BRIDGES IN MATHEMATICS:
SMALL SUCCESSES OF SOME STRUGGLING MATH STUDENTS

by

Norman Kidwell

B.A., Simon Fraser University, 1992

PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS OF THE DEGREE OF
MASTER OF EDUCATION
IN
CURRICULUM & INSTRUCTION

UNIVERSITY OF NORTHERN BRITISH COLUMBIA

August 2010

© Norman Kidwell 2010
ABSTRACT

Issues surrounding math learning abound. This paper reviews topics surrounding poverty and education, surveys the debate involving best practices and math teaching and investigates the discussion on abilities and math learning: the inclusiveness all learners. This comparative analysis looks at pre-and post-test assessment results from a group of struggling elementary math students before and after the introduction of the constructivist program *Bridges in Mathematics* to discover an increase in their math understanding. These encouraging results suggest a more in-depth at-length study to look at issues in want of further investigation including measuring the efficacy of the program over time.
# TABLE OF CONTENTS

Abstract ii

Table of Contents iii

List of Tables v

List of Figures vi

Acknowledgement and Dedication vii

Chapter One  
Introduction 1  
  Background to the Study 2  
  The Problem 3  
  Accountability 7  
  Limitations of the Study 7  
  Definition of Terms 10  
  Chapter Summary 10

Chapter Two  
Literature Review 12  
  Poverty and Learning 12  
  National Council of Teachers of Mathematics 19  
  Debate Over Math Approaches 23  
  Constructivist Approach 25  
  Teacher Education 30  
  Chapter Summary 31

Chapter Three  
Research Design 33  
  Student Placement 34  
  Bridges in Mathematics Program 36  
  KeyMath 39  
  Chapter Summary 42

Chapter Four  
Findings and Analysis 44  
  Findings 46  
    Results by Content Area 46  
    Results by Grade Group 49  
    Results by Bridges Group 50  
    Results by Gender Grouping 52  
    T-Test Results 53  
    Result Comparisons 56  
    Scatterplot 58  
  Analysis 62  
  Chapter Summary 70
Chapter Five

Conclusions and Recommendations

Conclusions

Recommendations

References
LIST OF TABLES

Table 1 Student Placement by School Grade and by Bridges Group Level (n=34) 34
Table 2 KeyMath Areas of Content and Strands 41
Table 3 Frequency and Percent of Selected Demographic Characteristics of Research Participants (n=34) 45
Table 4 Mean KeyMath Percentile Ranking and Standard Deviations by Content Areas and Total Test Scores (n=34) 54
Table 5 Gain/Lost Comparison of Mean Scores by Gender To Overall Group Mean Scores Pre- and Post-test (n=34) 57
Table 6 Number of Students in Each Quartile (n=34) 65
Table 7 Percentile Gains Comparing Pre-test/Post-test Mean Scores -- Grouped According to Period of Time (n=34) 68
**LIST OF FIGURES**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Pre- and post-test results by content area reported in mean scores</td>
<td>47</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Total <em>Bridges</em> test scores - mean percentile by grade</td>
<td>50</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Total test score – percentile scores by <em>Bridges</em> group – Pre- and post-test</td>
<td>51</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Percentile scores by gender – pre- and post-test scores</td>
<td>52</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Percentile scores sorted by content area by grade</td>
<td>59</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Identified outliers of total test scores – all <em>Bridges</em> Groups</td>
<td>61</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENT AND DEDICATION

I extend my appreciation to members of my supervisory committee, Dr. Colin Chasteauneuf and Ms. Karin Paterson, who added their support and guidance with their insightful comments and suggestions throughout the editing process of this project.

My special thanks to Dr. Andrew Kitchenham, my project supervisor, who not only provided his time and expertise in helping me shape and mould this work to what it is today but who also showed patience and persistence in seeing me through it when there was no light to be seen.

I want to acknowledge anonymously the students whose scores became the statistics that are a central feature to this project. My wish is that they continue to grow and experience further success in their math learning and, furthermore, happiness in the big lesson called life. Thank you to school staff members who allowed me and helped me gather and find the necessary information that formed an important part of this work.

I would like to dedicate this project to my wife who patiently waited far too long for its completion. My gratitude and love go to Sharon, Bradley, Eric and Steven for understanding my absences from family and for their steadfast support for the duration. This work is as much theirs as mine.
CHAPTER ONE – INTRODUCTION

The National Council of Teachers of Mathematics (NCTM) argued in its Curriculum and Evaluation Standards (1989), and in subsequent releases (1991, 1995, and 2000), that everyone is capable of understanding math and that learning it should be both available and accessible to all. This belief stands in stark contrast to earlier assumptions and to what many still might believe today – that for some students math is very difficult to learn (Kasten, 2005; Reed & Schaefer, 2005). Currently, prominent and influential scholars in the mathematics professional literature (e.g., Ashlock, 2010; Burns 2006; Van de Walle, 2006) are adding credence to the NCTM’s advice. More and more, they are arguing that mathematics learning, delivered in a format high in expectation, at a level appropriate to develop further individual understanding, and with reasonable accommodations to meet individual needs, is something for everyone to attain. No matter what the ability, disability level, social or economic circumstance of students, learning math is increasingly being considered achievable and essential in a changing world.

In some inner-city schools, many students experience issues related to poverty. Often students come to school hungry, tired, and in need of basic hygiene. They may have experienced some form of violence or live in a home where drug or alcohol abuse is prevalent. For many students, because of a lack of resources, their worlds are limited to their own neighbourhoods and they have limited knowledge and experience beyond those parameters. For others, their lifestyles may be chaotic and transient, where basic survival is their foci. Many have personal experience with family breakdowns, loss, or legal and ministry intervention. They live in single-parent homes or are being raised by an aunt,
grandparent, or other family member. A few students may even be under the direction of
the Ministry of Children and Families; some exclusively under their care and living in a
group home.

Background to the Study

This study was conducted in north-central British Columbia in a school situated in
the downtown area. The surrounding area was supported by industry and a nearby
university. The school population was diverse and included representation from a variety
of ethnic groups; however, a majority of the students were of aboriginal descent. In
addition to assuming the role of researcher, I was also an administrator and math teacher.

A number of students involved in this study were living a similar plight of
poverty, and a few even experiencing Ministry involvement. School for some would not
have been a priority, but for a few it was their only safe place to be. Over half of the
student participants in this study were of aboriginal descent and some came from homes
where their adult guardians possessed the historical scars of a school experience that had
plagued them or others dear to them a generation or two ago. Many of these students’
parents were, at the minimum, suspicious of education and the education system. For
others, education was not valued in the way proponents of the education system would
have wanted. Consequently, there were issues of trust and buy-in by the families to
support their children and their children’s learning at school. Often these characteristics
were manifested in students’ attitudes toward their own learning.

There was a significant number of students at the school who relied on programs
that were modified (i.e., different grade learning outcomes) or adapted (i.e., same
learning outcomes as peers) to meet their unique academic needs. Math was one such
subject where there was a range of abilities and learning needs and meeting those needs was quite challenging for the classroom teacher. Given the variety of support needed, it was difficult for the classroom teacher alone, or even with the support of an aide, to meet everyone’s needs. To better meet their individual needs extra staffing was assigned and more classes were created to teach modified math to students with similar abilities in groupings that were reduced in numbers.

What was happening at the school was that each year the teacher responsible for teaching modified math to intermediate students was charged with developing a program suitable for lower-achieving students. While well-intentioned and undoubtedly academically sound, the long-term result was that these students often endured math programs consisting of a hotchpotch of learning resources based upon a number of older and unused alternative math programs. There was no consistency in the modified math program from year to year and consequently no consistency in the students’ learning. Anecdotal evidence indicated that modified math was often taught by staff members who were in transition or who were in this position while trying to establish roots within the school and district. This, in turn, led to turnover and inconsistencies at this position on a year-to-year basis. Students needing consistency in their modified math program often experienced their math learning in a way that lacked long-term planning, direction, and constancy. Additionally, students were placed in math groups using a variety of criteria which included class size, behavioural problems exhibited, and present math abilities.

One way that staff members at this particular school felt they could help address their students’ learning needs was by providing their struggling math students, most of
whom were on an Individualized Education Program (IEP) in math, with a practical math program. While staff had generally taken to teaching with the constructivist approach to learning in mind, they had done so with varying degrees of knowledge and with varying professional development experiences. This variance is reflective of educators, in general, who are all at different levels when teaching math with a constructivist approach to learning (Bruce, 2008; NCTM, 2000; Read & Schaefer, 2005).

One curriculum-based solution for the challenges of instructing these students was a program entitled *Bridges in Mathematics* (Hansen-Powell, Fisher, & Ruttle, 2007) (hereinafter also called *Bridges*). *Bridges* is a math program designed to be used in diverse settings and offers a full curriculum for students from Kindergarten to Grade 5. Some staff members had heard favourable reports about the program and one had had a very positive experience with the program at the early primary level while teaching previously at another school in the district. Upon further investigation, an initial Grade 3 level program was purchased during the 2007-2008 school year, scrutinized, and piloted for the duration of that year. Leading into the 2008-2009 school year, a Grade 1 and a Grade 2 level program were further purchased. While still in the relatively early stages of implementing the program, the staff wanted assurances that the program was providing a positive impact to student learning in the school.

This reassurance was the basis for both this study and the formulation of the guiding question of inquiry designed to help gauge the program's impact and which needed to be answered with relative immediacy. To this end, the research question for this study was: *To what degree does the Bridges Math program increase Grade 3 to 7 modified-math students' understanding of mathematical concepts?* The increase in
students' understanding was measured in an initial pre-assessment administered early in the school year and was followed by a year-end re-assessment which measured changes in percentile rankings.

In this context, prior to beginning the Bridges program, the students’ understanding of math concepts were assessed and their learning needs analyzed using KeyMath: A Diagnostic Inventory of Essential Mathematics (Connolly, 2000) (hereinafter also called KeyMath). This assessment was also used to help determine student placements within the modified math groups for the 2008-2009 school year. Consequently, as a result of the assessment, many of the students who were scheduled to follow the Bridges math program were placed in a curriculum two or more years below their current grade levels. Offering this program at the Grade 1, 2 and 3 level was a closer match to their ability levels in math and it was considered a more effective way in meeting the students’ learning needs. It was the hope of staff that such a decision would produce improving results for the students in modified math.

The premise on which staff established modified math groups paralleled the philosophical overtones made by many math authorities over the past two decades, that all students can succeed in math (Kasten, 2005; NCTM, 2000; Van de Walle & Lovin, 2006). Again, because of the diverse range of abilities of students at this particular school, specifically the range of math abilities in any given classroom, integration and effectively teaching to such a diverse group of learners in the classroom was extremely difficult. Given the variety of levels, integrating the lower achievers into other classrooms with students of like abilities was also an option and was considered but subsequently abandoned when, for example, the social-emotional impact of placing a
Grade 7 student into a Grade 3 classroom was considered. To wit, there was an obvious tension between whether students who were living in poverty had ability issues or had experienced significant math gaps some time in their educations.

From the teachers' perspectives, it made a lot of sense to alleviate some of that responsibility of reaching every learner in math by grouping them according to ability and then securing some support for these groups. Providing alternative instruction to like-ability groups better afforded the opportunity for teachers to teach to a more homogeneous grouping of students at grade level and or at least at similar level. Interestingly, several teachers, particularly at the intermediate level, also provided further opportunity for their students to reinforce their math learning at an adapted level in smaller groups as well. A teacher’s aide most often facilitated this opportunity.

The school’s administration tended to direct a significant amount of resources towards supporting remedial learning and supporting learners at their functional levels. This support was not only in programming and capital but also in human resources. As previously mentioned, for the 2008-2009 school year, administration purchased the *Bridges in Mathematics* program complete with class sets of manipulatives at the Grades 1, 2, and 3 levels. In addition, student workbook resources, home connection workbooks, and student journals were purchased at the same time. For the same school year, three hours per day of extra teaching time was directed to the modified math learner. Based on evidence from the preliminary discussions among staff, teaching time per day was increased to four hours for the 2009-2010 school year.
Accountability

Given the significant investment of both human and capital resources that was directed toward the modified math learner, a measure of accountability was needed. This project’s investigation was a reasonable start for the accountability process. The hope was that this analysis of the program’s original implementation was positive and that through an ongoing process of assessment and analysis changes and adjustments to the program would further enhance the effectiveness of the program and the learning opportunities of the students with IEPs in math. The overall purpose of this study was to initiate a process designed to measure the effectiveness of the Bridges program as it related to improvement in understanding mathematical concepts by those students involved with the program in a modified math group setting.

Limitations of the Study

Limitations that could have influenced the results of this study included differences in class size, limits to teaching time, differences in class settings, differing levels of expertise among teachers and different teaching styles, and test administration.

Initially, when deciding on an optimal size of each Bridges math group for the school year of this study, the staff believed that a maximum of 10 students per class was prudent. The teachers involved, given the diverse needs of this group of learners, felt that a larger group size would negatively impact an effective implementation of the program. It was noted in the minutes for a meeting specifically struck for these Bridges groups that the math group populations actually averaged 13 and sometimes rose to 15 in a single class. Exceeding the predetermined limit was often a concern for Bridges teachers who felt that larger groups affected the students’ learning.
The *Bridges* program was designed to be delivered daily with one hour time recommended be dedicated for unit work and another fifteen to twenty minutes be reserved for daily number corner. In this case the school under study had a scheduled whole-school math period of an hour each morning after recess. At best, an actual hour’s time was used for math learning but usually less given the time required for transitioning. The reduced time sometimes required that the modified math teachers cut out components of the program or that they reduced a specific time allotment for a specific concept. It was, therefore, debatable that students experienced and benefited from the program to its fullest potential.

*Bridges* uses a number of manipulatives and required an appropriate amount of space to carry out a number of hands-on activities. During instruction, restricted space or other distractions may have impinged upon the effectiveness of the program. The Grade 3 *Bridges* group, for example, was taught in the school’s meals room and not in a traditional classroom. Often there were tasks being carried out by the support staff in this room during math class time. From observation, this distraction posed quite a challenge to students. The Grade 2 *Bridges* group met regularly in a science prep room. The Grade 1 program was taught in a classroom that was half the size of a regular classroom and space was restricted when the maximum was exceeded.

More so in recent years, math is taught to meet significantly different ways that students learn it and understanding it. The constructivist approach to learning math is relatively new and philosophically different. The teachers at this school were not familiar with the *Bridges* program nor were they completely comfortable or well versed with its methodology. While they could support the *Bridges* program in a more traditional way, a
lack of adequate development and training could plausibly have impacted an effective
and optimal implementation of the program.

While there were well articulated instructions and expectations included with the
KeyMath assessment used to measure student progress over the year, there could
undoubtedly be subtle differences in the methodology and levels of tolerances in the
administration of the tests were a possibility. Given that there were more than one tester
involved in administering the assessment tool what could be anticipated are minor
discrepancies in the assessors’ subjectivity or degree in wait time, or in the minor
subtleties that he or she accepts as appropriate student responses during testing and
retesting. Given these concerns those administering the assessment were aware of the
potential for discrepancy and worked closely together to minimize the effect.

Finally, most re-assessments were carried out during the last weeks of the school
year, as course work and other projects were being completed in anticipation of the
summer break. Some students completing assessments during this time of the year could
potentially be distracted and less committed and motivated in focus impacting their
assessment results. It was especially concerning that students may have had less
motivation or would not have spent the think time nor have had the fortitude to follow
through with processes that were relative complex, multi-leveled or perceived by the
student to be arduous. These issues, of course, emerge as concerns for testing at any
given time of the school year.

Delimitations included the scope of this current study. This researcher only
focused on the results of a select few of the elementary school’s population who were
performing below and some well below grade level in mathematics. A few were even
designated learning disabled. The results of this study, therefore, will only be representative of these students who were achieving below grade level in math.

**Definition of Terms**

An IEP is an Individualized Education Program describing program adaptations and/or modifications and the special services that were provided for students so designated.

The constructivist approach to learning involves the learner constructing knowledge, by using their own ideas and the ideas of others to build upon their own existing knowledge. For students to construct new ideas they must be mentally engaged in the learning process calling upon existing ideas and transforming them into new or emerging ideas as they develop.

New math is what the media often calls the math learning that is based in constructivist theory.

**Chapter Summary**

For the past two decades the NCTM has been in the forefront of promoting a philosophy of equitable access and attainment of mathematics for all. Equitable does not mean the same delivery or methods of instruction for everyone, but an expectation of a high quality instruction with reasonable and appropriate accommodations supporting a diversity of abilities and levels of learning should exist.

The staff at the school participating in this study shared a similar vision for a student population that was diverse culturally and socio-economically, and which had wide-ranging academic abilities and achievement results. The staff specifically held a collective desire and willingness to provide students an alternative to overcome shortfalls
in their math performance. Their deficiencies in this area of the curriculum were quite an ongoing concern to many of the teachers.

Staff brought in the *Bridges in Mathematics* program, a program that closely adhered to National Council of Teachers of Mathematics' philosophy for teaching and learning mathematics, and targeted students on modified IEPs in math in a consistent and organized way. A *KeyMath* assessment was administered to determine students' placements when entering into the program and a second re-assessment, and after a year working with the program, it was administered again at end of the school year to assess any student progress.

A need was that some form of re-assessment was to occur on a regular basis to gauge the efficacy of the program over time as well as to maintain a continuing assurance that IEP students were placed at the appropriate level within the program. This research project involved reporting on the initial steps and the analysis of the initial results after using the *Bridges in Mathematics* program with students for a year. The purpose was to find out whether implementing this constructivist-based program significantly helped modified math learners better understand math as evidenced through improved math scores. Results from this initial investigation show encouraging results indicative of improvement to the students' overall math performance.

These results fall in line with what current literature suggests regarding the constructivist approach to math. A synopsis of this literature is looked at in more detail in the following chapter.
CHAPTER TWO – LITERATURE REVIEW

The following is a survey of literature investigating characteristics, similar living circumstances and similar attitudes held toward learning as held by these students involved in this study. Many of the students involved in this study were living in or on the cusp of poverty and it is important to establish the role poverty played, if any, in their learning and to their overall school experience. Second, these children began their school experience at a socio-economic disadvantage and an investigation into the literature to gain a better understanding of their plight was necessary to further rationalize the school’s attempts at and investment in helping these modified math learners. Third, these students were put in a learning situation that had at its core a constructivist approach to learning math. In the past they had been learning through a hotchpotch of approaches, from a variety of programs, which facilitated by a continual changeover of teachers over time. There are differences of opinions and differing philosophies of how math is to be taught and learned. Fourth, this investigation will include a review of the debate and of beliefs about how math be taught and will conclude with a snippet of expert opinion and analysis of what is currently considered leading-edge assumptions about math learning.

Poverty and Learning

As previously noted, many students involved in this study were from single-parent homes or were being parented by extended family members whose socio-economic situation indicated that they were living in poverty or similar conditions. There are a variety of opinion of what constitutes poverty and whether it is a factor affecting the learning opportunities of individuals who live in low income situations. At one end of the spectrum, Sarlo (1996) of the Fraser Institute suggested that the low-income cut-offs
(LICO) which Statistics Canada uses as their unofficial line or defining criteria identifying people living in poverty exaggerated the amount of money an individual, or family, needed to survive. According to Sarlo, the same was true with the Canadian Council of Social Development’s own “poverty lines” which described the number of as families living in poverty as being even higher than Statistics Canada. Sarlo suggested that these measures overstate the “basic needs” and inflate the number of those living in poverty. He also suggested that very little is really explained except that inequalities are compared to average incomes and average consumption patterns, that any differences between middle income earners and a standard of living below which we hope no one will fall represent the criteria used to classify someone living in poverty. Sarlo believed that poverty in Canada, according to our traditional understanding of it, does not exist and should not be considered a problem.

Using data from two longitudinal surveys, Ross and Roberts (1999) were at the other end of the spectrum. They link 27 variables measuring child outcomes and living conditions to income levels. A number of the twenty-seven variables such as frequency changing schools, living conditions, social and emotional problems, and math performance were directly related to this current study topic.

Ross and Roberts (1999) noted that children of low-income families tended to change schools with greater frequency. They reported that nearly 30% of children from low-income families changed schools at least three times before they were 11 years of age. That was compared to just over 10% of children from high-income families. Frequent changes in schools is symptomatic of other stressful family events such as family break-up, loss of job or the need to find more affordable housing, adding to
current levels of a household already under stress. This level of transience leading to a higher frequency of children changing schools had a detrimental impact to the children’s learning and they specifically noted lower math scores. Of the latter they observed that "problems with math appear to decrease as family incomes rise" (p. 9).

Ross and Roberts also noted that substandard housing also contributed to the lesser living conditions impacting good child development. Poor air quality including contaminants such as moulds, lead or asbestos are found more frequently in substandard homes. Cockroach infestations and higher instances of lice infestations are other likelihoods of such living conditions. Distracting and uncomfortable living conditions, unsuitable study environments and unsuitable play areas all contribute and negatively impact the emotional health of the individual’s family and the individual himself. Children living in low-income families are twice as likely to live in this type of environment than are children in high-income families.

In their study Ross and Roberts commented on health factors that they felt impacted students and their learning. They noted that children from low-income families were twice as likely to experience higher levels of anxiety than those living in families earning $30,000 or more. Their results are similar with children diagnosed with hyperactivity. Children from low-income families exhibited higher levels of hyperactivity and inattention than did children from families earning higher incomes. On issues of their children’s general health, fifty percent of their adult respondents from higher income families indicated that they were generally in excellent health while those in low-income families responded that their children were in excellent health about thirty percent of the time.
Other studies (First Call; BC Child and Youth Advocacy Coalition, 2008; hereafter, First Call; Hirsch, 2007; Horgan 2007) found that children from single parent families and who live in poverty appeared to be at a disadvantage educationally. Referring to 2006 statistics, First Call reported that the poverty rate for children of single parent families headed by mothers was a little over 50 percent. The poverty rate of Aboriginal children living off of reserves was at 40 percent, twice the percentage for non-Aboriginal children. Furthermore, this same report described children who lived in poverty as suffering a greater risk of performing poorly in school and more likely not to graduate from high school. An easy conclusion, given that for many of the students who are part of this study and who are living in poverty-like situations, is that they are in a precarious situation. Having to cope with greater risks to health, more dangerous and likely unhealthier physical environment, and a lesser likelihood to graduate, to achieve employment and job security is a less than an encouraging prognosis for a positive school outlook.

Student participants in this study are provided with an optional meals program offering both breakfast and lunch. Hirsch (2007) discussed this need as being a strong predictor— that children who are regularly supported by a meals program are also more likely to be lower achievers. Along the same lines, Horgan (2007) noted that it was only the children who were living in extreme poverty that took advantage of the school’s meals program on a daily basis. For others who are less dependent on such a program the degree that it was used was dependent on other factors well. The prominent factors included: whether the student liked the food, whether there was any stigmatization
attached to students using the program, and whether within any given school culture such a program was used.

A significant portion of the students attended the meals program at this school. Similar to what Horgan found in his research, there were some complaints regarding some menu items but there was no indication that participating in the program was a cause for embarrassment for any of the students. Although some families were unable, apprehensive or unwilling to pay for such a service, the meals program was an accepted and ingrained structure at the school and was generally valued and expected by most parents and families. The staff also firmly believed that without the proper nutrition the meals program provided learning was impeded and they in turn promoted the meals program as an essential life-line to enhancing student learning.

Hirsch reviewed a number of studies examining the experiences and attitudes of children from a variety of backgrounds, including those living in poverty, and noted a number of themes emerging from the investigation. Although valuing school as important, a history of familial resentment toward school coupled with a child's own early experiences with educational failure both contributed to the child's development of low self-confidence and played a significant part in the escalation of a negative attitude toward learning. Early on in their school years disadvantaged children developed a keen awareness of their plight and often developed an extremely negative perspective toward school discipline and held an extreme sense of disdain of their relationships with teachers. Issues about discipline were more at the forefront and teacher interaction were described as much more coercive and controlling toward those with an impoverished background within the school population. Key to his findings was that children from less
advantaged background felt less control and less involvement over their learning, were less participative in the process and were much less inspired as learners.

Hirsch stressed two other key points. First, out-of-school learning experiences were thought by students to be unrelated to school and considered to be auxiliary to school learning. Students therefore perceived this form of learning as being a very positive experience. Second, students with disadvantaged backgrounds had much more negative homework experience, Hirsch noting that a physical living environment full of distractions, this is a reoccurring theme in the literature, and the lack of parent participation were both factors playing a role.

In his conclusion, Hirsch recommended improved efforts to provide extracurricular experiences for disadvantaged children that parallel those opportunities experienced by better-off students at home. He also called for efforts to improve the homework experience for the sake of strengthening students' confidence and building their independence for learning. Finally, he recommended that we continue to build and nurture relationships between the disengaged and school. Without any efforts to empower disadvantaged learners, Hirsch concluded that a sense of disenfranchisement between the learner and school will be perpetuated.

Horgan interviewed over 200 children and spoke to parents and teachers in Northern Ireland and through their conversations explored how living in poverty affected the children's educational experience. Horgan pointed out that there were numerous, well established studies which correlate family income to a child's ability to learn. He also noted a trend that children living in poverty tended lower rate of cognitive and social development, and poorer physical or mental health. An overriding factor to be
considered in the Horgan study is the past experience of civil unrest leading to the 1994 IRA ceasefire.

Horgan's interviewees, both advantaged and disadvantaged, all saw education as valuable although the way they framed it in their own context differed substantially. For the learner living in poverty learning presented a way to avoid future problems while for the advantaged learner it was a way of ensuring a good life. Disengagement and disenchantment of the disadvantaged learner early on in their years of schooling, particularly for boys, was noted in this study as well. As did their perception on authority, among the most disadvantaged students, they felt teachers dealt with them much more severely than they would a rich child.

Horgan's interviewees who lived in poverty presented themselves as being less stressed about taking tests and less concerned of their results than those living an advantaged lifestyle. He pointed out that many who lived in poverty were less likely to experience the same pressures from parents demanding success as would the others. On the other hand, costs of school trips, thought by his interviewees to be extremely valuable to broaden and provide new experiences for the students, were thought to be prohibitive by both the advantaged and disadvantaged families.

Many of these characteristics and circumstances described by Hirsch and Horgan were evident in the general student population under study and fairly representative of the profile of the student who has been attending modified math over the years. Often, these modified learners possessed a displacement of passion and motivation toward learning and for a few, the passion was lacking only in terms of learning math. These students
seemed to have an awareness of their plight, and through repeated failure seemed to have accepted it.

This sense of failure can often be detected in students' conversations and comments that were heard inside and outside of class-time. Kasten described this chronic failure in math as having a negative effect on the students' motivation. Repeated failures, without any evidence of productivity, was seriously damaging to a student's sense of motivation. A sense of proficiency in math was seriously lacking, further affecting any feelings of accomplishment. For many students who struggled there was an implicit assumption that math was too difficult for them and it was impossible to master no matter the circumstances. This sense of inability or helplessness was also displayed in a number of students, in their behaviours and attitudes, and through their body language and in their unwillingness to participate.

National Council of Teachers of Mathematics

Schoenfeld (2004) described the National Council of Teachers of Mathematics' (NCTM) Principles and Standards for School Mathematics (2000) (hereafter also called, Principles and Standards) as being “both a radical and a conservative document” (p. 267). As a radical document it was seen to challenge traditional assumptions about how math should be taught. Many traditionalists saw it as an attempt by a radically dominant component of the NCTM to have the general math curriculum “dumbed-down” to allow more students to achieve success. As a conservative document it was considered to have been written to achieve greater consensus by a broad spectrum of math writers so as to meet the appeal of an even broader spectrum of math teachers across the country. What
it proposed was certainly toned down from its 1991 predecessor, *Professional Standards for Teaching Mathematics*.

Others (e.g., Ashlock, 2010; Calkins, nd.) saw the NCTM’s *Principles and Standards* as an attempt to help teachers become better instructors of math, moving them from teaching simple procedural math to one that prescribed a greater balance between conceptual understanding and algorithmic proficiency. Kenney (2005) wrote that with the introduction of a standards-based math curriculum, which he recognized as being driven distinctly by the NCTM, gaining math knowledge and proficiency was less about memorizing facts and seen more as a result of a process involving student-centered learning. Learning, emphasized Kenney, should take place in conditions where concepts were taught and built upon and that those concepts and associated understanding were ably communicated to others. For those who adhere to the principles of the new math or the constructivist approach to math the document was fairly reflective of that philosophy.

The NCTM’s *Principles and Standards* Equity Principle recognized that far too many students, especially those from lower socio-economic backgrounds who did not have English as their first language, and other minority groups based on ethnicity suffered from expectations that were low, inferior and essentially unjust. The NCTM claimed that remediation classes lacked substance and effectiveness, and that the Equity Principle demanded that expectations for learning and understanding in math, specifically for those achieving below the norm, be raised.

Implicit within this principle was that inadequate or misguided expectations and teaching practices have not served both minority and those children living in poverty well. Again, the framers of NCTM’s *Principles & Standards* claimed that there was a
myriad of documented and demonstrated cases which indicated that children of all abilities, whose learning needs in math have historically been underserved, have an equal right of access to high-quality appropriate math programming and teaching.

The NCTM’s Equity Principle acknowledged that learning math without a clear intention to teach for understanding has been a big problem for a long time—“since at least the 1930s” (p. 19). Memorizing facts and performing rote procedures, without really understanding, made learning precarious at best. On the other hand, the Equity Principle contended that learning with understanding made mathematics make sense to the average learner, and when it made sense—remembering no longer became an issue when students could make meaningful connections with new knowledge.

The Equity Principle acknowledged that we indeed “live in a mathematical world” and also recognized that “those who understand and can do mathematics will have opportunities that others do not.” The Equity Principle also acknowledged that, through a lack of opportunity, commitment or simply through disengagement, NCTM’s vision of mathematics teaching and learning was not being applied equitably to many students “especially students who are poor” and who “are victims of low expectations in mathematics” (Introduction, pp. 1, 2). While this document recognized that students have differences in their abilities and capabilities to learn and understand math it also reminded us that we increasingly need to be functional in math, to be proficient managing regular math challenges found either at home, the workplace, or in furthering our studies. Again, The Equity Principle recognized that a number of examples existed substantiating that everyone could experience success in learning math when they had access to quality math instruction.
In her review of literature relating to intervention and math learning Kasten pointed out that there was an assumption entrenched not only in general terms of teaching math but also in terms of remediation philosophy of math recovery -- that math was difficult to learn and near impossible to learn for a few. She explained in her paper that waiting until the student experienced failure damaged their motivation in math and further damaged their disposition to achieve in math. Prompt intervention, which was what Kasten was advocating, called for identifying gaps in understanding before a student experienced trouble. Logically, interventions should be applied early and when needed.

Furthermore, the support should be more than the traditional worksheet or re-explanation. Kasten wrote that effective intervention should encompass the NCTM’s and the National Association of the Education of Young Children’s (2002) recommendations contained in *Early Childhood Mathematics: Promoting Good Beginnings*. This latter piece was specifically written to guide practice for classroom teaching of young children. In brief, its research-based list of ten characteristics of an effective primary teacher recognized the need to promote the enhancement of children’s interest in learning math and building upon their current experiences in and knowledge of math using problem-based activities. To be brief, the list includes a student-centered focus calling for clear, engaging, varied, and connected tasks designed to maintain student involvement and encouraging them to build on their own ideas, which promoted effort and persistence and which encouraged reflection during, at the end and after the lesson. In her own state of Ohio, Kasten claimed, they were taking literally the conviction that all can learn math,
and have established a mandate to taking math learning to a higher level as a state-wide
goal.

Debate Over Math Approaches

Over the past few decades a debate has occurred about how math should be
taught, and learned for that matter. The debate was well-represented in mainstream
newspapers (e.g., New York Times), on internet websites (eg. http://www.wgquirk.com)
and in scholarly publications (eg. O’Brien, 2007; Schoenfeld, 2004). Intertwined in this
debate was a variety of beliefs held in varying degrees by a variety of groups as to
whether learning functional math can be attained by most without compromise.

Hartocollis wrote in the New York Times (April 27, 2000) describing the shift by a
specific New York school district to a more constructivist curriculum approach to math,
one that was to be more consistent with NCTM’s recommendation. Central in that article
and to that debate was the fear held by many parents that their children were lacking the
knowledge to use the most basic algorithms. The debate being waged involved the
notion that math could not be understood completely by some and minimally understood
by many more. The fear of parents, whose children were good at math, was that their
children’s learning would be compromised.

Also from this same side of the debate, another argument was that math should
continue to be taught and learned as it always has. This is the math that Van de Walle
(1999) characterized as “the mathematics that parents and legislators recognize as the
mathematics that they attempted to learn when they were in school,” consisting
“primarily of arithmetic or computation.” (p. 1). It is the content driven math that most
parents were familiar with and comfortable with, that is, learning math for the sake of
doing more math.

Wang (2001), in his review of new math materials, was critical of the new
approach to teaching math. He questioned why students needed to reinvent centuries of
established math methodology by being encouraged to practice discovery learning
through trial and error and experimentation through manipulatives. He accused the
constructivist movement as sabotaging the math program to the detriment of the higher
achiever. Wang characterized the new math as not only being challenging enough to
meet the needs of the high-achievers in math but that it also ill-prepared the weaker
learner for everyday mathematical challenges. His side of the debate wanted a return to
“back to basics” and argued that a focus on learning facts and memorizing tables is
necessary. His perception was that constructivist math excluded or neglected to teach
content and algorithms nor did it promote memorizing basic math facts.

Referring to the NCTM’s 1991 earlier controversial version of Professional
Standards for Teaching Mathematics, Schoenfeld (2004) claimed that fears were
“exacerbated” by the direction the NCTM appeared to be going. Those critical of the
changes to traditional math learning lamented the decreased attention to practicing paper-
and-pencil computations, rote practice and memorization of rules and facts. The reliance
on the teacher as the authority to teach and tell, and dictate rote memorizing of rules
seemed to be abandoned.

This traditional notion was diametrically opposed by others and perhaps best
exemplified first in NCTM’s radically perceived Professional Standards for Teaching
Mathematics and later in the more accepted NCTM’s Principles and Standards for
School Mathematics. Both these documents prescribed a standards-based mathematics curriculum and were at the forefront of an era of real change in thinking about how math should be taught and learned. These documents, suggested Kenney, made clearer the direction that math learning was going. Succinctly, these documents forwarded the philosophy that attainment of math knowledge was the result of teaching and learning for understanding and concept building rather than memorizing facts and algorithms.

Kasten, whose state of Ohio committed to this inclusive learning of math, thought that such a commitment, although “yet largely unaccepted” would “revolutionize mathematics instruction.” (p. 1). Fosnot (2005) characterized this change in approach as morphing math from a static rule-bound discipline to an “activity of interpreting, organizing and constructing meaning of situations with mathematical modeling” (n.p.). Ashlock (2010) saw such changes in math increasingly as “a science of patterns rather than a collection of rules” (p. 3).

Constructivist Approach

The constructivist approach, although commonly referred to as a teaching practice, is in reality a theory about learning (Fosnot, 2005; Van de Walle, 2006). The constructivist approach to learning has as its foundation in two compatible but distinct theories on learning – cognitive and social constructivism. Cognitive constructivism is based primarily on the work of Jean Piaget (cited in Fok & Watkins, nd) who identified four stages of cognitive development that individuals progressed through from childhood, through the adolescence years and into adulthood. Vygotsky’s (1978, 1989) social constructivism theory also recognized that knowledge was indeed personally constructed,
but that to facilitate deeper learning and to secure a clearer understanding for oneself, an element of social interaction and social experiences was also necessary.

Piaget believed all children passed through each of the four stages to advance to the next level of cognitive development. In each stage, children developed and demonstrated new intellectual abilities and increasingly developed in a more complex way their understanding of the world. From his observation of children, Piaget understood that children were creating ideas. They were not limited to receiving knowledge from parents or teachers but they actively constructed their own knowledge. Piaget's work provided the foundation on which constructionist theories are based.

Cognitive constructivist believed that knowledge is constructed and learning occurs when children produce or make things. They asserted that learners are more likely to be engaged in learning when the knowledge they have created is personally relevant and meaningful. This view argued that “meaningful learning requires learners to construct rather than receive knowledge” (Fok & Watkins, p. 1). It would be critical in mathematics instruction that the students learned to construct meaning.

Social constructivists postulated that each student came into a classroom with differing views and could hold differing views within the same learning environment and that community interaction was implicit to making meaning for the learner. Vygotsky's theory stressed the fundamental role of social interaction in the development of cognition where the more knowledgeable other, with a higher ability level or greater knowledge, provided assistance to the learner by imparting their knowledge to the learner (Bransford, Brown, & Cocking, 2000).
While the two theories have distinct similarities they differed significantly on how and when exactly learning and cognitive development happened. Vygotsky theorized that social learning preceded cognitive development while Piaget theorized the opposite, cognitive development preceded learning. Their theories, nevertheless, have had a significant impact on models of education and learning.

Seldon and Seldon (1996) noted that there do indeed exist a series of theories based on constructivism from the moderate to the radical, from the socio-cultural to the sociology of scientific knowledge. Van de Walle (2006) pointed out that it really was not necessary to choose between constructivist theories when deliberating about their learning so long as students were engaged in reflective thought promoted through social interaction so that they could build upon previous ideas that they have brought to the discussion. “When, for any given child, the conversation of the classroom is within his or her zone of proximal development, the best social learning will occur.” (p. 5)

The rising interest in the theory of constructivist learning advised that students were no longer envisioned as the “empty vessels” waiting on their teachers to fill the void. Fosnot affirmed the notion that students do not simply take in information but rather actively and consciously participated in interpreting, organizing and inferring about it within what they previously established cognitively. It was the active engagement through relationships that one reflected upon, modeled and constructed deeper and wider-ranging explanations.

Van de Walle and Lovin (2006) thought that how a teacher conducted her class played an important role in the way students learned. Van de Walle’s “mathematical community of learners” took place in an environment where students shared, compared,
challenged and negotiated results, strategies and ideas. Van de Walle claimed that such a mix created in a rich environment and raised the chances for deeper thinking and reflection about mathematical ideas. In such an environment students were entrusted to work on problems together with other students and engaged in and learned mathematics. In their math struggles, and using their ideas and strategies together, what they learned was integrated with their existing ideas which assisted them in revising present meaning structures or developing new meaning structures (Van de Walle, 1999).

Van de Walle and Lovin (2006) claimed that “the fundamental core of effective teaching of mathematics combines an understanding of how children learn, how to promote that learning through problem solving, and how to plan for and assess that learning on a daily basis” (p. 1). They thought that the key factor to improved math teaching was for teachers to allow math to be problematic for students. The primary goal to solving problems was not simply for students to apply and practice mathematics that they already knew but to learn new mathematics embedded in the problem-solving tasks. Student learning, then, was a result of math being taught through problem solving.

Marilyn Burns (2000) also claimed that “problem situations should be the starting place for developing arithmetic understanding” and that these problem situations themselves created the “need and context for computational skills” (p. 13). Burns wrote that students needed to recognize that problem solving serves a purpose and that purpose was to help students practice computation, quite the reverse of the usual belief held that computing existed to help students solve problems.

Burns (2000) thought that problems should be practical and “real life” where not all the information was given or readily available and maybe not ever available. The student
in this situation must call upon all the resource – understanding and knowledge – that they have in place so that she could “analyze, predict, make decisions, and evaluate” and that “skills, concepts, or processes be used to arrive at the goal” (p. 15). Important too, Burns claimed, students must possess a genuine motivation to solve or resolve the problem.

Ashlock (2010), in discussing common error patterns in mathematics, recognized the importance of computational fluency, but also recognized that skillfulness in computation was no longer a prerequisite before beginning an investigation in math as mathematics was becoming less about the facility of knowing rules and procedures but more of “a science of patterns” (p. 3). Instead, Ashlock advocated for the ability that math learners “be able to use different methods of computation in varied problem-solving situations” and to not limit the learner in believing that there was simply one way (p. 4). He pointed out that a “standard” for an algorithm is a standard chosen by a curriculum designer and that world-wide significant differences existed.

Ashlock (2010) claimed that to focus solely on procedural learning in math without a foundational understanding of ideas, and furthermore, without making connections among ideas, could likely lead to learning misconceptions. Ashlock differentiated between misconceptions and careless mistakes noting that the former were simply “procedures … taught without adequately connecting the steps to mathematical ideas” but that “[s]tudents need to understand the meaning” to make very basic choices of what operation to use or what button on the calculator to press (p. 7).

Given our ever-changing technological world, Ashlock (2010) acknowledged that goals for math instruction needed to also change. Math programs needed to be relevant,
investigative and enabling to students. Students needed to be able to solve real-world problems requiring not only decisions of what computation method to use but when to compute and with what options. As verbal literacy was so important to being a functional well-serving society member, so too was being literate in math, and being adept in numeracy, in a society that was driven by both data and technology.

Teacher Education

Teacher education and professional development and the ability to expand personal knowledge of constructivist learning and math are key to a successful and absolute change to teaching math. Simon (1995) pointed out that while constructivism was useful as a framework for learning math and indeed has influenced in a very big way how we think students learn math, it did not show us how to teach it. While the goal (when encouraging a constructivist approach to learning) was to teach for understanding, the reality was that many teachers themselves struggled with their own understanding of math operations. Goya (2006), in her research documenting teacher struggles of basic math operations, claimed that while the intent of the NCTM's recommendations included in the Principles and Standards were significant, they were essentially irrelevant when teachers themselves lacked skills and could not provide the adequate instruction to improve mathematics instruction.

Van de Walle (2006) further suggested that districts not only needed to find ways to supply continued support and encouragement for teachers in math, but also that teachers needed to develop a clearer understanding of student growth. He claimed that "we need to understand that kids' learning is a product of reflective thought" (n.p.) not simply what were the best activities, the best manipulatives, or the programs that were out there.
Continued support in this area should have involved teachers mirroring and practicing the same process that were considered effective for student learning. It should have also included for teachers time for ongoing and reflective thought about their own teaching practices.

The *Principles and Standards* Teaching Principle prescribed a number of suggestions toward effective teaching, some related specifically to teacher education. Teaching math required that the teachers possess a deep understanding of math. Choosing effective materials, instructional tools and techniques was what good math teachers do. Effective teaching required a serious engagement of the learner in an intellectual environment. Teachers needed to continue their efforts to learn and improve their own knowledge about math, pedagogy, and student learning. To this end the Teaching Principle recommended teachers have opportunities to collaborate, observe, analyze and discuss, and be supported to achieve these and other avenues of professional development.

Chapter Summary

Many students attending the elementary school involved in this study fitted the profile of a learner living in poverty. Studies confirmed that these children were at a clear disadvantage when it comes to learning. The NCTM’s Equity principal proposed that disadvantaged learners who experienced challenges to their math learning have the same right to high-quality math programming, teaching and learning as any other child.

The constructivist approach to math learning postulated the same. When teaching math for understanding, where students made meaning from their own ideas and built upon the ideas of others in a student-centered setting, and where they were given a venue
to challenge, practice and experiment with math problems and to develop their math ideas, every student would learn something.

The more traditional element in mathematics learning argued that such a process, one that was devoid of memorizing and rotely practicing the basics, was harmful to both the strong math learner and the weak. For the strong learner the perception was that the new approach was watered down and neglected to teach the basics, to be less challenging. For the others, the new curriculum ill prepared them for everyday challenges. At the crux of the math learning debate was that teachers have different levels of expertise in math, have differing knowledge of teaching math and have different philosophies of how to teach it.
CHAPTER THREE - RESEARCH DESIGN

The literature in the preceding chapter indicated that there has been a shift in how math was being taught and learned. The professional literature suggested that math should be taught within a problem-based environment and that students should be learning math by constructing their own meaning of procedures and concepts, and building upon what they already know cognitively in a social setting. Rote memorization of algorithms and general fact-based rules were now to play a much lesser role to learning math.

This study looked at the results of a group of elementary students who were struggling in math. Their teachers and other school staff described them as having a history of struggle, this being corroborated by their math performance and scores over time. Both teachers and administration recognized that these students needed support that not only matched their learning needs but also fit well within a constructivist framework. To this end, the Bridges in Mathematics program was identified and purchased to help meet the students' learning needs in math. The Bridges program was recognized by staff as having a truly constructivist approach to learning math which encouraged students to develop a variety of ways to problem solve, reason, and think and also encouraged a hands-on process to learning. The students' pre-test and post-test standardized math assessment results, administered before the students began the math program and again after participated in the program for a period of time, formed the basis of this project.
Student Placement

The decision where to place students in a specific Bridges group was only partially based on their performance as determined in their KeyMath pre-test assessment results. Other factors that were involved in deciding their placements included collaboration with the students' classroom teachers, consideration of the individual student's past performance and his or her standing in math in the classroom. The student's emotional and social needs within the school context were also considered as well. While far from rigid, most student placements reflected his or her needs within the school and beyond the context of math. The rationale that younger students were placed in the lower levels of the Bridges program and the older students along with most their peers in the higher levels was based on these factors mentioned above and the best practice for each specific student's learning and the impact the placement would have on his or her social and mental well-being.

Table 1

Student Placement by School Grade and by Bridges Group Level (n=34)

<table>
<thead>
<tr>
<th>Bridges Group</th>
<th>N</th>
<th>%</th>
<th>Gr. 3</th>
<th>Gr. 4</th>
<th>Gr. 5</th>
<th>Gr. 6</th>
<th>Gr. 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>12</td>
<td>35.3</td>
<td>7</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td>11</td>
<td>32.35</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Level 3</td>
<td>11</td>
<td>32.35</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>100</td>
<td>8</td>
<td>6</td>
<td>9</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

Data were gathered from 34 students participating in the Bridges program. Table 1 represents how the students were placed in their Bridges math groups. One criterion was to keep the groups' populations small and manageable in order to facilitate a lot of hands on and one-to-one activities. The configuration also represented a fairly even distribution
of numbers between groups. Each groups' populations were never static as the academic growth or decline of individual students meant their movement within groups, in or out of a group. There were also the typical transfers in to and out of the school during this time period. These realities in no way impacted the data, as they were not included in this study.

The data in Table 1 reflect only those student participants who were with their math groups from beginning to end, that is for the duration from pre-test to post-test. This period of time between which participants completed their pre-test to when they were administered their post-test varied from as little of seven months to as much as 20 months. This variation was due to such circumstances as when the student entered the program, when the teacher referred a student for assessment, or when there was time permitted to administer a post-test. According to records contained in the teachers' notes the typical Bridges math group contained numbers ranging from thirteen to fifteen students on any given time. Those numbers included students who moved into groups at any given time, as the need arose. Those students who moved into these groups at a very late date or those students who removed from these groups prior to their post-test were not factored in this study.

This study does not investigate the impact of the Bridges program on this group of students from an ethnic or cultural perspective, although such an investigation might interest someone carrying out a study on the learning experience of aboriginal students within the district. Briefly, the ethnic representation of this group mirrored proportionately that of the school. Anecdotal evidence from registration information suggested that between 60 to 70 percent of the students were declared to be of aboriginal
ancestry. Although there is the argument that the two might be inseparable, my perspective was that it was the students’ socio-economic plight that influenced their educational opportunities and performance, not so much their cultural heritage. Other cultures were not significantly present amongst the student population but could be at a minimal level.

The Bridges in Mathematics program

Many of the student participants in the Bridges program were on Individual Education Plans (IEP) directing that their math (and sometimes other subjects) be modified or adapted to better support their individual learning needs. IEPs are specifically designed plans that describe program adaptations or modifications and the special services to be provided to specifically identified students (British Columbia School Superintendents’ Association, 2002). IEPs are considered working documents and are under constant review and revision.

The guiding principles of the Bridges program are based upon some basic yet solid generalizations. The program’s authors recognized that learning is a process of constructing knowledge, and purports that everyone can improve in math. Furthermore, they acknowledged that feelings confusion and making mistakes are all part of learning. Finally, they recognized that learning is a social process and that both making mistakes and feelings of confusion are intrinsically part of that process. Distinguishing features of the program are that it: emphasized visual thinking; integrated both concept development and skills practice to promote fluency, as it spiralled through strands; it revisited key concepts over the year and throughout the grades; and it met the needs of teachers by providing them with very detailed teacher resources.
The *Bridges* authors noted that visuals, although not the only approach used to solve mathematical problems, helped students better understand mathematical concepts and procedures and that through their consistent use students would build mental models to help them understand concepts, invent and apply problem solving strategies, to communicate their thinking, and to further remember and augment their ideas. The *Bridges* program has a truly constructivist approach to learning math which encouraged students to develop a variety of ways to problem solve, reason and think and encouraged a hands on process to learning. They also wanted the program to be as rich visually as language rich serving as a springboard for conversations based on observations and perceptions.

Sketches and diagrams, sketching and diagramming, were used and were encouraged to be used to show thinking and to promote deeper thinking. The program’s creators noted that visual thinking effected strong problem solving strategies, challenged those students entrenched and comfortable working with traditional worksheet-type activities, and stimulated risk-taking by those uncomfortable with the abstract.

The goal of the *Bridges* curriculum is to develop students who were fluent in math computation, confident problem solvers and who understood concepts and had the skills and the repertoire to be successful. Entrenched in this premise was that math skills and computational fluency were most effectively learned in the content of authentic learning and investigation. The program, therefore, devoted time to developing the aforementioned concepts.

A feature of the *Bridges* program was its spiraling curriculum that visited and revisited key math skills and concepts at different times, in different ways, throughout the
grade levels. Its creators felt it met the needs of both student and teachers as during the program's genesis they relied on feedback from students and colleagues in classrooms, met with focus groups, field-tested the program and collected extensive detail and data.

*Bridges* is a complex program to deliver and required initially a substantial investment of teacher preparation to make some modifications to content that was American and not applicable to the Canadian students learning needs. Although divided into two basic parts—Units and Number Corner—there were a variety of activities, workouts, investigations, and work places that the teacher attended to. Grade 3 *Bridges*, for example, contained eight units, each unit containing from fifteen to thirty hour-long sessions. During each session students engaged in planned topics, and often involved activities for skill and concept development. Also included two times a week, were hour-long session where students work independently and sometimes in groupings with work places comprising of games and activities that often had a technology focus, or hands-on measurement activities. A homework assignment, usually a worksheet and a game or activity, was prescribed as homework usually once a week that encouraged a family member to participate.

The Number Corner, one of the two parts, consisted of a number of exercises and activities related to a particular concept or skill. Such exercises included working with patterns, workouts based on 10 by 10 number grids, work with magnetic tiles (computation, geometry, and fractions), games and activities rated to time, money and designed to practice and improve computational fluency. Number Corner also had activities giving the students opportunities to collect, organize and interpret data, problem solving, worksheets, data collection activities and so forth.
Bridges was purchased to be used as the primary math program for a group of elementary students who were struggling with their math learning. The program offered a very prescriptive constructivist approach to learning that the staff felt would be beneficial for this group of learners. The teachers involved with this group of learners wanted to gauge the effectiveness of the program and to do this they initially assessed the students using KeyMath to establish a baseline and then reapply it to further to assess for growth if any. The following describes the KeyMath assessment in more detail.

KeyMath

Given the new programming and the substantial commitment of financial support to these IEP students, staff wanted a clearer indication of how the students’ learning in math was being impacted. Staff deemed the KeyMath assessment to be an appropriate tool for “program evaluations as pre- and post-test measures of educational growth” and fittingly the same results were identified to be “used in research projects” by the author (p. 2). To this end, students were assessed, using KeyMath, before and at the end of the 2008-2009 school year. This study therefore provides both a summary and an analysis of those results providing staff with a clearer picture of how the students were progressing.

KeyMath is a standardized assessment instrument and was administered individually to students and gave a comprehensive assessment of a student’s abilities, understanding of applications of important math concepts and skills. Staff selected the KeyMath assessment because it was relatively easy to administer, and as an assessment for remedial instructions KeyMath performance data was considered an asset for guiding instruction. The initial KeyMath assessment was administered before their enrolment into and participation with the Bridges math program. Initially the assessment tool was solely
intended to level students who were on a modified IEP math program for placement into appropriate learning groups. Upon assessment, students were placed in the appropriate *Bridges* math group. A second post-test assessment was administered at the end of the school year. Administration and staff at the school felt it was beneficial to re-assess the students partly to help determine future placements. Those same assessment results are being used for this project – namely to see how students were progressing in math when using the *Bridges* program.

*KeyMath* provided a comprehensive assessment of students' understanding of key concept and mathematic skills. The instrument assesses in a balanced way three core content areas in math – Basic Concepts, Operations, and Applications. The authors of *KeyMath* have in turn divided these core areas into strands (thirteen in total) “selected and developed to have nearly equal importance” (Connolly, 2000, p 5). Each strand is then divided into three or four domains, again the goal being that a balance is maintained among the domains. In an attempt to further the analysis, the students' *Key Math* pre-test and post-test results were analyzed from four distinct perspectives: (1) by content area, (2) by individual school grade, (3) by individual *Bridges* math groups and (4) by gender groupings. My work did not break down nor analyze the results to the lower level of domain, rather for the sake of efficiency, the results were investigated and analysed in the core areas and, to a very limited degree, in their strands.

The *KeyMath* assessment was administered to individual students, one-on-one. Individual basal (three consecutive correct responses) and ceiling levels (three consecutive errors) were established for each student with the pre-test. Administration
of the post-test began at the basal level established by the last three consecutive correct responses.

For students’ results to be considered for this study, they had to have been administered a pre- and post- *KeyMath* assessment at the time of their intake and again at the end of the school year under study. Both the pre-test and post-test results were categorized according to content areas, and further into strands, in the same format as the *KeyMath* assessment (see Table 2). Results were posted in percentile rankings comparing and analysing the pre-test and post-test results of specific groupings using the same percentile rankings. The objective was to categorize the results both under general content areas and also according to strands in anticipation that these initial results would invite further deeper analysis. Given the scope of this project an in-depth analysis of the results in strands did not take place as it did not fit into the capacity nor time-frame of this current project. Nevertheless, without knowledge of what they were, and how they placed into the specific content areas it would have been difficult to gain an in-depth understanding of the whole analysis process.

Table 2

*KeyMath Areas of Content and Strands*

<table>
<thead>
<tr>
<th>Content</th>
<th>Numerations</th>
<th>Rational Numbers</th>
<th>Geometry</th>
<th>Addition</th>
<th>Subtraction</th>
<th>Multiplication</th>
<th>Division</th>
<th>Mental Computation</th>
<th>Measurement</th>
<th>Time and Money</th>
<th>Estimation</th>
<th>Interpreting Data</th>
<th>Problem Solving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Concepts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

...
The following descriptive statistics -- mean, median, mode, and the standard deviations of the respective individual raw scores were initially used to establish progress and growth, and whether post-test result gains were statistically significant. Once growth was indicated the focus turned to comparing pre- and post-test differences of mean percentile rankings of specific groupings to demonstrate, analyze and discuss general progress, similarities and disparities. Because the KeyMath assessment converted raw scores to percentile rankings and the easiness to interpret percentile rankings the primary form of interpreting and analyzing data for this project is through percentile rankings.

Researcher field notes in the form of Bridges teachers’ monthly meeting minutes and from other school-based reporting played a very limited part in this project’s analysis. Existing notes were used sparingly to inform, and to further corroborate general assumptions. Again, the qualitative part of the project is extremely limited only aiding in the narrative description of what was observed and learned through statistical interpretation of the results and the themes arising from that analysis. Chapter Summary Statistics were gathered in the form of percentile scores from pre- and post-test results of KeyMath assessments. These mean percentile scores were gathered to analyze the progress of a group of student who struggled with their math learning after being introduced to a new program Bridges in Mathematics. Staff selected this math program because it reflected a constructivist approach to math learning that fit well with the needs of this struggling group. The program was also prescriptive and user friendly providing essential lessons and manipulatives at the ready.
Student participants were assessed prior to beginning their participation in the program and at the end of the school year. The rationale for re-testing was for comparative purposes – to assess for growth in the students’ learning of math. The *KeyMath* assessment was chosen for a number of reasons including that it gave a well-detailed breakdown of student performances in a number of key content areas. These results are key to this project’s analysis.
CHAPTER 4 – FINDINGS AND ANALYSIS

This purpose of this study, as discussed in the first chapter, was to investigate and measure how effective the *Bridges in Mathematics* program was in bringing success to the math learning of inner-city students who were struggling in mainstream math classes. A number of the targeted students were on Individual Education Plans or an adapted math program specifying that interventions be put in place again to ensure greater success for the individual’s learning. In Chapter 2, I reviewed current literature relating to math learning, with a focus on the learner already deemed to be at a disadvantage. As well, this chapter investigated and reported on current literature on poverty and learning, looked at issues about math learning, touched on the debate between the traditional and the constructivist math camps, and investigated the strengths of constructivist math. The third chapter outlined the current research design elaborating on the number of participants, explaining the rationale for and key features of the *Bridges* program and the assessment tool *KeyMath*; the latter from which the statistics for this study were derived. This chapter will report on the findings using the latest statistics related to the students’ progress. These statistics will be a compilation of mean pre- and post-test scores gained from *KeyMath* in various student configuration including those categorised by grade level, gender and specified areas of content.

The demographics of the school suggested that a number of students were living in poverty. The school was in a middle- to lower-middle class neighbourhood setting but drew significantly from a disadvantaged neighbourhood in its catchment area. Students attending this school had to cope with day-to-day factors related to such an environment and were often distracted and unable to function adequately in their roles as learners.
Many relied on the extra academic, social, and emotional support that the school tried to provide.

There were 34 independent participants who contributed to the data for this research project. These students were either on a modified or adapted math education plan or were experiencing a high degree of difficulty meeting learning outcomes at grade level. For the purpose of gathering data, the results of 16 female students and 18 male students who attended this inner-city elementary school and who participated in the guided math groups continuously for the duration of time from pre-test to post-test were considered. Of the 34 students, five were in the third grade, eight were in fourth grade, ten were in fifth grade, seven in sixth grade, and four were in seventh grade (see Table 3).

Table 3

*Frequency and Percent of Selected Demographic Characteristics of Research Participants (N=34)*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>16</td>
<td>47.1</td>
</tr>
<tr>
<td>Male</td>
<td>18</td>
<td>52.9</td>
</tr>
<tr>
<td><strong>Grade</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>14.7</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>23.5</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>29.4</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>20.6</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>11.8</td>
</tr>
<tr>
<td><strong>Bridges Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td>12</td>
<td>35.3</td>
</tr>
<tr>
<td>Level 2</td>
<td>11</td>
<td>32.35</td>
</tr>
<tr>
<td>Level 3</td>
<td>11</td>
<td>32.35</td>
</tr>
</tbody>
</table>
Findings

The statistics used for the purpose of this inquiry were gathered from the students’ pre- and post-test math results. The assessment instrument used for both the pre- and post-tests was the *KeyMath: A Diagnostic Inventory of Essential Mathematics*. The value of the results reported here will be in percentile rankings; that is, the value of a certain percentage of the variables fall in relation to a reference group in a standardized sample. Another term used to report results will be quartile. A quartile simply represents a data set that is divided into four. In the case of percentile scores, for example, the first quartile is the 25th percentile and scores falling within the range of the 1st to 25th percentile.

Although the initial testing was time consuming, the predetermined baseline allowed for the post- and any subsequent testing to be completed in a much timelier manner. The results from the pre- and post-*KeyMath* assessments provided the basis for this chapter’s findings.

As mentioned in the previous chapter, both the pre- and post-test student *KeyMath* results were to be compared and analyzed in four distinct ways. Pre-test and post-test mean percentile results were categorized and analyzed according to: (1) content area, (2) grade level, (3) individual Bridges math groups and (4) gender groupings. The results will be first reported on non-descriptively as findings and then those findings will be subject to additional analysis further on.

Results by Content Area

Referring to Figure 1 below, the pre- and post-post results were represented in the three distinct *Key Math* content areas – Basic Concepts, Operations and Applications. A fourth category, Total Test Scores, was added to the graph for summative purposes to
help compare and analyze how the students, collectively, were achieving when using the 
*Bridges* program.

![Figure 1. Pre- and post-test results by content area reported in mean scores](image)

The highest mean scores, in both pre-test and post-test results, were achieved in Basic Concepts. In this category, students were assessed on their understanding of the foundational knowledge of basic mathematics—numeration, rational numbers, and geometry. The students’ post-test mean score result was more than double (230 percent increase) that of their pre-test scoring. The ensuing result was that the students’ mean percentile score was raised to the second percentile from the first. The students’ post-test mean score in Basic Concepts was 68 percent higher than the next highest post-test score at the 24th percentile in Applications.

The students’ lowest mean scores, both in pre- and post-test results, were registered in Operations. This area measures students’ abilities to use math in a hierarchical progression beginning from basic math facts and ranging to performing algorithms. Their level of mental proficiency in math would also be assessed in this area. While
representing the lowest scores of any of the content areas there was a threefold increase in the post-test over the pre-test scores in Operations. That was the second largest percentage increase in any of the content areas between pre- and post-tests at 292 percent.

In Applications, students’ abilities to use their fundamental knowledge of math and their computational skills as applied to practical and functional math were assessed. The five strands looked at in Applications were: measurement, time and money, estimation, interpreting date, and problem solving. The largest percentage increase between pre- and post-test mean was achieved in this content area. A 442 percent increase in mean percentile score was gained in post-test results compared to pre-test scores. The difference between post-test and pre-test scores (18.9 percentile points) nearly parallels the difference between pre- and post-test (19.4 percentile points) scores in Basic Concepts.

Connolly (2000) noted that the development of the Applications content area, especially the Problem Solving strand, was made a priority by the National Council of Teachers in Mathematics and according to him mastery in this area “should be recognized as the highest level of performance in mathematics” (p. 8). The results as graphically displayed in Figure 1 (above) give a clear indication that gains were made in all three content areas. Of the three content areas, the second highest mean scores were achieved by students in both their pre- and post-tests in the Applications.

Thirty-three out of 34 students made gains in their total test scores. Seventeen students made gains between one and ten percentiles points. Twelve of those students, or 38 percent, made minimal gains improving their overall scores by three percentile rankings or less. One student remained at the first percentile with both his pre- and post-
test scores. On the other hand, 16 students made gains over ten percentile points including one gaining over 30 percentile points, two gaining over 40 percentile points and one over 60.

Twelve percent made gains that were significant enough to move them up at least one quartile. One student registered a percentile ranking over the 50th percentile in his post-test total test score. One scored right on the 50th percentile and three others achieved rankings placed them in the second quartile in their post-test total test results, up from the first quartile in their pre-test. The remaining participants’ made gains within the first quartile, four students with increases of twenty-one and twenty-two points.

Results by Grade Group

Total test results, with percentile scores categorized according to grade, showed that gains were made at every grade level (see Figure 2). Third grade students who attended Bridges math achieved the highest post-test tallies scoring a mean at the 24.8 percentile and posted the greatest cumulative gain between pre-test and post-test scores of 20.2 points. Fourth grade students posted the lowest mean post-test score scoring at the 9.88 percentile and made the least amount of gain, just over eight percentile points between their pre- and post-test scores. There was a slightly negative slope when comparing post-test results from lowest to highest grades indicating that lower grade student made greater achievement than senior grade.
Figure 2. Total Bridges test scores – mean percentile by grade

All five grades had mean scores under the fifth percentile in their pre-test scoring but had a greater diversity in their post-test scoring results. Fourth and seventh grade students' had similar results for both their pre- and post-test having scores between the first and second percentiles in their pre-tests and both scoring near the tenth percentile in their post-tests. Both these grade groups achieved the lowest mean of any of groups in their respective pre- and post-tests. Grade six and grade seven students achieved the greatest percentage increase between their pre- and post-test at 820 percent and 867 percent, respectively. Grade five students had the smallest margin of improvement at 435 percent. None of the Grades scored greater than the first quartile in percentile rankings in their test scoring.

Results by Bridges Groupings

Percentile comparisons of pre- and post-test mean scores, this time grouped according to assigned Bridges math group (as described in the previous chapter), indicated that students in the upper intermediate grades achieved the highest score and
made the greatest gains (see Figure 3). Students from grades 5 to 7 who attended the Bridges Three group achieved the highest mean post-test percentile score at 23.73. This group’s pre-test mean score was at the 3rd percentile, representing more than a twenty-point gain between pre- and post-test scores. Students in the lowest level Bridges group, Bridges 1, scored a mean pre-test score at the 2nd percentile and post-test score at 13.58 percentile gaining 11 points between pre-test and post-test. Bridges 2 students’ mean pre-test percentile score was 3 and their post-test mean score is almost at the 11th percentile, posting a gain of nearly eight percentile points.

![Bar chart showing pre- and post-test scores for Bridges groups](image)

**Figure 3.** Total test score – percentile scores by Bridges group – pre- and post-test

All three Bridges groups scored between the 2nd and 4th percentile in their pre-test scores. Again, none of the groups scored beyond the first quartile in any of their scoring. The Bridges 2 grouping posted a 353 percent increase in their post-test score over its pre-test score, while the Bridges 3 group more than doubled that increase posting a 726 percent increase in its post-test mean score. Bridges 2 achieved at 653 percent increase in its post-test mean score over its pre-test.
Results by Gender Grouping

When comparing total score results along gender lines (see Figure 4) gains were made by both the male and female groupings. The males’ and females’ pre-test mean percentile scores were 3.44 and 2.06 respectively. Male students scored a higher mean post-test score (18.06) than compared to the females’ post-test outcome (13.69) and achieved a larger difference (14.62) between its post-test results and its pre-test results when compared to the females’ result (11.63).

Figure 4. Percentile scores by gender – pre- and post-test scores

The females’ pre-test score (2.06) represented 60 percent of the males pre-test score (3.44), while their post-test score (13.69) represented 75 percent of the males’ (18.08). When comparing each group’s scores according to percentage gains, the females’ gain (665 percent) was greater than that achieved by the males (525 percent).
In terms of this research, for the purpose of determining the probability of difference between the pre- and post-test means, a *t*-test procedure was used to determine the level of significance. A null hypothesis would propose that there were not statistically significant differences between the mean percentile results of the *KeyMath* post-test when comparing results to the mean pre-test scores after students had participated in the *Bridges* program. The alternative hypothesis would suggest that there would be statistically significant differences between the results of the post-test over the pre-test. Using mean pre- and post-test scores as the dataset the intent was to test whether the null hypothesis would hold true. Subject to the results of a *t* test, we would expect that the alternative hypothesis would hold truer if the null hypothesis was determined false. Both the null and alternative hypothesis were in alignment with this project's current research question, that is whether a specifically chosen math program would lead to improved math results for a specific group of students.

Comparison of the results from *KeyMath* scores (see Table 4) indicated an increase in percentile rankings from the post-test over the pre-test in all three content areas of the assessment — Basic Concepts, Operations and Applications. Results from the *t*-test procedure are reported on in the following paragraphs including the level of probability of rejecting the null hypothesis and comments made on whether the result differences were statistically significant. A variety of comparisons of mean scores took place including: (1) by pre/post total test results by whole group, (2) by pre/post total test results by gender, and (3) whole group pre/post test results by content area. These results are reported on below.
Table 4

**Mean KeyMath Percentile Ranking and Standard Deviations by Content Areas and Total Test Score (n=34)**

<table>
<thead>
<tr>
<th>CONTENT</th>
<th>All</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Gain/loss</td>
</tr>
<tr>
<td>Basic Concepts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.00</td>
<td>34.26</td>
<td>+19.26</td>
</tr>
<tr>
<td>Operations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.03</td>
<td>11.35</td>
<td>+7.32</td>
</tr>
<tr>
<td></td>
<td>3.84</td>
<td>9.29</td>
<td></td>
</tr>
<tr>
<td>Applications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.35</td>
<td>23.97</td>
<td>+18.62</td>
</tr>
<tr>
<td></td>
<td>6.20</td>
<td>18.68</td>
<td></td>
</tr>
<tr>
<td>Total Test Scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.79</td>
<td>16.00</td>
<td>+13.21</td>
</tr>
<tr>
<td></td>
<td>2.46</td>
<td>14.76</td>
<td></td>
</tr>
</tbody>
</table>

There were statistically significant differences when comparing pre- to post-test total test scores. For the matched groups’ *t*-test the mean differences for Total Test Scores (n=34) showed a relatively greater mean percentile achievement for the post-test group, mean differences being: pre-test, 2.79; post-test, 16. For comparison, the table value of *t* critical is 2.03. The *t*-test for paired two sample for means yielded a *t* of 5.46, *p*<.05 for the post-test percentile results establishing a statistically significant improvement of post-
test scores over pre-test scores and very strong evidence against the null hypothesis in favour of the alternative.

The male group's (n=18) pre-test mean percentile ranking was 3.44 and their post-test score was 18.06, indicating a difference of almost 14 points. The table value for $t$ critical is 2.11. The $t$-test for paired two sample of means yielded a $t$ of 3.82, $p<.05$ for the post-test percentile results establishing a statistically significant improvement of post-test scores over pre-test scores for this gender group and strong evidence against the null hypothesis in favour of the alternative.

We have similar results with the gains made by the female grouping (n =16) in their total test scores. For the matched groups' $t$-test, the mean differences for total test scores for the female group showed a relatively greater mean percentile achievement in post-test scores, mean differences being: pre-test, 2.06; post-test, 13.69, a gain of over 11 points. The table value for $t$ critical is 2.13. The $t$-test for paired two sample for means yielded a $t$ of 4.01, $p<.05$ for the post-test percentile results, again establishing a statistically significant improvement of post-test scores over pre-test scores and again strong evidence against the null hypothesis in favour of the alternative.

Gains were also made from pre- to post-test results (n=34) in all three content areas (see Table 4) and in total test scores. Overall mean scores were 15.00 and 34.26 respectively from pre-test to post-test in Basic Concepts for a total gain of 19.26. The table value for $t$ critical is 2.03. The $t$-test for paired two sample for means yielded a $t$ of 8.30, $p<.05$ for the post-test percentile results, again establishing a statistically significant improvement of post-test scores over pre-test scores and very strong evidence against the
null hypothesis in favour of the alternative and very strong evidence against the null hypothesis in favour of the alternative hypothesis.

In Operations (n=34), the pre-test overall percentile ranking was 4.03 and 11.35 for post-test -- a gain of 7.32. The table value for $t$ critical is again 2.03. The $t$-test for paired two sample for means yielded a $t$ of 4.83, $p<.05$ for the post-test percentile results, again establishing a statistically significant improvement of post-test scores over pre-test scores and very strong evidence against the null hypothesis in favour of the alternative.

In Applications (n=34) the pre- and post-test percentile ranking were 5.36 and 23.97 respectively, for a gain of 18.62 percentiles. Once again, the table value for $t$ critical is 2.03. The $t$-test for paired two sample for means yielded a $t$ of 6.60, $p<.05$ for the post-test percentile results, again establishing a statistically significant improvement of post-test scores over pre-test scores and once again very strong evidence against the null hypothesis in favour of the alternative hypothesis.

In all the $t$-test results above a statistically significant improvement of post-test scores over pre-test scores was established. The p-value result for each group configuration and in each content area suggests strong ($p<0.001$) or very strong evidence ($p < 0.001$) against the null hypothesis in favour of an alternative. Both the $t$ test statistics and the p-value statistics suggest rejection of the null hypothesis in favour of an alternative.

Result Comparisons

Growth was achieved in Basic Concepts by all but one of the 34 students. The one student’s score declined by one percentile point from seven to six, when comparing his post-test results to his pre-test results. Fewer students scored above the group mean in
their post-test scores than when compared to the pre-test results. Sixteen students scored at or above the mean in their pre-test results while fifteen scored at or above in their post-test scores.

The students' highest mean rankings, both in the pre-test and post-test results, were also found in Basic Concepts. It is noteworthy that the post-test mean score was at the 34.26 percentile, and greater than one standard deviation (16.03) from the pre-test score of fifteen. This represents a significant gain. Three students scored exactly at the 50th percentile and five better, ten students scored in the first quartile and the remaining 16 scored in the second quartile (see Table 7).

Table 5

Gain/Loss Comparison of Mean Scores By Gender to Overall Group Mean Scores: Pre- and Post-test (N=34)

<table>
<thead>
<tr>
<th>Content</th>
<th>Pre-Test Mean Score</th>
<th>Pre-Test Male</th>
<th>Pre-Test Female</th>
<th>Post-Test Mean Score</th>
<th>Post-Test Male</th>
<th>Post-Test Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Concepts</td>
<td>15.00</td>
<td>+1.44</td>
<td>-1.62</td>
<td>34.26</td>
<td>+2.24</td>
<td>-2.51</td>
</tr>
<tr>
<td>Operations</td>
<td>4.03</td>
<td>+0.75</td>
<td>-0.84</td>
<td>11.35</td>
<td>-0.24</td>
<td>+0.28</td>
</tr>
<tr>
<td>Applications</td>
<td>5.35</td>
<td>+1.98</td>
<td>-2.22</td>
<td>23.97</td>
<td>+4.77</td>
<td>-5.28</td>
</tr>
<tr>
<td>Total Scores</td>
<td>2.79</td>
<td>+0.65</td>
<td>-0.73</td>
<td>16.00</td>
<td>+2.06</td>
<td>-2.31</td>
</tr>
</tbody>
</table>

All except one made gains in their percentile scores when comparing student post-test to their pre-test results in the Applications content area. The one which did not remained at the first percentile. This group's mean pre- and post-test scores were at the 5.35 and 23.97 percentile respectively. Three students scored above the 50th percentile at
the 61st, 63rd, and 77th percentile respectively, and two of the three made gains of over 60 percentiles points in their post-test when compared to their pre-test scores. Fourteen students scored at or above the first quartile while 20 scored below. Eleven students scored above the pre-test mean score and 14 students scored above the post-test mean. Again, all but one student improved their scores when comparing pre- and post-test scores. While improvement is noted, over 90 percent of the student scores remain below the 50th percentile.

Of the three content areas, students scored the lowest mean pre-test and post-test scores in Operations (see Table 5). Operations was also the content area where students achieved the smallest margin of improvement between post- and pre-test scores. None of the students scored above the first quartile in their pre-test while four students scored above the first quartile in their post-test. Post-test Operations results were the only area where the female participants achieved higher scores than the male participants did. It is also the only content area where the female group scored above the group mean as well. Male participants scored above the mean in all in all other content areas, while the females scored below.
Figure 5 gives a graphic representation of gains made between pre- and post-test scores by grade in all content areas. When categorized this way the highest mean score both in pre- and post-test scoring was registered in Basic Concepts, followed secondly in Applications. Both the pre-test and post-test scores in Operations were the lowest. When comparing gains or loses made between pre-test and post-test scores, students at every grade level and in every content area made gains. Students in Grade 3 had the highest mean pre-test scores in all content areas and also had the highest mean post-test rankings. Students in seventh grade achieved the greatest overall margin of gain when comparing their post-test to their pre-test scores in Basic Concepts. This same group also made the least amount of gains in Operations again when comparing their pre-test to post-test scores.
A scatter plot diagram of Total Test scores of all Bridges groups (see Figure 6) indicates distinct outliers. These outliers were results inconsistent to the group norm.

Two distinct outliers for the Bridges 1 Group include Student 3 who scored in the third percentile in her pre-test total test score and scored in the 34th percentile with her post-test score. Student 9 had a pre-test score of seven and a post-test score of 50. Both post-test results are at least double the next highest post-test score and significantly beyond the group mean of 13.58. Both students had scored above the group’s mean percentile score of 2.08 in their pre-tests with Student 9 scoring at the seventh percentile, four percentile points greater than the next nearest score and approximately five percentiles above the group mean.

Total test results for the Bridges 2 group also contained outliers. Compared to the groups’ mean pre-test percentile score of 3.1 and the group’s post-test mean of 10.9, student 16 had a pre-test score six points greater than the group’s mean of nine. Yet his post-test score, eight points higher than the mean, did not significantly fall beyond Bridges 2 group mean when compared to two others. Students 13 scored two percentile points above the mean in the pre-test and had a cumulative post-test score significantly beyond the mean at 27. Student 22 had a mean pre-test total score of one, two percentile points below the mean, and showed significant improvement in his mean post-test scores scoring at the 23rd percentile and almost 13 points above the group’s mean post-test score.
Figure 6. Identified outliers of total test scores – all Bridges groups

Bridges 3 Group’s results show the greatest gains made from pre- to post-tests. It is also the group that has individuals who have made greatest gains. Student 25, with a pre-test score near the group mean (3.27), scored significantly higher than the group mean (23.73), at the 68th percentile, with his post-test score. This score was the highest amongst all the participants. Student 29 also made significant gains scoring at the 3rd percentile in her pre-test score and at the 45th percentile in her post-test. Another interesting anomaly are the scores posted by Student 28 who scored well-beyond the mean average at the 12th
percentile with his pre-test score but only improved by one percentile point when comparing his pre- to his post- total test scores.

Analysis

Initial results of all the data gathered from the Key Math pre- and post-tests suggested that students were making gains in their math learning while attending Bridges math groups. This growth was evident with increased mean post-test scores in all three concept areas over pre-test scores. According to t-tests performed in the data analysis the gains made in all three content areas were statistically significant.

The p-value results corroborate such evidence with $p < 0.001$ or $< 0.01$ in all analysis suggesting a rejection of the null hypothesis suggesting no difference between pre-test and post-test mean scores. Instead, these results suggest there is a statically significant difference between the pre-test and post-test mean scores and that we accept the alternative hypothesis. Given that post-test mean scores are greater than those of the pre-test, the alternative hypothesis would suggest improvement.

The students’ highest mean rankings, both in the pre-test and post-test results, were found in Basic Concepts. This result would suggest that students were further developing their functional understanding of foundational knowledge of basic math. This was an area that staff focused on with the students prior to introducing the Bridges program with many of the students who were participating in alternative math programs being supported in various ways using a variety of resources, but without long-term planning, in the very basic concepts of numeration, rational numbers and geometry. It is not surprising that students showed some ability in this area in their pre-test results as they have had very basic and repeated exposure to these concepts. In fact their math learning
experience prior to the introduction of the *Bridges* program had not deviated much away from working with very basic concepts.

It is noteworthy that the post-test mean score was at the 34.26 percentile, an improvement from the 15th percentile of the pre-test mean score, and moving this group collectively from two to one standard deviation from the mean standard score. This group of students scored higher than 15 percent of students of similar age tested at this level with their pre-test score and scored higher than 34 percent with their post-test results. Another way to put this finding is that 15 percent of the scores are the same as or lower than the group’s pre-test mean score, and so, 85 percent of the scores are higher.

Regarding the post-test mean results, 34 percent of the scores are the same as or lower than this group’s and only 66 percent are higher. This is a statistically-significant gain, moving to within one standard deviation of the mean reflects significant movement closer to the mean of a standardized sample.

Students’ lowest mean scores, both in their pre- and post-test results, were registered in the content area of Operations, as were the gains made between pre- and post test. This would not be surprising to staff involved as this area had already been identified as an area of struggle for the students. Specifically, students had been struggling being consistent with the algorithmic portion of their math learning. Many of these students possessed or displayed characteristics associated with learning disabilities and often struggled with remembering algorithms procedures for computing from day to day.

A correlation between improvement in Basic Concepts and improving Operations scores should also not be surprising as, according to Connolly (2000), performance in the
latter is dependent on students’ understanding of both numeration and rational number concepts listed under Basic Concepts. There was significant improvement in Basic Concepts and small improvement in Operations, even less so with students in seventh grade. This is somewhat inconsistent with the prior assumption, or an indication that students have not yet reached a functional skill level in the areas of numeration and rational numbers yet. Improving scores in Operation, dependent on students understanding of Basic Concepts, as indicated above by Connolly, has not yet been clearly manifested given the lower scores.

The strands in the Applications area, measurement, time and money, estimation, and so forth, represent a very authentic and practical dimension to math learning. Many of the students used a number of these skills on a daily basis and therefore performing those skills seemed second nature and familiar to them. They were often able to give accurate and often correct responses but did struggle to recognize and articulate their thought process when asked to explain the logic behind their responses. Occasionally, students would demonstrate their lack of foundational and conceptual knowledge in responses that lacked logic. For example, an unsound response would be to report that ten thousand pennies equals a million dollars, or that their measurement of a book cover would be in meters. When queried to explain how they got to their answer in such examples, they would be at a loss to explain their thinking, struggling where to begin solving such a problem.

There were increases from pre- to pre-test scores in Applications, and significant growth was noted for most students when comparing these results. It was a small number who scored well beyond the mean in their post-tests. In certain circumstances a few
exceptional scores certainly skewed the mean in a positive direction and as a result there was a positive increase in the mean score. Improving scores resulted with an increase of nine in the second quartile, one in the third quartile and one in the fourth. While noting there was some movement from the first to the second and to the third quartiles when comparing pre-test to post-test results of individual content area, in reality there was not a lot from the first quartile to other quartiles in total test results.

The results from total test scores, while not as spectacular as the scores derived in the individual content areas, have indicated improvement. The majority had relatively small increases, increasing three or less percentiles. Yet when those increases were transformed into percentages they were two, three, and four hundred percent improvement over the pre-test score. Larger increases, which included percentage improvements of up to 1700 percent, were also prevalent. These improved total test scores augment the progress noted in individual content areas and certainly confirms the growth taken place.
As indicated previously, gender representation in this study was relatively balanced with 16 female and 18 male student participants involved in the three math groups. While this study does not feature significant differences between gender groups, the male group achieved slightly greater overall test scores (see Figure 4). Male students achieved the top places scoring at the 68th and the 50th percentile in their total test scores. Two female students achieved a third and fourth standing with scores recorded at the 45th and 34th percentile respectively. Recent studies (Hyde, Lindberg, Linn, Ellis & Williams, 2008; Hyde & Mertz, 2009) suggest this to be now an anomaly as current research indicates that gender differences in math performance no longer exist or exist for reasons other than ability.

A number of students who placed as outliers in the scatter diagrams are anomalies due to their exceptional positive scores either in their pre-test or post-test scores or both. Although they have academic struggles, their outlier designation is a result of a higher than normal scores in one or both of the tests. These students show glimpses of ability and are able to verbalize their math skills and knowledge on an inconsistent basis. Inconsistency is the norm for many of these students in their academic performance and throughout their school years as their inability to focus and the associated behavioural issues often seem detrimental to their learning.

When successful, their responses and the skills that they applied to solving math challenges reflected their “street smarts” as they integrated a personal skill set and unique life experience to solving math problems and other challenges. The top five students in total score percentile rankings all exhibited these characteristics. They struggled with academics and with some of the ways typically students were assessed. Yet in certain
circumstances their knowledge and their ability to negotiate, navigate, and solve problems reflecting common, everyday situations gave them an opportunity to show a unique sense of ability. In this context, it was not surprising that these students made the gains they did in the Applications where the focus was certainly on these practical skills. Gains made within this content area measured a close second to the gains made in Basic Skills indicating a certain level of development and competence.

It is difficult to conclude for certain why the outliers. An explanation giving credence to the *Bridges in Mathematics* program, the impact of its content and its delivery methods, is certainly plausible. It was well-known and well documented that students 25 and 29 (Figure 6) had been struggling with their math learning over the years and needs like theirs were the impetus for seeking and establishing and alternate math program. An unknown variable, and one more difficult to track, could be a specific teaching style that significantly impacted their learning. Other variables to consider could be a reduced class size, or consistency and regularity of the math timetable.

Again referring to Figure 6, students 16 and 28 had scores beyond and well beyond the mean in pre-test scoring yet were identified as students who would benefit from *Bridges* math group support. Their pre-test scores might have suggested that they remain in their mainstream math classroom yet their post-test scores would support them being involved in the *Bridges* program. These two students were only two of a total of five students who experienced a declining score when comparing their post-test to their pre-test score in a content area and the only two with a decline in Operations. In an attempt to maintain anonymity, the results would suggest or re-affirm that their difficulties are not
simply deficiencies in math but rather be indicative of more complex issues involving learning abilities.

A portion of these students was in fifth, sixth and seventh grade and given their record to date have made significant gains since beginning the *Bridges* program. Some students are in their seventh year of formal math learning (Kindergarten to seventh grade) and have had a history of struggle over time. They scored low in their pre-test percentile scoring that confirming their on-going struggle. Since their participation in this program they have shown progress evidenced in significantly increased percentile gains in their post-tests suggesting credit to their participation in the program.

The time lapse between pre-test and post-test for all participants in *Bridges* math ranged from seven months to no more than twenty months. In Table 7 the participants were divided into two lists according to the time periods that had lapsed between individual pre- and post-test. These results suggests that continued improvement over time may possibly not be so much a feature as was the immediacy in improvement at the introduction of the intervention.

Table 7  
*Percentile Gains Comparing Pre-test / Post-test Mean Scores – Grouped According to Period of Time (n=34)*

<table>
<thead>
<tr>
<th>Time Period</th>
<th>1 – 12 months</th>
<th>13 – 24 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>Percentile Rank</td>
<td>3.6</td>
<td>19.2</td>
</tr>
<tr>
<td>Gains</td>
<td>15.6</td>
<td></td>
</tr>
</tbody>
</table>
The time span between the administration of the *KeyMath* (Connolly, 2000) pre-test and the administration of the post-test to one group of students is significantly longer than the other, but the scores indicate reduced progress made by the group who had a greater length of time of the intervention between pre- and post-tests. It is arguable despite when the *KeyMath* pre-assessment was applied it is not the time lapse that positively influences the students’ progress but rather the application of the math intervention.

When comparing post-test math results by grade to those by *Bridges* groups, while gains are recorded for all groupings, those by *Bridges* group showed the greatest gains and highest percentile rankings were achieved senior *Bridges* 3 grouping. This is contrasting to when the statistics are presented by grade groupings the data shows that the highest score and greatest gains were at the lowest grade level. The configuration of these two groups is different with ability and performance being significant criteria impacting the placement key results. Students who were selected to participate in the modified math groups were tested for their age levels. They were sorted and placed into their *Bridges* group to these results. Lower scoring students tended to be placed into the lower level group thus reducing the mean pre-test mean scores in that lower level group. Higher scoring students were typically placed at the next group level up and increased that group’s mean score. Theoretically, after the intervention was applied, in this case the *Bridges* program, growth should be apparent and consistent, throughout the groups. Growth was apparent. Consistent growth was not.

It is arguable that for those at the higher grades and who made progress during the period of this study that this progress was a significant advancement. This is even more
noteworthy when set in a larger context. Many of the participants in the Bridges program were in senior grades and have made little gains over time (as evidenced in their pre-test scores). The gains made during the period of the Bridges intervention under this study were statistically significant, and a substantial improvement especially given the limited progress made over the prior years.

Chapter Summary

There are a number of factors that contribute to students achieving at lower levels in inner city schools. Environmental factors, including the level of parental support and the impact of living in poverty to name a couple, play a big part in impeding a student’s progress. As discussed previously, studies show that students living in poverty are likely at a disadvantage academically right from the very start of their school experience and that disadvantage seemingly worsens over time.

Similar in experience to many others attending inner-city schools, the student participants involved in this study struggled to be successful in their academics. Their struggles in math became a feature for this study. The student participants were placed in relatively smaller math groups, their placement determined by the individual’s ability and maturity level among other things, and teachers used the Bridges in Mathematics program as their primary resource. Their aims and theirs goal were for these students, who have a history of struggling in math, to experience greater success in their math learning.

While past beliefs held that not all would have success in math current literature suggests hope to those who are struggling. Many prominent scholars suggest that for students to make their own meaning of math learning it must take on a constructivist
bent. That was largely the rational for the school to implement the *Bridges* program for these struggling learners.

There were a total of 34 student participants from which data was gathered, 18 males and 16 females. These students were in elementary school attending grades ranging from three to seven. A number of these students had adapted or modified Individual Education Plans in math that directed those involved with ways help in their learning. These students were specifically selected to attend special modified math groups during a time coordinated by the school when most of the student population was attending math classes.

These math groups were intended to be smaller than regular class size so that more hands on and one-to-one learning could take place. Typically these math groups had numbers ranging from thirteen to fifteen. The *Bridges in Mathematics* program was utilized and formed the basis for math learning resource for these groups. Although not without its critiques it represented a sound and user-friendly constructivist approach to learning. Perhaps its most attractive feature was that it was very methodical and thorough in prescribing what to do and how to deliver the various elements of the program.

The students attending these math groups completed an initial *KeyMath* assessment prior to being assigned to their *Bridges* group. This assessment, along with the student’s past performance in math, along with the classroom teacher’s input, were all factors in helping staff decide whether they were likely candidates to participate and at what level they would participate in the *Bridges* program. With the intention to discern further growth in their math learning, the majority of these students were re-assessed using
KeyMath once again. These pre- and post-test results provided the data for this project’s findings.

The data gathered from both the pre-test and post-test was presented in percentile rankings. The data was categorized and analyzed in a variety of ways. Specifically it was organized for analysis according to grade divisions, math group levels and along lines of gender. There were distinct and definite improvements from post-test over pre-test scores when analyzing the scores from these different perspectives. In fact, a significant difference was found between the percentile means of post-test scores when compared to pre-test scores when t-tests were performed indicating significant differences between the two.

There were improvements at varying degrees in all areas and by all groups. The largest improvement and greatest margin of improvement was in Basic Concepts. The least, and in both their pre-tests and post-tests, was in Operations. This and other findings will be discussed further on.

Results were analysed in attempt to gauge the efficacy of the program as it relates to teaching students who struggle academically and are on modified math IEPs. Students in grades ranging from 3 to 7 attend ability appropriate math lessons separate from their classroom peers. The staff held the belief that all students at their school could learn and had implemented Bridges in Mathematics with the intent of improving the learning experience of those students who struggled with math. The analysis was intended to discuss the impact the Bridges program had on the students’ learning.

Initial analysis of post-test KeyMath results compared to pre-test results from the same assessment indicated that students’ achievement scores in all content areas
increased. The greatest gains and highest mean scores in both pre-test and post-test results were made in Basic Concepts followed, again in both result categories, by Applications. Students scored lowest in both their pre- and post-test mean scores and made the least amount of gains between pre- and post-test in Operations. Statistical analysis by way of a $t$ test indicated that the gains made in all three content areas are statistically significant.

While the results are encouraging the gains made remain subject to further and ongoing review. The percentile scores for post-test results in all content areas remain low with 94 percent of the percentile scores falling below the median quartile. In general terms this kind of achievement would be disappointing. But given these students’ history of struggle with understanding math the gains they made in their post-test results compared to where they began as evidenced in their pre-test results makes the impact of the program intriguing.
CHAPTER 5 -- CONCLUSIONS AND RECOMMENDATIONS

This study was an investigation into whether a specific math program impacted, in a positive way, the learning of an identified group of elementary students struggling in math. The group consisted of 34 students, from grades three to seven, who had exhibited a history of math difficulties and had been identified in a variety of ways as unable to cope with the current math curriculum and its teaching in the regular classroom. A high percentage of students attending the target school were best described as living in poverty. Issues surrounding regular attendance, adequate food and clothing, familial dysfunction, inadequate living conditions, lack of trust of educators and the education system, and how students spent their time out-of-school all gave some indication that these students lived life under less-than-ideal conditions.

Conclusions

The school and its staff, best reflected in the support that they wanted available, made significant efforts to counter their students' life's challenges. A number of supports were put in place over the years including supplemental personnel such as youth and community workers, an aboriginal education worker, a councillor and extra full-time equivalents to facilitate smaller class sizes (specifically at the primary level). There were a number of other support teachers hired to specifically support students with their various learning needs. There was also an extensive meals program that ran at the school offering hot breakfasts and lunches for those students who were enrolled. Many families took advantage of the extras.

One area that staff had recognized as needing bolstering was in the area of math, specifically for those students who found mainstream math too difficult. Staff had
recognized these challenges for some time, and had made serious efforts to support
students' math learning in the past, but further intervention was wanting. Prior
experiences by two teachers using the *Bridges in Mathematics* program made it a
desirable option to pilot and initial success gave impetus for further investigation. First
piloted with one modified math group, two more levels of the *Bridges* program were
purchased and the initial one enhanced. All three were used for 2007/2008 school year in
three different levels of modified math classes containing a variety of students from
different grade levels and at varying ages.

Staff wanted to measure the effectiveness of the program and this study
incorporates the assessment results derived from *KeyMath: A Diagnostic Inventory of
Essential Mathematics* first administered to help determine the initial placement of the
students, and then re-administered again near the end of the school year to measure for
growth. At the genesis of implementing the *Bridges* program, there had been no intention
for this current study project. Fortunately, pre-test and post-test results were kept and
these results played a significant function in answering if and how much the *Bridges*
program helped increase these modified-math learners' understanding of math concepts.

For the sake of expediency, *KeyMath*’s pre-existing framework was used to report
on the investigation and the results. What was confirmed was that these students were
indeed low in math often scoring in the lower to lowest percentiles in each of the three
content areas that *KeyMath* assesses. What was also evident in these results was that
students’ pre-existing strengths and weakness were also reflected. Unknown factors
included the need for a detailed analysis and how much improvement took place.
Relative to an average class of students these students’ scores were unsurprisingly low given their struggles with math. But previous attention to very basic concepts in previous years led to low yet promising pre-test results in Basic Concepts. Further attention to this area with the Bridges program throughout the school year resulted in improving post-test scores. In fact, so significant were the improvements that the post-test mean score moved the group from two to within one standard deviation of the mean. Scores were lowest in Operations and mirrored the students’ already-known difficulties retaining and performing algorithmic operations. Students scored second highest in the area of Applications where again their results reflected low scores but promising progress and featured a couple of students’ strong aptitude in this area. Although the percentile scores in all three concept areas were relatively low, most notably in the students’ pre-assessment results, statistically significant growth occurred in all three of the content areas.

These findings and the ensuing analysis of these findings will augment and contribute to the lengthy and on-going debate surrounding effective and inclusive math learning in education. The results are consistent with and give credence to the message that the constructivist approach, often mentioned in current literature and discussed in Chapter 2 of this project, is effective. To review, constructivists advocate moving away from rote memory learning and toward involving students in their own meaning of math within their own frames of reference. Given timely intervention and appropriate resources, constructivists argue against the notion that math learning is selective but advocate that math learning is achievable for all.
Given their academic, social, and economic deficits many of these students struggled to be successful in school and specifically in math on a day-to-day basis. What these current results show is that a resource like the constructivist *Bridges in Mathematics* program, when used in a specific learning environment and with a school staff motivated to help struggling students, in the short term, assisted students to improve their math skills and gave them an opportunity to experience success within their own contexts.

**Recommendations**

These findings are important as they not only give hope for further success for the students and for school staff in similar circumstances but also district personnel who are always looking to better the learning experience of students with similar experiences who are in comparable situations. Given the importance, it would be useful if this current study were both continued longitudinally and replicated in other circumstances. Discovery of further success with this current cohort of students would be both interesting and reaffirming that the current evidence of progress was not simply a temporary spike but rather the beginning further continued improvement.

It would also be worthwhile to further investigate and expand the analysis of the current results. An in-depth analysis of the results in strands, for example, did not take happen as it did not fit into the scope or the timeframe of this current project. Further investigation would undoubtedly strengthen and add perspective to the current findings. Gender differences related to performance were only touched upon in this current study but with the results already at hand combined with future results gender issues and math learning could be further investigated in more depth and detail. Another angle to take in
the analysis of the current results is to investigate how students who are truly learning
disabled compare with those who are undiagnosed yet who are also struggling in math.
The teacher effect as a variable would also be an interesting and potentially useful
approach in analyzing the data for information. How much do teachers, with their
different teaching styles and different styles of management affect the students’ learning
and impact results?

Replication of this math adventure at another school, with students who are in
similar circumstances or even with students who are not, would also be invaluable to
verifying (or not) the effectiveness of running such a program within a similar framework
but with a different group of students. It would be interesting to discover what kind of
impact such a program has in a more mainstream classroom with more math savvy
students. And again, replication would give the opportunity to better gauge the effect of
the teacher as a variable and as an agent for success with math learning. Other further
variables to consider would include the effect of the reduced class size, and the impact of
a consistent and regular math timetable.

A criticism the staff had of the Bridges in Mathematics is that it is published in the
United States and that some of its content reflects American standards. Staff needed to
make adjustments to some of the program’s content and materials to better reflect
Canadian standards and culture. For example, American currency had to be converted to
Canadian. American standards in measurement needed to be changed to metric scales
While not insurmountable, these edits require time and the luxury of time is often in short
supply in education. Also, the publication source and the associated content dilemma
make the Bridges program less likely to be an approved source within the district and
likely within a Canadian school context. The question worth asking then is whether there is a program which would meet the needs of this segment of our learners and which produces comparable results for our learners but is published in a Canadian format containing Canadian content. In that vein, a side-by-side comparison of another program might be warranted, complete with an in-depth analysis of results. This would be worthwhile to find a comparable Canadian resource to satisfy those who make Canadian content a high priority, or if not, a justification to continue using the current *Bridges* program and changing the American slant.

At the start of this writing, reference was made to National Council of Teachers of Mathematics' (NCTM) assertions first contained in its Curriculum and Evaluation Standards (1989) and in its subsequent releases (1991, 1995, & 2000), as well as the assertions of other prominent scholars' (Ashlock, 2010; Burns 2006; Van de Walle, 2006) who advocated that math learning should be accessible for all as learning it was possible for everyone. To ensure that learning was inclusive and successful the experts prescribed involving a high level of expectation, that it was delivered using a constructivist model and made the necessary accommodations to meet a diversity of learning abilities. This idea was not without its detractors (see Hortocollis, 2000; O'Brien, 2007; Schoenfeld, 2004; Wang, 2001) who felt that some math is very difficult to learn.

Within that context the results presented in this study tend to buoy the former argument suggesting that success in learning math is achievable for all. This study looked at a group of elementary school students who chronically struggled with their math learning. After the implementation of a constructivist oriented math program, *Bridges in Mathematics*, which was framed around the NCTM's philosophical bent of
math learning for all, there was distinct growth and achievement for the majority of the students in all areas of math. These results suggest continued implementation of the math program with continued analysis of the results.
REFERENCES


Van de Walle, J.A. (1999, April 23). Reform mathematics vs. the basics: Understanding the Conflict and dealing with it. Presentation for the 77th Annual Meeting of
NCTM Retrieved June 6, 2009, from Mathematically Sane Web site:

