JUMP MATH IN A GRADE FOUR CLASSROOM

by

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Abstract

It is important for any new curriculum to go through a series of tests to ensure its effectiveness before a widespread adoption of the material into school systems. This evaluation should examine how students, including those who are low achieving (LA), perform with the use of the program. The primary purpose of this study was to compare the progress that three groups of students made, when teachers used different methods of mathematics instruction. One group of teachers used exclusively JUMP Math (JM1), one group of teachers used the materials used by the school district in the past (Control) and a third group of teachers used a combination of these two methods (JM2). Computational skills, fluency of simple addition, subtraction and multiplication questions, and number series measures were used to assess students in a pretest post-test quasi-experimental manner. The analysis conducted was achieved by using the change in scores between the pretest and the post-tests. For the whole sample, significant results were found on two of the measures. On one of the computational skills measures the control group was significantly better than JM1, and on the number series measure JM1 performed significantly better than JM2. For the students who were low achieving, JM2 performed significantly better than JM1 on the fluency measure. The other comparisons did not show statistical differences. As this was the first year for the teachers in the experimental conditions to use the JM program, future research should inquire whether there is a difference between the students when they are more comfortable with the program.

Preface

The graduate student and the members of the school district where the study took place conducted this study. This data is a subset taken from a larger study taking place in the district with the JM program. The student did so under the advisement of her supervisor. The graduate student was responsible for assisting in the data collection, analyzing the data and writing this thesis. Therefore this is representative of her work as the primary researcher for this project and as the lead author. This study met the requirements put forward by the UBC Behavioural Research Ethics board for ethical treatment for research involving human subjects. The Ethics Certificate Number was H10-02640.

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To my parents

Chapter 1: Introduction

Mathematics proficiency is an essential skill for many aspects of daily life, including the arithmetic needed for paying for good and services, measurement for baking, as well as the ability to tell and keep track of time for scheduling daily activities. Since mathematics is such a significant part of everyday life, it is important for educators to ensure they are using current, evidence-based materials that meet the standards put forward by the National Council of Teachers of Mathematics (NCTM). Regrettably, there are still many classrooms in today's schools that are using textbooks created on outdated standards. In 1989, the NCTM released standards suggesting teachers move away from having their students memorize math facts and work with algorithms and procedures towards an approach using problem solving as a way for students to discover mathematical concepts (Mighton, 2007). The NCTM (2000) stated that "... some of the pedagogical ideas from the NCTM *Standards* – such as the emphases on discourse, worthwhile mathematical tasks, or learning through problem solving – have been enacted without sufficient attention to students' understanding of mathematics content" (pp. 5-6). This meant some teachers were misapplying the constructivist notion of mathematics the standards (NCTM, 1989) were promoting (NCTM, 2000; Mighton, 2007).

Mayer (2004) reports that teachers should abandon the use of unassisted discovery based learning because he feels there is a lack of evidence for this method of instruction in improving students' learning outcomes. Discovery based learning hasn't shown to help students learn problem solving rules and it does not ensure students understand or learn the targeted skills through the lesson (Mayer, 2004). Bruner (1961) found even though discovery based learning has the potential to enhance learning experiences, students require having a good knowledge base before it is used, and he found that the incorrect use of discovery based learning provides very limited benefits to students. Klahr (2009) echoes this concern stating students, especially novice learners, often do not possess the skills required to discover the concepts they are expected to with the materials they are provided. For example, Klahr and Nigam (2004) when looking at instructional approaches in a science curriculum found that 77% of students met the mastery criteria for the unit while only 23% of students met the mastery criteria taught using a discovery learning instructional model over the same time period. Klahr (2009) believes using a direct instructional approach saves time and allows extra time to be spent practicing the new concepts.

The NCTM (2000) notes that students must develop mathematical understanding through actively building their familiarity by connecting their prior knowledge with newly learned skills. Mighton (2007) argues that such materials are often based on the assumption that through having the students play with the concrete materials, they will develop a natural understanding of the mathematical concepts with little guidance from their teacher. This method of unassisted discovery based learning contradicts the NCTM (2000) proposal that for mathematics instruction to be effective, educators must recognize what their students know and what they still need to learn. Hiebert (1999) cautions that if students continue to practice a concept before they have a true understanding of it the student will have a harder time comprehending the concept later. When teachers have an understanding of their students' limitations, they can improve their pupils' success by connecting their prior mathematical knowledge with the new material (NCTM, 2000). Mighton (2007) believes that for educators to assess successfully where students are in their learning, teachers must break new concepts in to small steps. Hiebert (1999) also mentions that many of the traditional teaching approaches used in mathematics are deficient but he feels these methods can be improved by incorporating more opportunities for intervention and practice during a lesson. Teaching done in this way will allow the teacher to discover at what stage the student is struggling so the appropriate remediation may occur. This method follows Gobet's (2005) recommendation of presenting new concepts in chunks that are the right size and difficulty level to assist students in directing their attention to the important aspects of the new material, which in turn helps the acquisition of the new material. According to Alifieri, Brooks, Aldrich, and Tenenbaum (2011), to assist students in learning new tasks, teachers should have scaffolding in place to help support the student, if they need it, while they are attempting to reach the learning objectives.

In 2011, a member of the Pacific Institute for the Mathematical Sciences submitted a document to the BC Ministry of Education discussing the current state of mathematics education, which discussed areas of concern with the current British Columbia curriculum, and some of the popular textbooks used in today's classrooms (Pacific Institute for the Mathematical Sciences, 2011). Many of the textbooks currently used in classrooms do not present the materials in a straightforward manner making it difficult for teachers who do not feel confident in their mathematical ability to teach the lessons. Some teachers report being unable help students make connections in the lessons from the textbooks because they do not have enough familiarity with the concepts themselves. This PIMS report stresses the importance of writing curricular materials in a manner to help teachers understand the concepts they are expected to teach students. Additionally, it provides suggestions on how to teach these concepts and how the topics they teach fit into mathematical understanding as a whole (Pacific Institute for the Mathematical Sciences, 2011).

1.1 The JUMP Math Program

Dr. John Mighton is an award-winning playwright and he holds a Ph.D. in Mathematics from the University of Toronto. Through his experiences tutoring students who struggled in math and his extensive knowledge of mathematics, he developed a non-profit, Canadian-designed math program called Junior Undiscovered Mathematics Prodigies or JUMP Math (JM) for short. The struggling students that were sent to his tutoring program required Mighton to reduce his lessons into small, incremental steps to ensure the students could learn the material. From these tutoring sessions he created a handbook for the other JM tutors to teach from and he later developed the workbooks that can be used in the classroom.

As indicated in a recent book review, this program uses a Piagetian-inspired constructivist framework; the teaching creates conceptual learning through challenging students' current beliefs and what they experience in a lesson (Kirshner, 2010). JM is now available for classroom use with two workbooks per grade that meet the Ontario, Canada curriculum standards, teacher guides and a variety of other resources. Maciejewski (2012) used the JM program with college students and did so because each lesson is clearly presented, not overwhelming students with unnecessary pictures, wordy explanations and unclear questions. There have been several informal reports, put out in association with JM, which have shown success students have found using the JM program in both Canada and in England (Aduba, 2006, 2007, 2009; Biswas Mellamphy, 2004; Hughes, 2004). The principles behind JM provide insight into how the program works. Primarily, it is important to remember almost all numerical concepts can be thought of as either counting or grouping objects into sets (Mighton, 2003, 2007). It is essential for individuals to be able to create a model or a picture that represents abstract mathematics concepts or questions. Mighton (2003) notes that it is better to teach students new concepts before introducing the rules. He also believes that whenever it is possible, students should be allowed to discover the principles of math on their own, but if they do not make the discoveries themselves, they must be taught these principles (Mighton, 2003). For example, commutativity in addition means that it does not matter which order you add two addends together because regardless of the order you will always end up with the same sum. Therefore, instead of teaching the rule addition is commutative first, it is better to have the students to do a number of problems where they can see for themselves the commutativity of addition and then introduce them to the rule. This allows some students to 'discover' the commutativity of addition. However, in a JM model those who do not discover the property are explicitly taught the rule and therefore they still learn this important rule at the same time as their classmates.

The JM philosophy is that all children, even those with slight cognitive deficits, can succeed in mathematics (Mighton, 2003, 2007). Mighton (2007) believes "that if they didn't understand something in my lesson it would be my fault for not explaining it properly, so they could ask me to explain it again" (p. 3). The program promotes the use of praise and encouragement for the students throughout the lessons. JM uses an incremental approach, teaching new concepts by breaking them down into simple steps with a short diagnostic quiz before the students go on to completing worksheets with the new material. Any student who is struggling with the new step is remediated immediately by the teacher before completing the worksheet and moving onto the next concept with the class (Kirshner, 2010). Students who understand the step are challenged with questions that appear harder but still only require the student to extend the steps they have already been taught (Biswas Mellamphy, 2004; Kirshner, 2010). For example, when introducing carrying numbers in addition the teacher could go from a one digit plus one digit question to a two digit by one digit question. If students are struggling with a step in the problem, it can always be simplified (Biswas Mellamphy, 2004).

There are several strengths to the JM program, its simplified design is inviting to students and the teachers' manual provides lesson plans for each activity. The simplified design avoids the problem of containing too many diagrams and pictures that research has shown to be distracting to students (DeLoache, 2005). The ways the lessons are formatted provide opportunities for teachers to intervene when students do not fully understand the lesson while their classmates are practicing. The website has many additional resources available, including activities that can be used interactively with a SMART board. Unlike many other programs, any additional materials that may be needed for some of the lessons are common, low-cost objects that, if teachers do not already have them on hand, could be purchased inexpensively. Other programs often make use of manipulatives that can be purchased through the different companies at an additional cost. The JM program only requires the purchase of workbooks and their sale is based on a cost recovery basis.

The exercises in JM are designed sequentially in a manner that allows students to accumulate procedural knowledge in each unit (Kirshner, 2010). This program has a specific way that it is to be taught in order for it to be most effective; this method does require effort on the teachers' part the first year they are using the program. Teachers need to go through each lesson plan before they teach it to ensure they understand what material is expected to be covered and how the activities are supposed to be used. Without this review of the lesson plan, the teacher may encounter some difficulty teaching the lesson for the first time. After using the program for a year, teachers tend to become familiar with the JM methods and do not need to spend as much time, if any, reviewing the lesson plan before teaching it.

Since each JM lesson in a unit builds on the previous concepts and lessons in that unit, there is time for concept review in each lesson. This allows the teacher to provide reinforcement for the previous lessons and students have a continuous review throughout the unit making reviewing for a test less of an onerous task. The workbook provides plenty of opportunities for students to practice their newly learned skills, but the program does not intend for every student to do every question. While the students are working on the workbooks in class, the teacher is to circulate and ensure the students understand the concept that was taught. Once the students have demonstrated they understand the new concept the student does not need to continue the exercises. When informally talking to teachers about their opinions about the program there are two common things the teachers have issues with. One issue is the amount of work students are expected to do. This is because some teachers expect all of their students to complete each page in the workbook and students tend to tire of the work. Yet as mentioned above, not all the questions in the workbook are intended for each student. They are in the workbook to provide practice for students who are struggling with a concept. Secondly, teachers are concerned about the amount of marking they perceive is needed; however there are different ways teachers can have students correct some of their own work.

1.2 Literature Review

In the summer term of 2006, 24 primary schools in Lambeth, England piloted a six-week JM program adapted from the grade three workbooks covering the topics of number sense and fractions as well as patterns and algebra. Lambeth has a diverse, transient population with 79% of the population coming from minority ethnic groupings. In each of the schools, students were nominated for this program if they were performing below the grade level expectations at the end of grade five. The schools were left to decide on how the groups were to be formed as well as how to deliver the instruction. The intention of this study was to evaluate the teaching methods of JM as well as the materials found in the workbooks. While they were using the JM program, teachers noticed improvement in the students' attitudes, test scores and the number of questions the students attempted. The teachers who participated in this pilot all wanted additional professional development and access to all the resources and materials (Aduba, 2006).

After the success of the summer 2006 JM pilot described above, Lambeth expanded the program into more schools within the district and focused on students who were achieving below their grade level expectations in mathematics. These students were taught using the JM material in pull out sessions with the size of the groups varying depending on the size of the school. The schools who participated in the pilot project were given all the materials and resources for the grade three, four, five and six workbooks and the teachers were asked to adapt the program to meet the national curriculum mathematics requirements. Schools who did not participate in the pilot program in the summer of 2006 were given the option to run the summer 2006 pilot in January of 2007. These schools were asked to nominate low achieving students in the same manner that was used before. Students appeared to make rapid and immediate progress in their math ability with more substantial gains over the school year. Of the students who were achieving two years below their age level, sixty-nine percent of these students were close to or at their age-related expectations after one year of using JM. Based on the results of the national testing done in Lambeth, many students participating in the JM program showed an accelerated rate of learning when compared to the growth they made in previous years before starting to use the JM program (Aduba, 2007).

After the success of using JM in previous years, Lambeth continued to use JM in twenty-five of their schools over two years in different ways and different amounts. Prior to using JM, only 16% of the students participating in the study were close to or achieving at their grade level. The results of students who participated in the program for two years had 25% of the students making the expected progress of typically achieving students over the time period with an additional 35% of the students achieving more than expected gains for typically achieving students in their progress over the time period on the national testing. For students who participated in the program for one year, 22% of these students made expected progress for typically achieving students over the time period with 33% of the students making more than expected progress for typically achieving students over the time period on the national testing. Considering that 84% of the students in the program were achieving below or significantly below their grade level at the onset of the program, these gains are more than to be expected (Aduba, 2009).

The Vancouver School Board (2007) reported on two different surveys with open-ended questions that were completed by teachers after completing professional development on the JM program. One hundred teachers filled out the first survey immediately after they attended professional development. The survey asked teachers their opinions about the JM program and how they thought it would affect their future teaching. These teachers felt that JM's approach to teaching new concepts in step-by-step, incremental manner and ensuring that all of their students understood the new material would help their future teaching of mathematics. The teachers felt more confident in their teaching of mathematics and their students gained confidence and efficacy in their mathematical skills just from attending the training. After using the program for a year, twelve of these teachers filled out a more in-depth second survey about their experiences using the program with their students. These teachers felt that the simplified, limited language in the workbooks was beneficial for the students because it allowed them to focus on the relevant information. The teachers found the recurring core systematic strategies used by the program provided comfort to the students when approaching new problems because they had a couple of different ways to approach the question. Overall, the use of JM increased in both the teachers' and students' confidence created better attitudes towards the subject (Vancouver School Board, 2007).

In Ontario, Maciejewski (2012) implemented the JM curriculum in three separate remedial and foundational college courses. He decided to try the curriculum because he believed it was designed around two factors he felt were important. First, the use of explicit instruction, where tasks are divided into small subtasks taught with extensive guidance, has consistently shown strong results for learners (ex: Kroesbergen & van Luit, 2003; Kroesenbergen, van Luit, & Maas, 2004; Swanson & Hoskyn, 2001). Second, there has been new research showing students may gain a deeper understanding of new concepts and have greater level of transference of these concepts when they are taught in an abstract manner (Kaminski, Sloutsky, & Heckler, 2008). An example of the JM program introducing concepts in an abstract manner can be seen throughout the fractions unit. Of the three courses Maciejewski (2012) sought to use the JM program with, one instructor decided to discontinue using JM materials after discovering the most of students were performing above the intended level of the course. The students in the other two courses attained gains in their achievement but because of the lack of research in the area of college level achievement the data can only indicate that there was improvement in the students' skills.

Previous research has shown JM to help improve students' confidence in mathematics as well as increasing both strong and weak students' enthusiasm towards mathematics (Hughes, 2004; Biswas Mellamphy, 2004). Hughes (2004) examined pre and post surveys collected on 120 students in grades three and four who were using JM for the first time. Analysis of the data revealed a significant relationship between the use of the JM program and the students' confidence in math. Biswas Mellamphy (2004) surveyed teachers from 14 classrooms who were using the JM program using a Likert scale. The results from this survey suggest a positive relationship between the use of JM and students' confidence in mathematics as well as increasing their enthusiasm for the subject regardless of their ability level.

1.3 Rationale for the Current Study

The previous research mentioned above (Aduba, 2006, 2007, 2009; Biswas Mellamphy 2004); Hughes, 2004; Vancouver School Board, 2007) provides, according to Jonker (2009) anecdotal evidence of the effectiveness of the JM program. Currently, there is a lack of research on JM using quantitative measures of students' improvement when compared to a control condition to evaluate its effectiveness. This quasi-experimental, prospective cohort pretest post-test study is intended to add quantitative evidence of the effectiveness of JM by judging student progress on commercially available standardized measures and comparing the progress of students in a control condition within the same school district.

1.4 The Current Study

The current study took place in a remote school district on the coast of British Columbia where all five schools in a town and one small school on a neighbouring island participated in some capacity in the study. All the students attending these six schools were invited to participate in the study. Those students whose parents gave informed consent to participate in the study were included in the sample. The final sample consisted of students whom had both the signed consent and were present for the two testing sessions.

The purpose of the study was to assess the effects of a new curriculum on students during its first year of implementation. This was judged by tracking the progress of the grade four students in these schools over six months (October 2011- April 2012) and comparison of their progress based on the JM group to which they belonged. Altogether there were three curricular groups: one group whose teachers used JM exclusively and followed the JM lesson plans (JM1), a group of students whose teachers used JM in combination with other materials (JM2), and the final group acted as a control group where the teachers did not use the JM materials, with the majority of their materials coming from the grade four Math Make Sense program (control). All of the elementary teachers in this district received professional development through JM prior to the onset of this study. The teachers of the JM1 and JM2 students relied on what they had learned through this professional development along with the teacher resources in the program manuals and on the website. The district made the decisions as to which schools in the district would serve as the target schools (JM1), which schools would combine JM with other materials (JM2) and which schools would continue with the curriculum used in the district in previous years.

Classroom observations were conducted by the district's Director of Instruction to ensure treatment fidelity. The JM1 teachers were observed on a few occasions over the study period and were judged to be following the lesson plans and using the JM materials according to the lesson plans specifications. The teachers were attentive to the student's learning during the lessons and circulated throughout the classrooms as the students completed their seatwork. The observation of the JM2 teachers showed they varied in how well they followed the lessons plans.

Based on self-reports from the teachers in the JM2 condition, none of them used the JM lessons or material for more than sixty percent of their curriculum throughout the implementation period of the study. The control teachers had used Math Makes Sense in previous years and because of the familiarity with the program, teaching methods and progression of the materials, they were comfortable with using that program.

The current study sought to answer the following questions:

1. Do students taught with JM1 make more progress than students who receive the materials used in the control condition?
2. How does the progress of students who receive instruction in JM1 compare with the progress of students who receive instruction-using JM2?
3. Does receiving instruction-using JM plus other materials (JM2) provide students more progress than students in the control condition?
4. Do students who are low achieving (LA) who receive JM1 instruction make more progress than students who are LA who received JM2 or the control instruction?

Based on the theory behind the design of JM, it was hypothesized that students who are in the JM1 group would make more progress during the intervention period than the students in JM2 and the control condition. The same was hypothesized for students who were considered LA. For the purposes of this study, students were defined as LA if they achieved a standard score lesser or equal to 90 on all three of measures that produced standardized scores. A standard score of lesser than or equal to 90 meant that students were performing below the twenty-fifth percentile when compared to their same aged peers on all three of these measures.

Chapter 2: Methods

2.1 Design

This quasi-experimental prospective cohort pretest posttest design study involved all ten grade four classrooms in one school district. Two different schools used the JM program exclusively. Three of the classrooms (JM1) were taught using the JM program where the teachers were very vigilant about teaching in accordance to the JM method by following the lesson plans as closely as possible. There were five classrooms (JM2) at four different schools where the teachers used the JM workbooks in their lessons but did not follow the lesson plans exactly. They used it like a workbook program and some of the teachers supplemented it with other material. The final two classrooms that acted as control classrooms were at two different schools where the teachers were using the Math Makes Sense textbook and program with their students. The students in the control classrooms did not use any of the JM materials. The study took place over 21 weeks (excluding holidays and professional development days) with an additional 2 weeks for pretesting and post-testing. All of the teachers were expected to teach according British Columbia Ministry of Education's prescribed learning outcomes for grade four.

All the teachers in the district attended a JM professional development workshop to familiarize them with the JM program and method of teaching. The JM program has many resources available to teachers on their website to assist with using the program. The classrooms were observed by the district's Director of Instruction to monitor how the programs were being used. Based on these observations, we decided to split the experimental group into the two separate groups, JM1 and JM2.

The principals of the schools were instructed and given scripts for the administration of the measures for pretesting in a classroom setting. All of the students were given the pretest by their principals during the same week of October 2011. The teachers were given the same script and instruction on the administration of the measures for the posttests and they were administered to all the students over a two-week period in April of 2012. Two separate markers marked all of the protocols, the scoring of the protocols was completed twice and as the data was entered, it was double-checked by two scorers before analysis was done on the final data file. The markers were employees of the school district who were given answer keys and formal instruction in how to mark the measures.

2.2 Participants

In the summer of 2011, a small school district on the coast of British Columbia contacted the researchers informing them of a prospective study using the JM program in their district for the 2011/2012 school year. All ten of the classrooms with grade four students from a remote school district on the coast of British Columbia participated in this study. All the students in these classes were invited to participate in the study and those students whose parents granted formal written consent were included for the study. The only other criterion for inclusion in the study was that the students completed both the pretest and posttest measures. In the final sample there were 57 males and 49 females (N=106). The mean age at the time of pretesting was 9 years 5 months (range 8 years 10 months to 11 years 5 months). In JM1 there were 11 males and 13 females (N=24) with a mean age at pretesting of 9 years 6 months (range 8 years 11 months to 9 years 9 months). In JM2 there were 33 males and 24 females (N=57) with a mean age at pretesting of 9 years 5 months (range 8 years 10 months to 11 years 5 months). In the control classroom there were 13 males and 12 females (N=25) with a mean age of 9 years 5 months (range 8 years 11 months to 9 years 9 months).

There were 37 students in the sample who were considered LA for the purposes of this study. Students were considered to be LA if they had a standard score of 90 or below on the Wide Range Achievement Test Third Edition, Arithmetic subtest (WRAT-3) (Wilkinson, 1993), the Calculation test (CALC) from the Woodcock-Johnson Third Edition Tests of Achievement (WJ III ACH): Form B and the Math Fluency (FLU) test was taken from the WJ III ACH: Form B (Woodcock, McGrew, & Mather, 2001). A standard score of 90 or below means that the individual is performing below at least 75% of the population of students at their age level on the test. Based on these requirements there were 16 students who were LA in JM1, 16 students who were LA in JM2 and 5 students who were LA in the control group.

2.3 Measures

The aim of selecting the measures was to assess three different types of mathematical skills: computational skills, math fluency and number patterns. The measures were chosen because they were able to be adapted to be used in a classroom setting and because they assessed three important aspects in mathematics that were addressed either directly or indirectly by the programs in the study.

2.3.1 Computational Skills

The first measure was the blue form of the Wide Range Achievement Test Third Edition, Arithmetic subtest (WRAT-3) (Wilkinson, 1993). This measure consists of fifteen oral questions and forty written questions. The oral questions are only intended for students who cannot answer five of the written questions correctly, the researchers assumed the grade four students would not need to have the oral questions administered. The pencil and paper questions start out with basic calculation questions and get increasingly more difficult ending with complex questions. The students were only expected to complete the questions they understood. The second computation measure was the CALC from the WJ III ACH (Woodcock, McGrew, & Mather, 2001). This measure has forty-five questions, and like the WRAT-3 subtest, the questions start out with simple addition and subtraction questions that increase in difficulty to more complex questions involving algebra, trigonometry and calculus operations (Mather & Woodcock, 2001). The students were not given a time limit and were directed to answer the questions they were capable of. The change in raw scores were calculated and used for analyzing the WRAT-3 data, while the change in W scores were calculated and used for the analysis of the CALC data. For both of these measures the standard scores were used to determine if students would be considered LA.

2.3.2 Mathematical Fluency

Measuring mathematical fluency allowed researchers to see if, through the implementation period, the students progressed in their automaticity of basic math operations. The FLU test was taken from the WJ III ACH: Form B (Woodcock, McGrew, & Mather, 2001). This measure consists of one hundred and sixty basic addition, subtraction and multiplication problems using the numbers 0 through 10. This task is meant to measure how many of these problems students can answer in three minutes (Mather & Woodcock, 2001). The change in the W scores for this measure was used for the data analysis and the standardized scores were used to determine if students were LA.

2.3.3 Number Patterns

The number patterns measure was adapted from the second subtest of the WJ III ACH Quantitative Concepts test (Woodcock, McGrew, & Mather, 2001). This test has individuals analyze a series of numbers to figure out the pattern and provide the number that is missing in the series (Mather & Woodcock, 2001). The original intention for this measure was to be used as an orally with an easel, but the researchers adapted it into a pen and pencil task by transposing the questions onto a worksheet and adding some examples at the beginning of the worksheet. Since this measure was modified from its original format, only raw scores were used in the data analysis. A copy of the worksheet is in Appendix B.

Chapter 3: Results

Preliminary analyses were run on the data set to ensure it met the criteria for the ANOVA assumptions of normality and homogeneity of variance for each treatment condition. This examination revealed the datasets for the WRAT-3, the CALC and the FLU met these conditions but the Number Series subtest did not. It failed to meet normality and homogeneity of variance in the pretest, but met these requirements for the post-test. The results from these analyses are presented in Table 1 in Appendix C. The ANOVA also revealed that in the whole sample, groups differed significantly at the pretest so it was decided to do all further analysis on the change for each student's raw score between the pretest and posttest (Tables 2, 3, 4, 5 & 6).

The main analysis was done to explore the effects of the different curricular conditions as measured by the change in raw score for the WRAT-3 and the Number Series subtest. The changes in W scores were used for the CALC and the FLU. W scores are an equal-interval derived scores that are based on item response theory and represent both ability and difficulty level on the same scale(Jaffe, 2009). W scores are available for tests from the Woodcock-Johnson Third Edition – Tests of Achievement (Mather & Woodcock, 2001).

3.1 Wide Range Achievement Test- Third Edition (WRAT-3)

A one-way ANOVA was conducted on the change of students' raw scores between the two testing periods and group differences were found for the whole sample on the WRAT-3. The post hoc analysis using the Scheffé criterion for significance revealed the control group performed statistically better than JM1 but that JM2 showed no significant difference between the groups (Tables 7 & 8). The change measured in the LA groups on the WRAT did not indicate significant differences between the three groups in the study (Tables 9 & 10).

3.2 Woodcock-Johnson Third Edition, Tests of Achievement, Calculations test

A one-way ANOVA and Scheffé criterion for significance were conducted on the change of the W scores between the pretesting and posting on the CALC. When looking at the differences between the groups, there was no difference between the conditions for either the whole sample or the LA sample (Tables 11, 12, 13 & 14).

3.3 Woodcock-Johnson Third Edition, Tests of Achievement, Math Fluency test

The one-way ANOVAs run on the changes in the W scores between the pretest and the post-test for the FLU only showed an interaction effect for the LA students and not the whole sample. A Scheffé criterion for significance revealed statistical difference between the LA JM1 and JM2 students, the JM2 students performed significantly better than JM1. The control group was not significantly different than the JM groups (Tables 13, 14, 15 & 16).

3.4 Woodcock-Johnson Third Edition, Tests of Achievement, Number Series subtest

Even though the Number Series subtest did not meet the criteria for normality of variance, the change score for the measure did meet the criteria for normality of variance (Table 1) so an ANOVA was conducted. A one-way ANOVA run on the change in raw scores for the whole sample from the two testing sessions displayed an interaction effect between the conditions (Table 17). The subsequent Scheffé criterion for significance revealed JM1 performing significantly better than JM2 but none of the other comparisons were at a significant level (Table 8). A one-way ANOVA run on the change in raw scores for the students who were LA showed no significant results between the groups (Table 18).

Chapter 4: Discussion

This study was designed to collect data on the improvements students made based on three different approaches to teaching mathematics using commercially available standardized measures. The conditions included an experimental condition where students received their mathematics instruction exclusively from lessons using the JM program (JM1), a condition that received lessons using both the JM program and the program used in the control condition (JM2), and a control condition where lessons were taught based on the Math Makes Sense grade four textbook. The same measures were used at the pretest and the posttest.

The first question this study sought to answer was to determine whether students receiving all of their mathematical instruction using the JM program, the experimental condition (JM1), would make more progress than students in the control condition, receiving the curriculum used in the district for many years. Based on the four measures used in this study, the only statistical difference found was on the WRAT-3 measure for the whole sample where the control condition performed better than JM1. However, the second measure that looked at computational skills, the CALC, did not show the same significance. This means that for computational skills, no concrete conclusion can be made as to whether one program shows better results for the students' progress than the others. Considering that no statistical difference was found in the other measures used in this study, there is no strong evidence that students in the control condition performed better than the students in the JM1 condition.

The second question concerned whether students who received instruction only using the JM program (JM1) would perform better on the measures than students who were taught using the JM program in combination with the previous program that had been used in the district (JM2). On both measures of computational skills (WRAT-3 and CALC) there was no statistical difference between the changes in the students' scores. On the measure of math fluency (FLU) the only difference seen between these two groups was in the subset of students who were LA and the students in JM2 performed significantly better than the students in JM1. On the measure for numerical series (Number Series), the students in JM1 performed statistically better than JM2. Based on these results and when considering the whole sample, it seems that both conditions made similar improvement on their computational skills and fluency while students taught with only the JM materials made more progress in the pattern recognition for numerical series.

The third question considered whether using JM along with the materials used before in the district (JM2) helped students advance more than the Math Makes Sense materials alone (Control). These two conditions in the study performed at the same level after the intervention period on all of the subtests. This would imply that these two different modes of delivering curricula provide similar levels of improvement for the students.

The final question inquired whether any of the programs were superior for helping students who were LA at the pretest on the standardized measures. The only subtest that showed statistically significant improvement for any of the groups who were LA was on the measure of number fluency (FLU) where students who were in the JM2 condition performed better than the JM1 group. This indicates that using JM in combination with other programs helps students who are LA improve on their number fact fluency more than when it is used alone. As far as computational skills and recognizing patterns in numbers, no one program proved to be more effective than the others.

To summarize, this study failed to produce empirical evidence from standardized tests that students taught exclusively with the JM program make significant gains compared to students taught by other methods. The results suggest that the different programs have strength for improving different types of skills in students based on the measures used in this study.

4.1 Limitations

There are some limitations to the current study. Since this was the teachers in the experimental condition's first year using the JM program they lacked experience with this program. They were at a disadvantage to the control teachers who were familiar with the program they had taught in previous years. Hiebert (1999) notes it is difficult for individuals to make changes in the way they teach and he states that when using new programs educators are required to make significant changes to their practice. He notes that these changes do not happen automatically and take time. Given this, it would be interesting to look at the results of a similar study when the teachers have more experience with the JM program. This was also the experimental students' first year learning with the JM method. It may have put them at a disadvantage as well because they were learning the program's format in addition to its material at the same time whereas the other students had used their other program in previous years. Like their teachers, it will take time for the experimental students to adopt the new methods for solving mathematical problems and the implementation period may not have been long enough for the students to adapt to these methods.

Another limitation is that the groups were heterogeneous as evident by the pretest scores. This difference could have arisen because students were not randomly assigned to each group. It is possible that a difference pretest score, such as seen in this study, influences the magnitude of improvement that can be achieved with different teaching methods. Future studies should try to randomly assign students to each condition.

Of the chosen measures selected for this study, two of these measures, the WRAT-3 and the CALC, are meant for students from primary school up to those taking advance level mathematics. They do not ask questions covering all the concepts covered in grade four and for that reason they may not have been sensitive enough to detect the changes made in less than a year of schooling. It is suggested that future research examines standardized measures designed to cover more of the curricular goals for the age level of the students because they will likely be more sensitive to the change made during the intervention period.

4.2 Strengths

A strength of the current study include that it captures the use of the JM program in a natural environment. The teachers in this study who used the program attended the professional development and implemented the program using the resources available to them online and through the teacher's guide. They did not receive any additional support that would not be available to others trying the program for the first time. This gives a realistic expectation of teachers using the program for the first time after attending professional development on the program.

For the first time for research conducted on the JM program, this study included a concurrent control within the same district to compare the experimental groups to. This allowed comparison of the progress students made using the JM program to other student who received their mathematics education with different curricular materials over the same time period.

This study used commercially available, quantitative standardized materials to measure students' progress during intervention period. This is a first step in providing the quantitative evidence Jonker (2009) says is needed for the use of the JM program. It means readers can have a better understanding of what materials were used to judge the progress made. It also allows for replication of the study in the future.

4.3 Conclusions

This study used quantitative measures to examine the effectiveness of the JM curriculum being implemented in two different ways using a quasi-experimental, prospective cohort, pretest posttest design. Based on the results of this study it can be concluded that even in its first year of implementation, students taught with the JM curriculum can make comparable progress to students using other currently accepted curricular materials.

Future research should enquire how students perform compared to their peers when taught exclusively with the JM program for their mathematical education as opposed to their peers who were taught using another curriculum. It should also look at progress students make using the JM program with teachers who are not using the program for the first time. Future studies should use a randomized controlled design to form their groups.

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Appendices

Appendix A **Informed Consent Form**

THE UNIVERSITY OF BRITISH COLUMBIA

Department of Educational & Counselling Psychology, & Special Education

Mathematics Instruction Study
Consent Form for Child Assessment October 2011

Principal Investigator: Linda Siegel, Ph.D. 604-822-0052 604-822-5720

Dear Parent/Guardian,

Please read the following form carefully. Sign one copy and have your child bring it to his/her school. Keep the other for your records. Your signature indicates that you have received a copy of this consent form for your own records.

This is a request for you and your child to take part in the study that we are doing in your child's school. The purpose of this study is to learn more about the instruction that helps children learn mathematics skills.

This project will take place during this school year. We will do the assessment twice during the school year.

The assessment will be given to the whole class at one time. There will also be some individual assessment will take place in one visit for about 25-30 minutes.

Your agreement to let your child take part is voluntary and will not affect any services that your family or child receives. You and your child have the right to withdraw from the study at any time and they have the right to not answer any of the questions. If your child does not take part in the study they will just continue to take part in the regular classroom activities.

We are not aware of any risks if your child takes part in our study. Our experience in the past is that most students enjoy the activities. However, if your child wants to stop at anytime that is fine and testing will stop. By taking part in this project, you may help us learn ways to improve mathematics instruction for children. Reports of the results of this study will be available from school when the study is finished.

The information you give us is confidential. No individual information will be reported and no parent or child will be identified by name in any reports about the study. We will provide information about your child to the teacher who will communicate with you.

If at any time you have any concerns about your treatment or rights as a research participant, you may contact the Research Subject Information Line in the UBC Office of Research Services at the University of British Columbia at (604) 822-8598. If you have any questions or concerns regarding the project you may contact the investigator at numbers above

Linda Siegel
Linda Siegel, PhD

____ Does your child receive any additional math work or instruction outside of school? (Examples: Kumon, Silvan or tutoring)

____ Yes, I agree that my child may take part in this study.

____ No, I do not wish my child to take part in this study.

Page 1 of 2

Parent's/Guardian's signature (please sign): ______________________

Parent's/Guardian's name (please print your name): ______________________

Date: ______________________

Child's Name: ______________________

Child's Birth Date: ______________________

Postal Code: ______________________

Appendix B **Adapted Number Series Measure**

Name:____

Complete the sequence by writing in the missing numbers.

Examples: 3 4 _____ 6 9 8 _____ 6

1) 1 2 3 _____

2) 1 _____ 3 4

3) 5 6 7 ____

4) 7 8 _____ 10

5) 15 16 17 _____

6) 18 19 20 _____

7) 7 5 3 _____

8) 5 _____ 3 2

9) 2 4 6 _____

10) 6 5 4 _____

11) 4 7 10 ____

12) ____ 3 5 7

13) 5 8 11 ____

14) 30 45 60 ____

15) ____ 5 9 13

16) 3 ____ 8 12 17

17) 11 10 8 5 ____

18) 33 30 26 21 ____

19) ____ 19 25 37 61

20) 81 27 9 ____

21) 1 3 7 15 ____

22) 1 1 3 9 9 27 ____

23) 2 18 26 ____

24) 42 15 6 3 ____

Appendix C **Tables**

C.1 **Table 1: Tests for normality and homogeneity of variance**

	Levene Stat (Sig.)	Skewness	Kurtosis
WRAT Pre-test	2.522 (.086)	.066	-.089
CALC Pre-test	2.283 (.107)	-1.198	2.918
FLU Pre-test	.547 (.581)	.589	1.621
Series Pre-test	5.314 (.006)	-1.003	1.050
WRAT Post-test	1.208 (.303)	-.573	-.047
CALC Post-test	.294 (.746)	-.179	.909
FLU Post-test	1.549 (.218)	.609	.911
Series Post-test	2.4 (.096)	-2.084	6.090*
Series Change	1.54 (.220)	-.679	-1.216

** does not meet requirements for normality of variance*

C.2 **Table 2: One-way ANOVA for Wide Range Achievement Test-3 Pretest**

Source	*df*	*SS*	*MS*	*F*	*p*
Between groups	2	80.929	40.464	3.741	.027
Within groups	98	1059.883	10.815		
Total	100	1140.812			

C.3 **Table 3: One-way ANOVA for Caculation Pretest**

Source	*df*	*SS*	*MS*	*F*	*p*
Between groups	2	136.764	68.382	6.975	.001
Within groups	98	960.721	9.803		
Total	100	1097.485			

C.4 **Table 4: One-way ANOVA for Math Fluency Pretest**

Source	*df*	*SS*	*MS*	*F*	*p*
Between groups	2	2329.658	1164.829	4.576	.013
Within groups	97	24691.652	154.553		
Total	99	27021.310			

C.5 **Table 5: One-way ANOVA for Number Series pretest**

Source	*df*	*SS*	*MS*	*F*	*p*
Between groups	2	176.629	88.315	11.290	.000
Within groups	98	766.579	7.822		
Total	100	943.208			

C.6 **Table 6: Post hoc comparisons for pretesting one-way ANOVA**

Subtest		Mean Difference	Std. Error	Sig.
WRAT	Control X JM1	1.478	.970	.317
	Control X JM2	-.753	.817	.655
	JM1 X JM2	-2.232*	.817	.027
CALC	Control X JM1	2.565*	.923	.024
	Control X JM2	-.279	.777	.938
	JM1 X JM2	-2.844*	.777	.002
FLU	Control X JM1	11.889*	4.758	.049
	Control X JM2	.344	3.962	.996
	JM1 X JM2	-11.545*	4.025	.019
Series	Control X JM1	3.087*	.825	.001
	Control X JM2	-.092	.991	.991
	JM1 X JM2	-3.179*	.694	.000

** The mean difference is significant at the 0.05 level.*

C.7 **Table 7: One-way ANOVA for the change in the Wide Range Achievement Test -3 raw scores**

Source	*df*	*SS*	*MS*	*F*	*p*	η^2
Between groups	2	68.635	34.318	4.258	.017	.075
Within groups	98	789.919	8.060			
Total	100	858.554				

C.8 **Table 8: Post hoc comparisons for the change in raw scores one-way ANOVA**

Subtest		Mean Difference	Std. Error	Sig.
WRAT	Control X JM1	2.391*	.837	.020
	Control X JM2	1.524	.705	.099
	JM1 X JM2	-.857	.705	.480
Series	Control X JM1	-1.217	.912	.414
	Control X JM2	-.092	.770	.481
	JM1 X JM2	2.153*	.770	.023

** The mean difference is significant at the 0.05 level.*

C.9 **Table 9: One-way ANOVA for the change in the raw scores for the students who were low achieving Wide Range Achievement Test-3**

Source	*df*	*SS*	*MS*	*F*	*p*	η^2
Between groups	2	15.158	7.579	.845	.438	.047
Within groups	34	304.950	8.969			
Total	36	320.108				

C.10 **Table 10: Post hoc comparisons for the change in raw scores for students who were low achieving one-way ANOVA**

Subtest		Mean Difference	Std. Error	Sig.
WRAT	Control X JM1	.600	1.543	.927
	Control X JM2	-.775	1.543	.881
	JM1 X JM2	-1.375	1.059	.439
Series	Control X JM1	-4.288	9.937	.911
	Control X JM2	-9.350	9.937	.646
	JM1 X JM2	-5.063	6.857	.763

* *The mean difference is significant at the 0.05 level.*

C.11 **Table 11: One-way ANOVA for the change in W scores on the Calculation test**

Source	*df*	*SS*	*MS*	*F*	*p*	η^2
Between groups	2	274.564	137.282	.448	.640	.009
Within groups	98	30329.956	306.363			
Total	100	30604.520				

C.12 **Table 12: One-way ANOVA for the change in W scores for the students who were low achieving Calculation test**

Source	*df*	*SS*	*MS*	*F*	*p*	η^2
Between groups	2	406.092	203.046	.540	.588	.031
Within groups	34	12789.637	376.166			
Total	36	13195.73				

C.13 **Table 13: Post hoc comparisons for the change in W scores**

Subtest		Mean Difference	Std. Error	Sig.
CALC	Control X JM1	-2.143	5.1073	.916
	Control X JM2	-3.999	4.282	.648
	JM1 X JM2	-1.865	4.346	.913
FLU	Control X JM1	3.780	1.610	.068
	Control X JM2	.326	1.334	.972
	JM1 X JM2	-3.464*	1.375	.046

C.14 **Table 14: Post hoc comparisons for the change in W scores for the students who were low achieving one-way ANOVA**

Subtest		Mean Difference	Std. Error	Sig.
CALC	Control X JM1	-4.288	9.937	.911
	Control X JM2	-9.350	9.936	.644
	JM1 X JM2	-5.063	6.857	.763
FLU	Control X JM1	1.964	3.442	.851
	Control X JM2	.713	3.442	.979
	JM1 X JM2	-1.250	2.375	.871

C.15 **Table 15: One-way ANOVA for the change in W scores the Math Fluency**

Source	*df*	*SS*	*MS*	*F*	*p*	η^2
Between groups	2	219.742	109.871	3.693	.028	.070
Within groups	98	2915.624	29.751			
Total	100	3135.566				

C.16 **Table 16: One-way ANOVA for the change in W scores for the students who were low achieving on the Math Fluency**

Source	*df*	*SS*	*MS*	*F*	*p*	η^2
Between groups	2	20.236	10.118	.229	.800	.013
Within groups	34	1534.575	45.135			
Total	36	1554.811				

C.17 **Table 17: One-way ANOVA for the change in the Number Series**

Source	*df*	*SS*	*MS*	*F*	*p*	η^2
Between groups	2	76.282	38.141	3.986	.022	.074
Within groups	97	928.158	9.569			
Total	99	1004.440				

C.18 **Table 18: One-way ANOVA for the change in the student who were low achieving Number Series**

Source	*df*	*SS*	*MS*	*F*	*p*	η^2
Between groups	2	50.000	25.000	1.693	.199	.091
Within groups	34	502.000	14.765			
Total	36	552.000				