक्षणपेढी जागा रिक्त राहिल्यातर त्या ३% अर्जा मुलांना प्रवेश देण्यात यावा. याप्रमाणे कार्यवाही करण्यात यावी.

पुढील धनिष्ठ महाविद्यालयाच्या प्राचार्यांनी आपल्या कनिष्ठ महा-विद्यालयाच्या ज्ञान/विज्ञान/वाणिज्य शाळेसाठी यापूर्वी निश्चित करून दिलेली प्रवेश क्षमता तुम्हाच्या संस्थेत दुरुल नसल्यास तीच निश्चित संध्याची व ह्या प्रसंगात सर्वनिहाय राखीव जागा भरवाव्यात.

सोळा इ. ११वी प्रवेशाचे देनासकत व सर्वनिहाय माहिती सादर करावयाचा तक्ता जोडला आहे. या प्रमाणे हयत्ता ११वी प्रवेशाबाबत कार्यवाही करावी.

सर्वनिहाय माहिती दि. ५ जून २००१ रोजी समक्ष वास दुताकरवी तात्कात्रिने इस्तबटवडयाने या कार्यालयास सादर करावी.

आपला स्नेहाब्धित
M. S. ...
 शिक्षण उपसंचालक
 बृहन्मुंबई,

पुणे: गिःसल निरीक्त उत्तर/दक्षिण/पश्चिम मुंबई-७१/७/६० यांना माहिती व आवश्यक कार्यवाहीसाठी.

APPENDIX Z

CURRICULUM MAP: MATHEMATICAL AND STATISTICAL TECHNIQUES COURSE

Table 48: Degree college: First Year B. Com., Semester one (Welling, Saraph, & Diwanji, 2013)

Topic	Syllabus / skill	Prerequisite skills / Foundation/ Vocabulary
Mathematics	Shares	Vocab: capital, share, face value, market value, dividend, equity shares, preferential shares, bonus shares Computation Skills: Formula: total dividend = Word problems:
	Mutual Funds	Vocab: Computation Skills: calculation of net income after considering entry load, dividend, change in Net Asset Value (N.A.V.) and exit load; averaging of price under the Systematic Investment Plan (S.I.P.) Formula: Word problems:
	Permutation and Combination	Vocab: factorial, permutation, combination as selection Computation Skills: factorials and factorial notation Formula: ${}^n C_r$ and ${}^n P_r$ Word problems:
	Linear Programming Problem	Vocab: linear equation, linear inequalities, linear expression, feasible region, variables, constraints, coordinates, maximization, minimization Computation Skills: Formula: $Ax + By + C = 0$ (linear equation) Word problems: Visual spatial skills: sketching of graphs of linear equations and linear inequalities
Statistics	Measures of Central Tendencies	Vocab: average, mean, median, mode, grouped and ungrouped data, quartiles, deciles, percentiles, Ogive, Histogram, combined and weighted mean, continuous variate, continuous distribution, interpolation formula Computation Skills: Formula: $\bar{x} = \frac{\sum x}{n}$ (arithmetic mean); $\bar{x}_w = \frac{\sum wx}{\sum w}$ (weighted arithmetic mean); $\text{Median} = l_1 + \frac{(l_2 - l_1) \left[\frac{N}{2} - cf \right]}{f}$ (and similar variations for quartiles, deciles, percentiles) $\text{Mode} = l_1 + \frac{(l_2 - l_1)(f_1 - f_0)}{(f_1 - f_0) + (f_1 - f_2)}$ Word problems: Visual spatial skills: graph/draw the cumulative frequency curve (less and more than); graphing mode using a histogram
	Measures of	Vocab: dispersion (measures of variation), range, coefficient of range,

Dispersions	<p>quartile deviation or Q.D. (semi-inter-quartile range), mean deviation or M.D. (mean absolute deviation), mean, median, mode, standard deviation, variance, combined variance, coefficient of variation</p> <p>Computation Skills: Formula: range = maximum – minimum; coefficient of range = $\frac{\text{maximum}-\text{minimum}}{\text{maximum}+\text{minimum}}$ Coefficient of Q.D. = $\frac{Q_3-Q_1}{Q_3+Q_1}$</p> $\sum_{i=1}^n f_i$ $\sigma = \sqrt{\frac{n_1(\sigma_1^2 + d_1^2) + n_2(\sigma_2^2 + d_2^2)}{n_1 + n_2}} \text{ (standard deviation)}$ $\sigma = \sqrt{\frac{\sum_{i=1}^n x_i^2}{n} - \bar{x}_2}$ <p>Coefficient of variance (C.V.) = $\frac{\text{standard deviation}}{\text{mean}} \times 100$</p> <p>Word problems: Symbols: σ, Σ</p>
Probability Theory	<p>Vocab: random experiment/trial, sample space, discrete sample space, algebra of events, mutually exclusive and exhaustive events, complimentary events, probability, addition theorem, conditional probability, independence of events, laws of probability, venn diagrams, multiplication theorem</p> <p>Computation Skills: factorials</p> <p>Formula: $P(A \cap B) = P(A)P(B)$ (independence of events, simultaneous occurrence); $A \cup B$ (exhaustive events; either/both); $P(A) = \frac{n(A)}{n(S)} = \frac{m}{n}$ (probability of event A)</p> <p>Word problems: Symbols: \subset (subset), \emptyset (null set)</p>
Random Variable / Probability Distribution	<p>Vocab: Probability distribution of a discrete random variable; expectation and variance of random variable</p> <p>Computation Skills: Formula: $\sum_{i=1}^n P_i = 1$ (probability distribution of random variable x) $E(x) = \text{arithmetic mean of } x = \sum_{i=1}^n x_i P_i$</p> <p>Word problems:</p>
Decision Theory	<p>Vocab: decision making situation, states of nature, pay-off and pay-off matrix, uncertainty, maximin, maximas, minimax regret and laplace criteria, optimum decision, decision making under risk, expected monetary value (EMV or expected pay-off), decision tree, expected opportunity loss (EOL)</p> <p>Computation Skills: Formula: Word problems: Visual representations: decision trees</p>

Table 49: Degree college: First Year B. Com., Semester two (Joshi et al., 2011)

Topic	Syllabus / skill	Prerequisite skills / Foundation/ Vocabulary
Functions	Concept of real function Demand, supply, Revenue	Vocab: constants, variables (independent, dependent), domain, algebraic functions (constant, linear, polynomial), exponential functions, logarithmic function, demand function, law of demand, law of supply, break-even point (equilibrium point), equilibrium price, cost function, revenue function, profit function Computation Skills: Formula: $f(x) = c$ (constant function) $F(x) = ax + b$ (linear function) $D = f(p)$ (demand function) $S = g(p)$ (supply function) $C = f(x)$ (total cost function) $R = pD$ (total revenue function) or $R = p^3 + 2p^2 - 5p$ $P = R - C$ Visual/spatial skills: graphs of above functions, demand curve, supply curve Word problems:
Derivatives and Applications	Derivative as a rate measure Derivatives of functions Rules of derivatives Second Order Derivatives Applications	Vocab: derivative, differentiable (derivable), log, marginal functions, elasticity, inelastic, perfectly elastic, maximum, minimum, extreme values of a function, scalar multiplication, sum, difference, product, quotient, simple problems, marginal cost, marginal revenue, elasticity of demand, Computation Skills: Formula: $y = f(x)$ or $\frac{dy}{dx}$ Derivatives of standard functions (Constant function, x^n , e^x , a^x , $\log x$ Rules of differentiation MD (marginal demand) = $\frac{dD}{dp}$ MS (marginal supply) = $\frac{dS}{dp}$ MR (marginal revenue) = $\frac{dR}{dD}$ MC (marginal cost) = $\frac{dC}{dx}$ Price of elasticity of demand (η) $\eta = -\frac{p}{D} \cdot \frac{dD}{dp}$ Word problems:
Interest – Simple and Compound	Interest compounded more than once a year - calculations involving up to 4 time periods EMI Annuity Immediate and due	Vocab: principal (P), interest (I), amount (A), rate of interest, simple and compound interest, Equated Monthly Installments (EMI), present value, future value, annuity immediate and due Computation Skills: Formula: simple interest $I = P\left(\frac{r}{100}\right)n$; $A = P + I$ Compound interest Amount $A = P\left(1 + \frac{r}{100}\right)^n$; $I = A - P$ Word problems:

<p>Annuity and EMI</p>	<p>Equated monthly installments</p>	<p>Vocab: annuity, annual, quarter, duration, indefinite, perpetuities, contingent, ordinary, sinking funds, reciprocal, principal, amortization table, interest on reducing balance, flat interest rate, accumulated value, present value</p> <p>Computation Skills:</p> <p>Formula: Future value (for 5 years): $A = R(1 + \frac{r}{100})^4 + R(1 + \frac{r}{100})^3 + \dots + R$</p> <p>Annual payments in installments:</p> $A = R \left[\frac{\left(1 + \frac{r}{k(100)}\right)^{kn} - 1}{\frac{r}{k(100)}} \right]$ <p>Present value: $P = R \left[\frac{1 - \left(1 + \frac{r}{k(100)}\right)^{-kn}}{\frac{r}{k(100)}} \right]$</p> $\left(1 + \frac{r}{100}\right)^{-n} = \frac{1}{\left(1 + \frac{r}{100}\right)^n}$ $\text{EMI } R = \frac{P \cdot \frac{r}{1200}}{\left[1 - \left(1 + \frac{r}{1200}\right)^{-12n}\right]}$ <p>Accumulated value: $A' = R \left(1 + \frac{r}{100}\right)^n \left[\frac{\left(1 + \frac{r}{100}\right)^n - 1}{\frac{r}{100}} \right]$</p> <p>Present value: $P' = \frac{R \left(1 + \frac{r}{100}\right)}{\frac{r}{100}} \left[1 - \left(1 + \frac{r}{100}\right)^{-n} \right]$</p> <p>Word problems:</p>
<p>Bivariate Linear Correlation</p>		<p>Vocab: correlation (positive and negative; direct or inverse), ordered pairs, ungrouped data, un-correlated, covariance, product-moment correlation coefficient, rank correlation, repeated rank, corrected rank</p> <p>Computation Skills:</p> <p>Formula:</p> <p>variance = $V(x) = \frac{\sum (x_i - \bar{x})^2}{N}$</p> <p>covariance = $\text{Cov}(x, y) = V(x) = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{n}$</p> <p>covariance (x, y) = mean of the product – product of the means</p> <p>Karl Pearson coefficient of correlation $r = \frac{\text{Cov}(x,y)}{\delta_x \delta_y}$</p> $r = \frac{\text{mean of the product} - \text{product of the means}}{\sqrt{\text{mean of the squares} - \text{square of the mean}}}$ <p>Spearman's Coefficient of Correlation</p> $R = 1 - \frac{6 \sum d^2}{n^3 - n}$ <p>modified Spearman's coefficient of correlation for repeated ranks</p> $R = 1 - \frac{6 \left[\sum d^2 + \frac{1}{12} \sum (m^3 - m) \right]}{n^3 - n}$ <p>Visual spatial skills: scatter diagram</p> <p>Word problems:</p>
<p>Bivariate</p>		<p>Vocab: regression (linear, non-linear), line of regression, regression</p>

<p>Linear Regression</p>		<p>coefficient, standard form, slope of a line Computation Skills: calculator use permitted Formula: line of regression = $y = mx + c$ regression coefficient of y on x $b_{xy} = \frac{cov(x,y)}{V(x)} = \frac{cov(x,y)}{\sigma_x^2} = \frac{\frac{\sum xy}{n} - \bar{x}\bar{y}}{\frac{\sum x^2}{n} - \bar{x}^2}$ product of regression coefficients $b_{yx} \cdot b_{xy} = \left[\frac{cov(x,y)}{\sigma_x \sigma_y} \right]^2 = r^2$ arithmetic mean variance standard deviation covariance coefficient of correlation coefficient of regression lines of regression slope of a line $ax + by + c = 0$ analyze and identify regression lines Word problems: visual spatial skills: slope of a line</p>
<p>Time Series</p>		<p>Vocab: time series, trend, variations (seasonal, cyclical, irregular), quarterly and grand averages Computation Skills: Formula: Measurement of trend values: Moving average Least square method = $\Sigma y = na + b\Sigma x$; $\Sigma xy = a\Sigma x + b\Sigma x^2$ Visual spatial skills: reading graphs</p>
<p>Index Number</p>		<p>Vocab: index numbers (classification: price index, quantity index, value index, business activity index), simple aggregative index number, simple average of relatives, weighted index numbers, cost of living index number (aggregate expenditure method and family budget method), consumer price index number, wholesale price index number, income, inflation, deflation, percentage (increase or decrease) Computation Skills: Formula: $P_{01} = \frac{\text{current value of the variables}}{\text{Base period of the variables}} \times 100 = \frac{P_1}{P_0} \times 100$ weighted aggregative index number = $P_{01} = \frac{\Sigma p_1 w}{\Sigma p_0 w} \times 100$ weighted average of relatives index number = $P_{01} = \frac{\Sigma \left(\frac{P_1}{P_0} \right) w}{\Sigma w} \times 100$ Laspeyre's formula for weighted index number</p>

		$P_{01} (L) = \frac{\sum p_1 q_0}{\sum p_0 q_0} \times 100$ <p>Paasche's formula for weighted index number</p> $P_{01} (P) = \frac{\sum p_1 q_1}{\sum p_0 q_1} \times 100$ <p>Fisher's formula for weighted index number</p> $P_{01} (F) = \sqrt{P_{01} (L) \cdot P_{01} (P)}$ $\text{Real income} = \frac{\text{income for that particular year}}{\text{price index number for the same year}}$ <p>Word problems:</p>
Decision Theory		<p>Vocab: events, states of nature, acts, payoff, payoff table, decision making environments (certain, uncertain: maximax, maximin, minimax regret, Laplace criterions), expected monetary value (EMV), expected opportunity loss (EOL), corresponding to maximum EMV, minimum expected cost, roll back technique</p> <p>Computation Skills:</p> <p>Formula:</p> <p>Visual spatial skills: matrices, payoff tables and opportunity loss table, decision tree</p> <p>Word problems:</p>

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