VEDIC MATHEMATICS IN THE ADULT BASIC EDUCATION FUNDAMENTAL MATH CLASSROOM

by

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Abstract

For adult students, succeeding at fundamental math is a cornerstone to expanding their educational and occupational options. The rates at which students are able to progress through fundamental math vary, and for some achieving a basic understanding of math is challenging. Students who exhibit persistent difficulties with understanding the first level of fundamental math (CNC Math 015) skills were the focus of this project. Vedic math was chosen as the instructional method for a ten week project with students who are enrolled in fundamental Math 015. It was hypothesized that a different approach to teaching and learning math may result in an improvement in student success and in students' perceptions about learning math. After the ten week period, 40% of the Vedic math class completed Math 015 compared to approximately 8% for all Math 015 completions for the years 2007 – 2011. Chi-squared analysis indicated this result was statistically significant. I was also interested in the student's and instructor's experiences with learning and teaching math in a very different way. Students reported their learning experiences to be very favourable and the instructor reported the teaching experience to be very worthwhile. Students experienced more academic success and increased confidence and enjoyment while learning math skills. Overall, results suggest Vedic math is an approach worthy of further exploration.

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Chapter One: Introduction to Vedic Mathematics and the

ABE Fundamental Math Classroom

Fundamental math upgrading at the College of New Caledonia (CNC) is the gateway for many other programs and courses. Over the years, successful completion of this entry level math has proven itself problematic for many students. In response to learners' needs, new approaches for teaching math were sought. The impetus to try a different way of teaching math emerged from the instructor's desire to help students achieve increased success. Over time, a number of teaching approaches and modalities have been utilized to assist students in learning math with limited effect. The question remained, *"Was there another way to teach math that was effective and increased students' success?"*

The completion rate for adult students in ABE Fundamental Math at the CNC Lakes Campus did not reflect the commitment and effort put in by these students. CNC offers many programs and courses for all levels of learners, but a significant commitment is made to the most vulnerable learners. Some students attend daily for many years working on CNC Fundamental Math 015 (level one) without being able to progress to Math 020. Completing Math 015 and Math 020 has an equivalency of approximately kindergarten to grade seven, and Math 030 has an equivalency of completing approximately grades eight through ten. When assessing the student's math placement level, the Level B of the Canadian Adult Achievement Test (CAAT), and a locally developed assessment tool are used. The CAAT is standardized to provide a grade equivalency of grades five to eight (CAAT, 1988). During intake interviews it is commonly found that students either did not complete traditional school or finished school with a leaving certificate, but did not acquire basic math skills. The

first step for students to be able to move on toward higher level math, trades programs, and other educational opportunities is to successfully complete Math 015.

Students who choose to return to adult education classes are seeking a better life. They often have survived difficult experiences in their lives and are looking for a better future. Educators are compelled to seek out opportunities for students to be successful learners. Students who are assessed at a Math 015 level are commonly observed to have a particular pattern of behaviour and ability. Instructors report that students who test at this level often display neurological characteristics consistent with Fetal Alcohol Spectrum Disorders (FASD), Developmental Trauma Disorder, or other cognitive and behavioural related social challenges. CNC instructors of Math 015 commonly observe that students demonstrate the following characteristics:

- High frustration levels and/or math anxiety
- Slow math processing abilities
- Low recall of the concepts at a later time
- Inability to transfer math concepts to other situations
- Inability to use math strategies (to decide which is the best way to solve a problem)
- Inability to use estimation or other strategies to know if an answer is correct
- Failure to progress beyond a certain level regardless of effort
- Persistence and commitment, and yet have varying degrees of challenges learning the material
- Experience ongoing trauma and who find that school is a way to increase the structure and stability in their lives (CNC Instructors, personal communication, 2011)

In the instructors' experience, any combination of the above factors adds complexity and contributes to low math completion rates. Yet, despite all the challenges students' experience, they are driven to improve their lives and the lives of their families. They want to

feel better about their ability to learn. They want to feel like they belong and do as others do. They want to be eligible for better jobs. They want to experience more peace. It is from this starting place that instructors seek to find new methods to assist them.

Vedic Mathematics

Vedic (pronounced 'Vaydik') math is a system of math not widely utilized, yet may provide an opportunity for students to change the way they think and feel about learning math. Vedic math utilizes alternative algorithms to solve equations that bypass some of the traditional methods that students typically struggle with. This completely different approach can potentially minimize students' sometimes debilitating math anxiety while allowing them to experience success with math, often for the first time. Western dogma about math has followed a "separate the wheat from the shaft" philosophy that spouses that math is increasingly difficult and those that can do, and those that struggle are left behind. Vedic math follows a philosophy that everyone can; that even complicated math is simple, and everybody should be able to enjoy it (Williams & Gaskell, 2010d). After learning about Vedic math, a plan was put in place to assess whether these methods could be beneficial to CNC's Math 015 students.

Literature on Vedic Math

While searching for evidence based information about Vedic math, one thing became clear quickly; very little empirical information exists at all. The original book on this subject authored by Sri Bharati Krsna Tirthaji was originally published in 1965 and is the foundation for all other books on the subject. The editor's note at the beginning discusses the source of the author's inspiration. He was considered: "one of die-hard believers who think that the Vedas represent an inexhaustible mine of wisdom in matters both spiritual and temporal." Of

the sixteen volumes developed by the author, only this one survived to be published. The difficulty the reader may have in letting go of conventional methods is also discussed.

The actual descriptions of the math used seem more difficult to understand than in other texts read on the subject. This work represents the beginning of the Vedic method and the controversy that exists around its origins. While devout believers insist that he studied Vedic principles with such conviction that he was able to unravel and reveal the hidden mathematical truths (sutras) that existed within them, others contend that he was merely a mathematical genius who formulated the principles himself as the Vedas do not contain mathematical references. All resources about Vedic mathematics divide sharply on either side of this fault line. In either case, Vedic mathematics is an example of how tightly connected mathematics is to culture. Regardless of the controversy of origin, the opportunity for this method to assist learners is worthy of exploration.

Perhaps, in an attempt to avoid controversy, Vedic math may be described in Western popular literature as mental math or a series of alternate techniques. For example, in his book about mental math, Benjamin (2011) states that, "There is more to Vedic mathematics than division, although we have seen much of it in this course already" (p.52). Benjamin uses Vedic techniques for digit sum checks and multiplication, but regards them as "mental math strategies" and does not quote them as being "Vedic". Texts of this nature are most commonly directed at readers who want to improve their math skills and impress their friends with an ability to answer complex questions quickly. The promise is to be able to do math quicker and without the aid of a calculator or a pen and paper. While these methods may not be solely Vedic, the principles and topics covered are often based in Vedic math. For the purposes of this research, methods that have been repeatedly described in the

available literature as Vedic are used and we use the term Vedic math to identify the source of the method.

Several books on Vedic math have been published in Scotland. Authored by Ken Williams, these revised editions were published in 2009. The titles include Discover Vedic Mathematics, and Vedic Mathematics Teacher's Manual for Elementary, Intermediate and Advanced Levels. The Vedic system is described as a new approach to mathematics, offering simple, direct, one-line, mental solutions to mathematical problems. The Sutras on which it is based are given in word form, which renders them applicable in a wide variety of situations. They are described as easy to understand, easy to remember and a "delight" to use. The explanations of the math methods used are clearly outlined.

Williams is a supporter of the method and philosophy created by Tirthaji. He asserts to have built upon the original foundation of knowledge and hopes to appeal to a wider audience. In recent years, Vedic math has gaining popularity just as Williams hoped. Many websites abound, offering workshops in Vedic mathematics, often for a price. One website offers Vedic math workshops "suitable for ages 8+ to adults wanting to rid their fear of math or simply learn Vedic math for fun" (Scree, n.d). Worldwide, Vedic math is being taught in schools in several countries (Vedic Mathematics Organization of USA, 2010). School districts in Australia teach the Vedic method for fractions, as CNC instructors realized when marking an intake assessment from an Australian graduate applying for enrollment (instructor personal communication, 2010).

Although Williams' texts are separated into levels, when pulling together Vedic strategies to teach to Math 015 students, ideas from several books were needed. No one book had all the Vedic methods for this level of learner clearly laid out. All books tended to

move from beginning ideas to advanced ideas too quickly. As a result, methods and ideas were pulled from several texts to create the strategy that was used to instruct Math 015 students. Each book offered different explanations, which added to the mosaic of understanding and provided context that could be passed on to students.

Shortly before the Vedic classes began, a series of three texts were found that proved to be immediately useful. These books were The Cosmic Calculator: A Vedic Mathematics Course for Schools, Book 1, Book 2 and Book 3 (Williams & Gaskell, 2010a, b, c). These books were written in a workbook style, making them useful for transferring their ideas to the classroom setting quickly.

From this same publisher is a book written by Nicholas, Williams, and Pickles in 2010: Vertically and Crosswise. This text describes Vedic math as a fast and efficient approach to mathematics. This text begins with elementary multiplication and concludes with an advanced topic – the solution of non linear partial differential equations. It is described as a unified system or approach which can be swiftly learned. The subject of this book is calculations and the evaluation of functions, beginning with linear equations and moving on to algebraic and differential equations.

The text is easy to follow and the techniques are explained well, although most of the topics are too advanced for Math 015 students. Most of the books found about Vedic math have the same publisher and it can be inferred that the methods have not caught the attention of a wider range of critical attention. The term Vedic and its association with a particular faith may be part of the reason. It might also be partly explained by a similar difficulty to what the Vedic instructor and I experienced; pulling together the right set of methods for a particular type or level of student that does not advance too quickly.

These books, plus a smattering of newspaper articles and blogs, exhausted the available readings. Peer-reviewed articles were limited to those that discussed signal processing and the speed to which Vedic math improved the process. Newspaper articles, while not peer reviewed, provided some interesting information and added to the knowledge base.

One such newspaper article was entitled, "A different way of doing math", which was written by Chatterjee, M. in The Asian Pacific Post in 2008. This article reports on the effort of mechanical engineer Pradeep Kumar to promote Vedic mathematics. He believes that Vedic mathematics "could banish the fear that creeps into the minds of millions of children at the mention of math." He describes the many ways that he believes this method could be beneficial and how he is promoting the usage of this method.

An example of the type of peer reviewed article that is available includes one by Chidgupka and Karad, in 2004. The implementation of Vedic algorithms in digital signal processing was published by the *Global Journal of Engineering Education*. While searching for peer reviewed information about Vedic math, a few articles about digital signal processors were the only ones found. Digital signal processing (DSP) is the technology that is present in almost every engineering discipline, and being able to compute multiplication routines more quickly is an ongoing goal. The authors discuss using Vedic algorithms for the 8085 and 8086 microprocessors in a comparative study. They found that for two-digit multiplication a time savings of 59% can be achieved using a Vedic method and for three-digit multiplication 42% of processing time is saved. The conclusion of this study indicated that the Vedic approach could be extremely beneficial to DSP applications.

This paper is intriguing due to the idea that if Vedic math is quicker for computer processors, then it could be for students too. If fewer steps are required for a computer to achieve an answer, this could be good news for students too. One website advertises that Vedic math is now being used at NASA and is 10 – 15 times faster than conventional methods (Vedic Mathematics Organization of USA, 2010).

One article found was authored by a teacher. Forsythe (2003) wrote, "A Vedic Method for Subtraction." The author and teacher devised a test to find out whether teaching this method would have an effect. She had two target groups that were taught the Vedic method of subtraction and two control groups that were not. Groups were matched for ability. In her opinion, all students benefitted from spending time on appreciating the relative sizes of numbers. In respect to Vedic subtraction, she surmised that it is a worthwhile method to use, especially in the numerous situations when required to subtract from a number with zeros and in probability problems where decimals are subtracted from one. She also commented that the methods need to be practiced from time to time to become part of students' mental tools.

As far as contravening information goes, the most significant controversy seems to be whether the creation of these methods are indeed from Vedic origins, or from the mathematical genius of the original book on the subject. The search did not reveal any sources that claimed these methods were not worth pursuing.

The catalyst for this project came from conference proceedings facilitated by Dr. Rahael Jalan at the Adult Basic Education Association of British Columbia (ABEABC) conference in 2010. Dr. Jalan is a Math professor (Aboriginal Education Coordinator in the department of Pacific Institute for the Mathematical Sciences) at the University of British

Columbia. She was concerned with the lack of Aboriginal representation in UBC undergraduate sciences. She partnered with an Abbotsford school district and created a fundamental math review curriculum to enable grade eight students who were on the Math Essentials route to catch up and enter the Principles route. She incorporated a few Vedic math methods (specifically multiplication) to enhance the learning climate to make learning fun. The results were staggering, according to Dr. Jalan. Students enjoyed math, had fun with it, understood it, and most importantly finished the math courses required to enter the Math Principles route, a prerequisite to the science programs at UBC.

Her workshop was entitled, *Vedic Mathematics: Successful strategies for teaching and learning mathematics*. She presented a model for teaching and learning mathematics at the secondary level. Topics included the ways culture influences how we use mathematics and Vedic math. The presentation information supplied by Dr. Jalan was interesting and persuasive. Her message was closely followed, especially since she was working with Aboriginal youth which is a similar demographic to the learners at CNC. This conference sparked an interest in my colleague, Waneta Nealis who began gathering and analyzing Vedic materials to see if they might be useful to Math 015 students. During a subsequent phone with Waneta, Dr. Jalan expanded her message by saying that she used Vedic math to peak student interest.

During the planning phase of this project, referring to the Tri-Council Policy Statement (2005) was a useful task. This document described ethical conduct for research involving humans and was used to ensure the inquiry proposed would not cross any ethical boundaries. Keeping these ethical guidelines in mind while planning and carrying out a project is essential.

In summary, the limited literature on the topic can be traced back to the author of the methods; Sri Bharati Tirthaji from India, published Vedic Mathematics in 1965. He was recognized as a renowned mathematical scholar who presented his methods at conferences around the world including North America. Other interested people, such as Ken Williams from Scotland, have written books on the subject and claim to have expanded the knowledge base. Peer-reviewed articles on the subject of Vedic math tend to be focused on digital signal processing where it is found that using Vedic algorithms when designing computer microprocessors is more efficient than typical math methods (Chidgupka, 2004). Other related articles describe Vedic math as being a useful tool in the toolbox of instructor skills.

In addition to these external sources, and as a result of a desire to introduce college employees to Vedic math, a series of mini-lessons were presented to interested staff members. The intention was to share knowledge and gauge their level of interest and support in devising a plan to integrate Vedic math methods into Math 015 classes (Durban & Nealis, 2011).

Inquiry Project

In preparation for this project, a number of initiatives were taken. As mentioned, the keystone for this project occurred when a fellow instructor, Waneta Nealis, attended a presentation by Dr. Rahael Jalan. This event sparked an interest in whether Vedic math could be useful for fundamental math students at CNC. Waneta is a skilled Adult Basic Education educator with over fourteen years of experience. She committed her summer professional development time to learning more about Vedic math. She collected and analyzed literature on the subject and concluded that this method would be worthwhile teaching and the impact should be studied.

We applied to the CNC Institute for Learning, Teaching and Research (ILTR) for a grant and were successful in securing funding for the project pending ethics approval through CNC and the University of Northern British Columbia (UNBC).

This type of approach to math is very different from what has been traditionally taught. To gain a wider range of understanding and potential support for the methods, we facilitated three mini-lessons to introduce CNC Lakes Campus staff members to the method. The results of the mini-lessons were used in an inquiry project for the Leading for Learning Certificate as part of a Master of Education Degree in Multi-Disciplinary Leadership through the UNBC).

The inquiry project provided assurance that these methods had potential benefits for students and minimal risks. Participants were surprised at the simplicity of the methods and wondered why they were not already widely used. From these mini-lessons, it was learned that the value in the method may be because it is so different, and that students may not feel the same anxiety toward it. By decreasing the barrier of anxiety alone, we may find an impact.

A concern emerged regarding students for whom a typical method is working well; it might not always be wise to have them try to learn a new way if they have an effective strategy already. Our goal is not to cause confusion. In response to this concern, each research student was asked during the intake if they would be willing to try a new way of learning math even if they were good at the conventional way.

Also, this potential detrimental effect will be largely avoided in Math 015 as most, if not all students lack working effective strategies for solving most math questions. For example, at the first mini-lesson session instructors were asked to estimate how many of their

entry level math students do not know how to borrow or regroup. It was agreed that fifty to sixty percent (CNC Instructors, personal communication, 2011) of beginning students completely lack this math foundation skill, and fewer yet have it mastered. This is important because this is one of the first skills that Vedic math has a different approach for. There is value in making sure enough time is provided for practice and to create a positive learning environment by being supportive and emphasising the fun in math.

At the conclusion of the mini-lessons, it was clear that Vedic math was a method worth exploring with actual students, and that the potential benefits outweighed any concerns. It was also suggested that students should be screened to ensure they were willing to try something really new.

Also of critical importance, the support of colleagues was gained and they also saw value in these methods with Math 015 students. Knowing that colleagues saw value in these methods provided fuel to continue the project.

What is Vedic Mathematics?

Math 015 instructors have witnessed their students struggling with learning typical math methods. They suspect that students' frustration can be attributed to the methods' complexity, its reliance on working memory, and its dependence on abstract reasoning abilities. Students are expected to understand concepts based on the abstract value of numbers. For example, drawing a circle with lines intersecting it like a pizza is used to help students understand fractions. A real pizza can also be used. Pieces of the pizza are pulled way to show different fractions of the whole. This seems like a very concrete and effective way of teaching, except for students with poor working memory. At some point students will be expected to hold that image of a pizza in their working memory and mentally manipulate

the pieces within it. For students with limited working memory, sporadic short-term memory, and limited cognitive ability to understand abstract concepts the task can be increasingly difficult. Being shown over and over does not increase the capacity of working memory; it just reinforces what they cannot do.

Students are expected to be able to generalize that the pizza is a metaphor for fractions and they are expected to generalize the abstract knowledge that all fractions are parts of a whole. This concept too has proven itself to be very difficult to learn for some populations of learners. While we are targeting learners with multiple challenges, it cannot be overstated that many typical learners also struggle with these same concepts.

Adding and subtracting fractions are difficult concepts for many learners to grasp. The result of many consecutive lessons in "common denominators" is often frustration and anxiety for both student and teacher. After the time and effort of learning traditional fraction methods, students' retention is often minimal. It is not uncommon for students to admit to fraction anxiety and lack of method retention. Instructors have heard students say, "I never did understand that" or "I can never remember how to do all the steps". The complexity of adding fractions is illustrated in most conventional textbooks; the explanation can go on for pages. And then when students learn how to multiply and divide, a whole new set of rules must be followed.

What if there was a way for students to correctly solve math questions without frustration and anxiety? What if there was a less complex way? These are the questions. Maybe if Vedic Math was the answer. The following table includes some common problems Math 015 students have when using conventional math methods. The Vedic math approach

proposes to reduce or eliminate these problems with creative solutions. Table 1 compares

Table 1

Comparison of Conventional and Vedic Methods

Math concept	Conventional Method Students Struggle With	Vedic method
Subtracting	Borrowing/crossing out	No borrowing or crossing out
Times tables past 5x5	Memorizing up to 12x12	No memorizing needed past 5x5
Long division	Complicated method	One line answers
Adding and subtracting fractions	Finding a common denominator	No common denominator required
Checking work	Cumbersome/frustrating/ time consuming	Digit sums allow students to know when their answer is correct
Multiplying multiple digit numbers	Lining up digits correctly so that adding can be done accurately	One line answers

Note: Vedic versus conventional methods for different Math 015 concepts.

Using the Vedic math principles in table 1, Math 015 lessons were altered to teach

students how to solve questions in a different way. The Vedic principles that students learned

on their quest to complete Math 015 are described in detail as follows.

Digit Sums.

A digit sum can be made by adding up all the digits in a number until only **one digit**

remains. For example, the digit sum of the number 156 can be calculated by adding up the

three digits 1, 5, and 6. This equals 12. Then the 1 and 2 are added together to get the digit

sum of 3 (Williams & Gaskell, 2010).

$$\mathbf{156} = 1 + 5 + 6 = 12 = 1 + 2 = 3$$

Digit sum of $\mathbf{156} = \mathbf{3}$

Digit sums are used for checking all arithmetic answers and for reducing fractions as outlined in the following description.

Digit Sum Checks.

Digit sum checks allow students to quickly and easily check their addition, subtraction, multiplication and division answers. In the addition problem below, for the problem to be correct the digit sum of the answer must match the digit sum check (Benjamin, 2011).

	Digit Sum Check
235	2+3+5 = 10 = 1+0 = 1
+ 515	5+1+5 = 11 = 1+1 =+2
750	**3**
7+5=12 = 1+2=3	

Step 1: Find the digit sum of the answer. ($7 + 5 + 0 = 12$ $1 + 2 = 3$ digit sum $= 3$)

Step 2: Find the digit sum for each number in the problem and add the digit sums together.

Step 3: Check that the digit sum of the answer matches the digit sum check.

Doing a digit sum check allows us to know if our answer is correct (with a high probability) without having to either complete the question again as is or by using subtraction. As Benjamin (2011) states: "If all calculations are correct, then these numbers must match. A match does not mean that your answer is correct, but if the numbers don't match, then you've definitely made a calculation error" (p. 42).

Proponents of Vedic math assert that this is a much faster way of verifying an answer (Benjamin, 2011). Students may find it more interesting than re-answering a question by

either adding it up again, or by using subtraction. Tirthaji declared that the Vedic system can "turn mathematics for the children from its present excruciatingly painful character to the exhilaratingly pleasant and even funny and delightful character it really bears" (as cited in Williams, 2009b, p.11). The same digit sum check may also be used for division, multiplication or subtraction questions.

To further simplify digit sum checks casting out nines is taught. Before calculating a digit sum check, all 9's or digits that add to 9 may be crossed out (cast out). Casting out quickens digit sum checks significantly. Digit sum checks are versatile as well as having other benefits: "...[digit sum checking] also works for addition and subtraction problems, even those with decimals, and it may be useful for eliminating answers on standardized tests that do not allow calculators" (Benjamin, 2011, p.42).

Digit Sums for reducing fractions.

Digit sum techniques can be used for reducing fractions to lowest terms (Williams, 2009b). Knowing digit sums may make it easier for students to learn divisibility tests for reducing fractions. When the digit sum of the numerator and the denominator are 3, 6 or 9 the fraction can be reduced by the factor of 3 (Williams & Gaskell, 2010).

Digit sum 3, 6, or 9 ....divide by 3
Digit sum 9 ....divide by 9
Digit sum 3 (and even numbers) ....divide by 6

$\dfrac{123}{453}$ $\dfrac{\text{digit sum of numberator is 6}}{\text{digit sum of denominator is 3}}$ Therefore, can reduce fraction by dividing by 3

Subtraction.

General Subtraction is taught first, then the following steps (Williams, 2009d):

Step 1: Subtract left to right instead of right to left.

Step 2: Subtract the first two numbers (2 – 1). Before writing down the answer, check to see if the following top digit to the right is less than the one below it. If so, as the example shows (6 – 7), subtract 1 from the previous answer. Carry the 1 over.

$$
\begin{array}{r}
2^{1}6\,7\,8 \\
-1\,7\,5\,4 \\
\hline
0\,9\,2\,4
\end{array}
\qquad
\begin{array}{r}
5\,6^{1}7\,8 \\
-\ 4\,3\,9\,4 \\
\hline
1\,2\,8\,4
\end{array}
$$

The only additional rule for general subtraction is if you have a question where the top & bottom digit are the same, skip over them and go to the next set of digits.

$$
\begin{array}{r}
5\ ^{1}7\ ^{1}5\ ^{1}2 \\
-\ \ 1\ 7\ \ 6\ 5 \\
\hline
3\ 9\ 8\ 7
\end{array}
$$

This digit is 3 because the 7s were skipped and the 5 requires that one is subtracted and carried to the 7

Subtraction using "All from 9 the last from 10" (Special Condition Subtraction).

This method was introduced because the instructor thought it would be beneficial to the students in practical situations such as shopping.

Step 1: When the first number ends in multiple zeros, change the zeros to "all from 9 the last from 10" and the first number is reduced by one (Williams, 2009b).

$$
\begin{array}{r}
5000 \\
-4876 \\
\hline
124
\end{array}
\qquad
\begin{array}{r}
\$60000.00 \\
-4559.42 \\
\hline
\$55440.58
\end{array}
\qquad
\begin{array}{r}
\$10.00 \\
-\ 9.21 \\
\hline
\$\ \ .79
\end{array}
$$

What is the change from a $10 bill?

Step 2: If both numbers end in zero, cross them out drop the zero to the answer.

Multiplication with 6 × 6 To 9 × 9.

This method teaches the block of multiplication tables that students have the most trouble with. It is an expected foundation of math that students memorize these tables, but this is not possible for all students. Students who have problems with working memory and short-term memory may be unable to memorize regardless of the amount of effort they expend.

In our experience, many students stumble over memorizing 7×8, 9×6, etc. The ongoing stress disables students and they report feeling 'stupid' or think they are unable to do any math at all without the crutch of a times tables chart.

Proponents of Vedic Math espouse that the Vedic method of multiplication method enables students. They can suddenly do multiplication without a times tables chart. This gives incredible power back to the student so that they can continue to study further in math (Tirthaji, 2008). The following example outlines how these difficult times tables don't have to be memorized.

Step 1: Line the problem up vertically.

$$\begin{array}{r} 7 \\ \times 8 \\ \hline \end{array}$$

Step 2: Think "How far from 10 is my number" and write it to the right of the number.

$$\begin{array}{r} 7 \\ \times 8 \\ \hline \end{array} \quad \begin{array}{r} -3 \\ -2 \\ \hline \end{array} \quad \boxed{\begin{array}{l} \text{7 is 3 less than 10 (-3)} \\ \text{8 is 2 less than 10 (-2)} \end{array}}$$

Step 3: Multiply the right side (3×2) and write the answer below.

Step 4: Subtract diagonally (whichever is easier) and write the answer below.

(i.e. $7 - 2$ or $8 - 3 = 5$).

$$
\begin{array}{cc}
7 & -3 \\
\times 8 & -2 \\
\hline
5 & 6
\end{array}
$$

Adding Fractions: First Method.

Fractions, specifically adding and subtracting fractions, are among the most difficult concepts for the typical ABE Math 015 student. This difficulty is not restricted to ABE students as Williams explained while offering a solution, "This [fractions] is a notoriously difficult subject for the children to learn and remember. But the Vedic method allows us to write the answer straight down using a simple pattern" (2009a, p.45).

Step 1: Cross multiply and add/subtract together for the numerator (start at top left).

Step 2: Multiply the denominators for the new denominator.

Example 1 $\dfrac{1}{4} + \dfrac{1}{3} = \dfrac{(1x3) + (1x4)}{4x3} = \dfrac{7}{12}$

Example 2 $\dfrac{1}{5} + \dfrac{3}{4} = \dfrac{(1x4) + (3x5)}{5x4} = \dfrac{19}{20}$

Example 3 $\dfrac{2}{3} - \dfrac{1}{4} = \dfrac{(2x4) - (1x3)}{3x4} = \dfrac{5}{12}$

Example 4 $\dfrac{1}{10} + \dfrac{4}{5} = \dfrac{45}{50} = \dfrac{9}{10}$ Do this problem by the first method and then reduce to lowest terms. However, this gets more cumbersome as the denominator gets bigger. It is better to use the second method when the denominators have a common factor (the denominators are not relatively prime).

Fractions with common factors (without relatively prime denominators):

Second Method.

The previous question has a common factor that gets cancelled out by reducing the fraction at the end. To simplify this, Vedic math cancels out the common factor creating sub-denominators before starting the problem.

Step 1: Find a common factor using divisibility tests (the skill learned when reducing fractions). Take the common factor out of each denominator. Put the sub-denominator (quotient) below each denominator.

$$\frac{1}{10} + \frac{4}{5}$$
$$(2) \quad (1)$$

Notice the benefit of not having to calculate common denominators.

Step 2: Use the sub-denominators to cross-multiply the numerators with the denominators.

$$\frac{1}{10} + \frac{4}{5} = \frac{(1 \times 1) + (4 \times 2)}{}$$
$$(2) \quad (1)$$

This method reduces teaching time of adding and subtracting fractions because no new complicated concepts are learned (i.e. lowest common denominator and LCM). Students only build on the skills they already know about reducing fractions.

Step 3: To find the denominator, cross-multiply a sub-denominator with a denominator.

$$\frac{1}{10} + \frac{4}{5} = \frac{9}{(10 \times 1) \text{ or } (5 \times 2)} = \frac{9}{10}$$
$$(2) \quad (1)$$

Table 2 further illustrates Vedic math methods (Tirthaji, 2008, Williams, (2009a b,c).

Table 2

Math 015 Solutions Using Vedic and Current (Conventional) Methods

Vedic Method	Vedic Notes	Conventional Method	Conventional Notes
Subtracting $\begin{array}{r}5008\\-\ 2345\\\hline 2663\end{array}$	Subtract left to right with no borrowing or crossing out	$\begin{array}{r}\overset{4\ 9}{5008}\\-\ 2345\\\hline 2663\end{array}$	Uses borrowing and crossing out. Relies on working memory.
Fractions $\frac{1}{3}+\frac{1}{4}=\frac{4+3}{12}=\frac{7}{12}$	No common denominator	$\frac{1}{3}+\frac{1}{4}=\frac{1(x4)}{3(x4)}=\frac{4}{12}$ $\frac{1(x3)}{4(x3)}=\frac{3}{12}$ $=\frac{7}{12}$	Common denominator needed
Fractions with common factors $\frac{5}{12}+\frac{7}{18}=\frac{15+14}{36}$ _{(2) (3)} $=\frac{29}{36}$	Uses a common factor instead of a common denominator	$\frac{5}{12}+\frac{7}{18}=$ $\frac{5\,(x3)}{12\,(x3)}=\frac{15}{36}$ $+\frac{7(x2)}{18(x2)}=\frac{14}{36}$ $=\frac{29}{36}$	Common denominator needed
Times tables over 5x5 *7x8* 7 -3 8 -2 56	No memorization needed - Can be figured out mentally	7X8=56	Memorization of tables required
Checking devices 2571 +6128 [5] 8699 [5]	Digit sum checks for adding, subtracting, multiplying and dividing	8699 -6128 2571	Must rework the problem or use a calculator!

These methods were incorporated into the Math 015 curriculum to see if they would improve student success, students' feelings about math, and instructor confidence in the methods.

Research Questions

What we want to know by the end of this study is:

1. Does teaching Math 015 using Vedic math methods improve student completion rates?
2. How do the students rate their learning experiences?
3. How does the instructor rate the teaching experience?

Research question 1 will be assessed using a chi-squared test of association.

Null Hypothesis: There will be no change in math completion rates. $H_{o:}$ $\pi_{Trad} = \pi_{Vedic}$

Alternative Hypothesis: There is a change is math completion rates. $H_{1:}$ $\pi_{Trad} \neq \pi_{Vedic}$

Significance

This preliminary study will inform entry level math instructors whether Vedic math is a method worth exploring further. The goal is to understand if Vedic math can improve student success and create positive feelings about learning and teaching.

Chapter Two: Methods

The scope of this project was to teach a Math 015 class using Vedic math methods for ten weeks from October to December 2011. This project compares the Vedic Math 015 completion rates to data of previous Math 015 classes that were taught in the conventional way. In addition, the learning experiences of adult students using Vedic math are recorded through questionnaires to gain an understanding of their perceptions of the learning process. Student perceptions about learning math are critical to their motivation and eventual success (Anderman, 2010). As well, the instructor's observations of the students' progress and her experiences during instruction of the class are indicators of whether these techniques will be used beyond this study. Assessment of learning was based on monitoring progress, student satisfaction surveys, instructor feedback, and completion rates.

Subjects

After the completion of a project proposal and approval from both CNC and UNBC ethics boards, this project began by recruiting Math 015 students to be participants in the study. Along with a poster campaign advertising the Vedic classes, students were recruited went I went into the two Adult Education Centre (AEC) classrooms and provided an informational session about the Vedic Math Project. Interested students were screened for eligibility into the study by their verbal demonstration of their willingness to try something new, prior instructor knowledge of their math abilities and challenges, and placement at the Math 015 level. Students were asked to commit to attend three, one hour classes each week. The commitment to finish the project within a timely manner and with a cohort of students was chosen over allowing continuous intake, which would have been problematic when trying to assess if a different way of teaching math was having a positive effect within a

specific amount of time. This adaptation to class structure to accommodate the tight time frame is a limitation.

Prior knowledge of each student's math abilities and challenges was necessary to ensure students were challenged in math and were assessed at the Math 015 level. The interest was in studying the hard-to-teach student. To accomplish this, the Level B math portion of the Canadian Adult Achievement Test (CAAT, 1988) was administered. This standardized assessment is used to gauge the achievement level of adults who have had varying amounts of formal education. Level B is targeted at learners with five to eight years of education. In addition, a CNC specific math placement was utilized which is commonly administered to all CNC Lakes Campus Adult Education students.

Instrumentation

Intake interviews were completed to gather general demographic information from the students and record their recollections of their previous experiences learning math. Interviews ensured that the students sought were learners who have had challenges learning math and were living in circumstances typical of CNC Lakes Campus fundamental level one students. To facilitate the process, interviews were scheduled at convenient times for students.

An absolutely key element of recruitment success was having existing relationships with the students, and the ability to build on these relationships. Math is a subject that students are not lining up at the door to take as it evokes negative memories and experiences of failure. It was with a gentle and reassuring manner that students were recruited, screened, and accepted. Once students were admitted to the study, they were informed that they would be compensated for their time in the class by being remunerated five dollars per class they

attended. A strong commitment to the students exists, and because Vedic math is an empirically unproven method, the students' merited payment for embarking on this journey with us.

Over the ten week period five Vedic math topics were covered. At the end of each Vedic math topic students were given a questionnaire to complete that assessed their self-reported understanding of the math method and their feelings about learning. These topic by topic questionnaires could be used to decide if some Vedic math topics were better received than others. If there were concerns or issues with any particular topic they could be easily identified.

The instructor also completed a feedback questionnaire after each Vedic topic. Having a better understanding of how the instructor felt about the teaching process is an important indicator of whether these methods will be used again. As with any class, the instructor looked for early indicators of anxiety and frustration so she could intervene before a situation escalated. She also watched for signs of understanding and self-belief during the learning process. She used this information to steer the classes, and the feedback gained from this process can be very useful.

Chapter Three: Results and Discussion

The following section describes what was learned from the students, their instructor, and from the data collected during the Vedic Math Project.

Instructor Ratings on Student Progression

Prior knowledge of students' abilities in math was important to understanding whether barriers to learning existed. As students who had learning challenges were sought, instructors were asked to rate their prior experiences with each student based on the following scale:

Table 3

Instructor Perception of Students: Progression

On a Scale of 1 to 4 please assess student's progression through Math 015:

	Quicker than average	Average	Slower than Average	Not at all
	1	2	3	4
Number of responses		1	8	2

Note: n = 11

Table 4

Instructor Perception of Students: Level of Frustration

On a Scale of 1 to 4 please rate the level of frustration this student experienced with Math

	None	Minimal	Moderate	Strong
	1	2	3	4
Number of responses		2	7	2

Note: n = 11

Generally, instructors rated students as being slower than average in their ability to progress through Math 015 and having a moderate level of frustration. These findings aligned with the type of students sought for the project. Instructors were asked if they had

additional comments on students' previous Math 015 experiences. The following comments were made:

- *Student started at CNC last year. She had been going to another centre for upgrading but when it closed she came here. Although she completed Math 015 M1-M4 topics at the other centre, she was unable to remember decimals or fractions. She worked on decimals for three months here (her attendance was excellent) and completed the course. She struggled with most of the units but because of her dedication she was able to pass with 58%. Her strong attributes are that she is very neat, very methodical, and very determined. She suffers from a recent brain injury (car accident) and she recognises that her brain works differently now and her memory has suffered.*

- *This student has been working on Math 015 for several years now. Although attendance has been an issue, frustration with math concepts is a bigger factor in not completing Math 015.*

- *This student has been working on Math 015 for years. She has the basics of adding and subtracting but struggles a bit with multiplying and dividing. She avoids math whenever possible.*

- *The student has been a Math 015 student for just over a year. She has completed adding, subtracting, multiplying, and dividing but she struggled through dividing.*

- *This student struggles with some math concepts. For example: rounding. She needs extra time with assignments. She has completed Math 015, M1 and M2 but has been working on them for more than the average time. She is extremely dedicated and her attendance is excellent.*

- *The student chooses to work on other subjects during math. She totally avoids it. She even says out loud she dislikes math.*

- *This student has been a student at CNC for many years and has remained at the Math 015 M2 level (she has never gotten past multiplying). She needs a lot of one-on-one assistance to grasp new concepts.*

Intake Interview and Socio-economic Survey Results.

Eleven participants completed intake interviews, with ten participating in the project. They ranged in age from 20 to 49. Their average age was 36.9 and their median age was 40. They were all females who lived in Burns Lake and the surrounding area. Ten participants reported being Aboriginal and one reported as being Other (Asian). Five of the eleven (45%) supported themselves by accessing Band Assistance, one person accessed employment insurance, one person was self-employed, one person was on social assistance, one person

had part-time employment combined with social assistance, and two people had other forms of support. In both of these later cases, they each had a partner or boyfriend who supported them and therefore, neither had direct access to any income. From these findings we can surmise that all participants are economically disadvantaged, and aligned with the profile of students sought.

When asked what grade they achieved in Math, the participants gave a range between grades eight and twelve with grade ten being the mode with seven participants choosing this grade. When asked what they liked about learning math, they replied:

- *pluses*
- *easy steps to help memorize way (techniques)*
- *I started memorizing numbers i.e. SIN, kids' birthdates, bank card, status card - her daughter asked her how she memorized numbers and she told her that ABT (Applied Business Technology) [class] taught her little things about numbers like 5 is not an S*
- *beginning is nice, but when you get into the hard stuff it's hard to figure out what they want you to do*
- *used to love geometry*
- *I was accurate, lots has changed with my memory since then*
- *calculation*
- *subtraction, addition, division*
- *it was ok until learning percentages then I kind of lost interest - its better one hour at a time, not a whole morning*
- *doing it - used to be my favourite subject*
- *times*

When asked what they did not like about learning math a variety of opinions also surfaced:

- *divisions, multiplication*
- *doing it without easy steps*
- *subtraction and division and problem solving - didn't like numbers when younger*
- *remembering I did not like it*

- *divisions*
- *six blank or nothing responses*

From these responses, it can be surmised that the students had some positive feelings about learning math, and also dislikes. All of the responses referred to basic math skills with very little reference to higher level math except for "used to love geometry." Six students chose not to say anything negative about math.

A rating scale was used for the next four questions. As Table 5 explains, question four asked students to rate how their previous grade school math experiences made them feel. Two replied unsuccessful with comments about "in the principal's office" and "my math memory is gone."

Question five asked participants to rate their previous CNC math experiences. One participant noted "finished three books.' One student added "I keep thinking I'm going to get everything wrong, but I'm not as stupid as I thought I was." Overall, students rated their previous math experience more as being more successful than their ability to achieve course completions would suggest.

Table 5

Students Perceptions of Success with Past Math Classes:

On a scale of 1 to 4 rate how your previous grade school math experiences (Q.4) and CNC math experiences (Q.5) made you feel.

	Unsuccessful	Somewhat unsuccessful	Somewhat successful	Successful
	1	2	3	4
Q.4	2	2	4	3
Q.5	0	2	6	3
Note: n = 11, Q.4 = Question 4 and Q5 = Question 5				

Anger was chosen as an emotion to measure as this is a common observation made by Math 015 instructors during the learning process. Students who become angry quickly have a harder time learning the material. Anger is a more concrete, and a more easily self-identified emotion than "overwhelmed" or "frustrated" even though these two descriptors may be a more accurate representation of what students are experiencing.

Table 6 demonstrates that no students replied that math hardly ever made them angry. Eight people reported that math makes them somewhat angry, one person replied occasionally angry, and two replied often angry. One person commented that "I get frustrated and leave it for awhile" and another replied "tests." It is interesting to note that all students reported some level of anger with math. Although anger is a common emotion observed by instructors during math class, these students did not identify it as readily as instructors might.

Table 6

Students Perceptions of Anger Expressed While Learning Math

On a scale of 1 to 4 describe how angry math can make you feel?

	Hardly ever angry 1	Somewhat angry 2	Occasionally angry 3	Often angry 4
Q.6	0	8	1	2

Note: n = 11, Q.6 = Question 6

Question seven asked about the level of happiness participants have experienced with math. Table 7 indicates most students' report some level of happiness which was used as an indicator of a willingness to try something new and as a foundation upon which math skills could be built. It was also a surprising response given that students have been struggling to complete Math 015.

Table 7

Students Perceptions of Happiness Experienced While Learning Math

On a scale of 1 to 4 describe the level of happiness you have experienced with math

	Hardly never happy	Somewhat happy	Occasionally happy	Often happy
	1	2	3	4
Q.7	1	4	5	1

Note: n = 11, Q7 = Question 7

Question eight asked students to circle words that described how they felt about math. Five respondents replied successful, four replied frustrated, one replied happy, and one replied confident. One respondent chose "other" and added "confused". When asked if there were other comments people had about math, the only comment received was "I just remember Sister Eileen drilling us." Given their difficulties with math skills, it was surprising that more respondents chose "successful" than any other descriptor.

The intake interviews and previous instructor feedback ensured the intended students were reached. These students were not achieving success at Math 015 and who were working to overcome challenges in their lives. The intake interviews demonstrated the participants had difficulty completing traditional math, and were from a socially and economically marginalized group.

Students reported their experiences with traditional math a little less favourably than their math experiences at CNC, but overall rated their experiences as somewhat successful. This flicker of hope was used as a starting place. Instructors generally rated students experiencing a moderate level of frustration while the students' most common response was somewhat angry vs. occasionally angry. It could be construed that while the students' and

instructors' ratings are somewhat similar, students perceived their math experiences and their math abilities as being more positive and stronger than the instructors' perceptions. One surprise was that students generally rated their experiences as successful even though they had not advanced through Math 015.

Participants were pre-tested before the Vedic math classes began with both a locally developed CNC assessment and the standardized CAAT assessment. While understanding the necessity of using a standardized tool for the research study, using the tool commonly used in practice to assess student abilities had value. The CAAT assessment is not always used in practice to assess student performance because students/staff report that it is stressful due to its multiple choice format and the use of "not given" for a choice, which students find extremely confusing. The locally developed CNC assessment is perceived to keep students' stress levels lower. There are fewer students reporting feelings of stress when using this tool. Surprisingly, the outcomes of the two assessments are similar as shown in table 8.

Table 8

Pre and Post Assessments Using CNC and CAAT Placement- Vedic Math Participants

Students	Oct CNC	Dec CNC	Mar CNC	Oct CAAT	Dec CAAT	Mar CAAT
n1	16%	NC	NC	6%	NC	NC
n2	26%	NC	NC	49%	NC	NC
n3	21%	42%	37%	20%	54%	37%
n4	42%	80%	68%	37%	80%	69%
n5	21%	47%	NC	17%	40%	NC
n6	16%	61%	58%	46%	74%	80%
n7	32%	68%	63%	23%	63%	77%
n8	16%	NC	NC	14%	NC	NC
n9	32%	NC	NC	20%	NC	NC
n10	21%	NC	NC	3%	NC	NC
Mean	24%	60%	57%	24%	62%	66%

Note: NC = Not Completed

While the table suggests a pattern, a histogram was produced; see figures 1 and 2.

Figure 1. Pre and Post Assessments: All Vedic Students
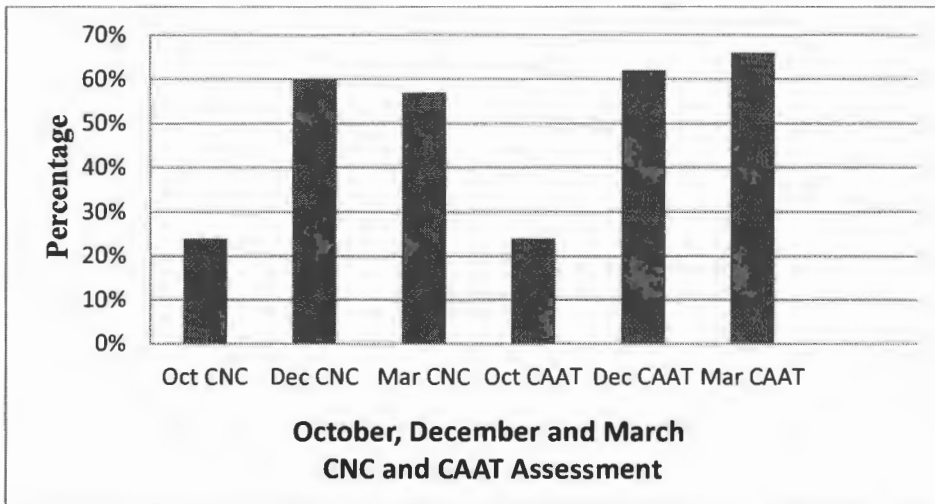
Figure 1 demonstrates the assessment placements for all ten Vedic math students. Students scored similarly between the CNC assessment and the CAAT assessment. The December scores illustrate their improvement over the ten week period. The March score shows how well they were able to remember what they had learned.
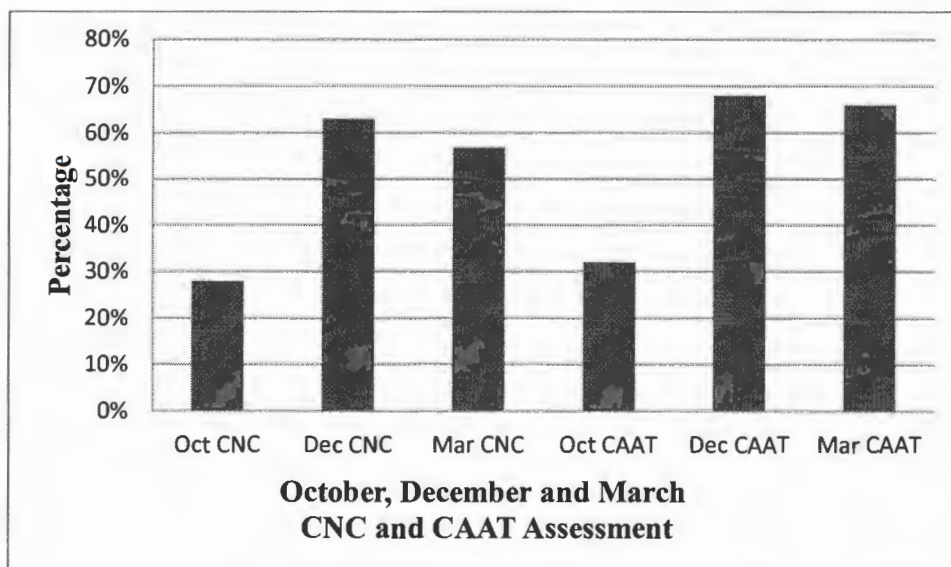

Figure 2. Pre and Post Assessments: Vedic Student Completions

The students' average pre-test score was 24% indicating that Math 015 was the correct placement for them. After the ten-week Vedic math classes, the post-test showed an average of score of 60% (CNC) and 62% (CAAT), a 20%, or 22% improvement. The assessment for skill retention was completed three months after the end of the Vedic class (March, 2012) and showed that students who completed Math 015 were largely able to retain the skills they had learned. Figure 2 only shows data for the four students who completed the course, and thus were the only ones completing the March assessment. One student completed the December assessment, but has not been able to hand in all remaining course work and is not counted as a completion. The data for figure 2 is on table 9.

Table 9

Pre and Post Assessment Percentages using CNC and CAAT Assessment: Completions only

Students	Oct CNC	Dec CNC	Mar CNC	Oct CAAT	Dec CAAT	Mar CAAT
n3	21%	42%	37%	20%	54%	37%
n4	42%	80%	68%	37%	80%	69%
n6	16%	61%	58%	46%	74%	80%
n7	32%	68%	63%	23%	63%	77%
Mean	28%	63%	57%	32%	68%	66%

Comparatively, the Vedic students as a whole started out with a mean of 24% while the four students that completed started with a mean of 28%. If the four completions are excluded from the class mean, the remaining mean is 22% for the students who did not complete. The students who completed Math 015 started from a slightly higher foundation than the students who did not complete. Also important to note is that the students who did not complete had a significant amount of non-math related stress in their lives that contributed to their inability to continue attending school.

To assess how the Vedic math class compared to other math classes, the mean, median, inter-quartile range and standard deviation are compared in table 10.

Table 10

Comparison of Vedic Math 015 Assessments to Prior Math Class Assessments

Classes	n	Mean	25th Quart	Median	75th Quart	Stand Dev
Vedic: All	10	24%	17%	21%	30%	8.7%
Vedic: Completions	4	28%	20%	27%	35%	12%
2011-12 Regular	38	23%	16%	21%	32%	11%
2010-11 Regular	40	19%	13%	16%	22%	8.9%

Note: Regular classes included Multi-leveled, Structured and Southside Math 015 students.

Important to note while looking at this data, is the number of assessments does not equal the number given for enrollments in Table 10. The reason is that while students are enrolled each year, the assessment or placement is done only once. Returning Math 015 students are not given a new assessment every year as the instructors already know what level they are at. As previously mentioned, it is sometimes common for Math 015 students in particular to stay at the Math 015 level for many years. Students who have long histories of struggling with math need ample time.

Also important to consider is that the regular assessment is given to new students only. These are students who are returning to school for the first time after being away from math class for a variable length of time. The Vedic math students were all returning Math 015 students who had previous Math 015 experience. While we can see that the median and mean for the Vedic class is higher, this should not be surprising as the material is not new to them. Considering that they have already been in Math 015 classes and are returning students, one might assume their pretests could be higher. For all other students, the assessment is often the first time they have solved a math question without a calculator in

years. Again, this confirms that the students we are seeking to assist with Vedic math classes fall within a most vulnerable category.

The standard deviation and inter-quartile range are reasonably comparable throughout the four groups. Fifty percent of all student assessment scores fall between the 25th and 75th quartile range. For example, for all Vedic students their median score was 21% with 25% of the marks falling within 17% and 21% and 25% of the scores falling between 21% and approximately 30%. The standard deviation for this example is 0.087 meaning that the median score plus or minus 0.087 is where 32 and 32 or 68% of the assessments rate.

Table 11 outlines the completion rates for previous Math 015 classes and for the ten week Vedic math 015 class are outlined. Over a four year period from 2007 to 2011, CNC had 393 enrolments in math with 31 learners, or approximately eight percent, completing the course. At the end of the ten week Vedic math class, four students completed the course and another is very close. These four students represent a 40% completion rate. Using a chi-squared analysis it can be determined that the outcomes could not have happened by chance alone and that something improved completion rates.

Table 11

CNC Lakes Internal Data: Math 015 Completions for Lakes Campus

Year	Enrollments	Completions	% Completions
2007-2008	94	9	9.57
2008-2009	109	9	8.26
2009-2010	107	7	6.54
2010 - 2011	83	6	7.23
Totals	393	31	7.90
Math 015 – Vedic			
2011	10	4	40.00

$\chi^2 = 57.93$, df = 4, p < 0.01

The time allocated for CNC Math 015 completion is between eighty to one-hundred and twenty hours for a typical learner (September to June). In our local experience it can take learners with challenges much longer; years longer. The Vedic math class ran for thirty hours and there were four completions. When comparing the pre-test assessment scores of these four completions to other typical Math 015 learners there is little difference. Yet greater rates of successful completions were achieved in a shorter period of time.

The ten Vedic enrollments represent students who were identified as having challenges with Math 015, and were able to commit to full-time class participation three days each week (were not working) for a specific period of time (October to December 2011). Typical Math 015 student registrations are ongoing throughout the year, for part-time students, for drop-in students, and for night students. To facilitate the process of determining if Vedic math was a viable option for Math 015 students, the process was expedited by limiting enrollment to a ten week commitment. The value of this approach was learning if it was significant in a short period of time, the detriment to this approach was having limited access to available students. The interview intake, and past experiences with the students, ensured that those who participated were part of the target group (students who live with ongoing struggles and find Math 015 challenging to pass).

The maximum number of students in class per instructor is fifteen, which was the target number. The enrollment numbers for previous years are based on three full-time and four part-time instructors spread over several classrooms; the multi-leveled classroom (for students working at their own pace), the evening classes, the structured classroom (for students not suited to the multi-leveled format), and the Southside CNC AEC classroom, which is located in a remote community across Francois Lake.

Also important to note is that the prior completion rates are based on an entire year of Math 015 compared to only ten weeks of instruction using Vedic math methods. The students that did not complete the math course left for an assortment of personal reasons, none of which were related to a poor fit between the subject and the learner. In fact, of those that left some hope the program will run again so they can be a part of it.

The statistical test in table 12 illustrates the significance of the results.

Table 12

Chi-Squared Calculation for Goodness of Fit

Year	Obs.	Expected	Difference	$(O-E)^2$	$(O-E)^2/E$
2007-2008	9.57	14.32	-4.75	22.56	1.58
2008-2009	8.26	14.32	-6.06	36.72	2.56
2009-2010	6.54	14.32	-7.78	60.53	4.23
2010-2011	7.23	14.32	-7.09	50.27	3.51
2011 Vedic	40	14.32	25.68	659.46	46.05
Total	71.6			Chi-sq	**57.93**

Note: df = 5-1= 4

It can be concluded that the difference in the completion rates for the Vedic math class did not occur by chance. The probability that expected values occurred by chance are low, less than 0.01. Therefore, chance is not an adequate explanation and we must accept the alternate view. The ten-week Vedic math class had an impact on completion rates.

Vedic Math: Student Feedback Questionnaire Results.

The following tables and feedback demonstrate the acceptance of the methods. Almost without exception, students rated the topics positively.

Table 13

Student Feedback: Assignment Completion

1. Were you able to complete assignments during Class time?

Topic	Yes	No
All from nine the last from ten	6	0
Multiplying six to nine	5	0
Digit sum checks	5	0
Subtracting fractions	4	0
Adding fractions	4	0

Over the ten week period, all students reported being able to finish their assignments during class time for all Vedic topics. The second question asked if students were able to complete their homework assignments. As the following table shows, all but one student reported being able to finish their homework for all topics.

Table 14

Student Feedback: Homework Completion

2. Were you able to complete the homework assignments?

Topic	Yes	No
All from nine the last from ten	5	1
Multiplying six to nine	5	0
Digit sum checks	5	0
Subtracting fractions	4	0
Adding fractions	4	0

The third question asked students to circle the sentence that best described how many assignment questions each student understood. As the following table shows, with the exception of the first week, all students reported that they understood all of the questions.

Table 15

Student Feedback: Describe your understanding

3. Circle the sentence that best describes how many assignment questions you understood.

Topic	None	Some	Most	All
All from nine the last from ten	0	0	2	4
Multiplying six to nine	0	0	0	5
Digit sum checks	0	0	0	5
Subtracting fractions	0	0	0	4
Adding fractions	0	0	0	4

None = I understood none of the questions
Some = I understood some of the questions
Most = I understood most of the questions
All = I understood all of the questions

Question four asked students to circle words that best described how they felt about this Vedic topic. By asking students how they felt about Vedic math topics, we hoped to glean what their emotional state was while learning this new type of math. Respondents overwhelmingly chose emotions on the positive end of the scale (happy, successful and confident). These findings align with how we know students learn best, and are markedly different from the students reports of past math experiences where some anger and frustration was reported.

Table 16

Student Feedback: Describe how you felt

4. Circle words that best describe how you felt about this Vedic topic

Topic	frustrated	angry	confused	indifferent	happy	successful	confident
All from nine the last from ten	0	0	1*	1**	5	4	3
Multiplying six to nine	0	0	0	0	4	5	5
Digit sum checks	0	0	0	0	4	4	4
Subtracting fractions	0	0	1	1	3	4	3
Adding fractions	0	0	0	0	3	3	4

*Topic 1: A responder circled confused; although this student was able to complete a worksheet containing 24 questions without any errors.

**Topic 1: Students had difficulty understanding the meaning of the word "indifferent". A discussion started within the class as they were confusing "indifferent" with "different" in the context of "Vedic math is a "different" way of doing math. The recommendation would be not to use this particular word as an option.

Comments from Topic 1: All from nine the last from ten.

Question five asks students if they have any other comments. In their comments we can more clearly see the impact that learning math in a new way had on them. The comments are in order from the topics covered from October to December. Comments are edited for spelling and grammar. Meaning and intent are not knowingly altered.

- *After I understood the question I got the hang of it.*
- *I enjoyed math work for today*
- *I like this math it is easy and I think everybody should do this new way of math*
- *I found Vedic math to be easier than the old fashioned way to solve the problem.*
- *It is alright*

Comments from Topic 2: Multiplying six to nine.

Question 5: Do you have other comments?

- *I really think this is a faster way to do my multiplication, and teach others.*
- *This would help all my times table. Now, I understand my times tables.*
- *I think it's very awesome to learn. I think we should do this for math all the time because it's a lot easier.*
- *Multiplication in Vedic Math is fun. I should've known this long ago.*
- *It's an easy way to solve the multiplication from 6 to 9.*

Comments from Topic 3: Digit Sum Checks.

Question 5: Do you have other comments?

- *I was very happy to learn new ways to do math and was confused at first until I got the hang of it. I really enjoy it now.*
- *I enjoyed all the math work so Thank you.*
- *I like this new math because I hardly get my work wrong with the new digit sum check is great because we get to see if we get the right answer.*

Comments from Topic 4: Subtracting Fractions.

Question 5: Do you have other comments?

- *This mathematics is so much fun. Learning the Vedic way, it was so much easier and faster.*
- *It's easy to solve the Vedic subtracting fractions than the old way (quick and short cut solving).*
- *I think this way is easier sometimes, a bit hard, but I like it.*
- *I enjoyed learning subtracting fractions in this class. I have learned in 2 to 3 hrs. Thank you. I have enjoyed this class very much.*
- *I am feeling good about doing subtraction of fractions if I am in a hurry. I'm so glad I've learned that I can get my math done easier. THANK YOU VERY MUCH.*

Comments from Topic 5: Adding Fractions.

Question 5: Do you have other comments?

- *I make mistakes sometimes, but this math is fun once you can learn it. Thank you for the time.*
- *I really enjoy doing the math the Vedic way and don't know the other method of fraction adding, but this way is faster and more fun.*
- *I really liked the bubbles. The Vedic way math helped me to understand math a lot better, than I did. Thank you.*

- *The Vedic adding fractions it easier than the old way solving.*

Instructor Feedback Questionnaire Results.

The results of the following tables and comments clearly demonstrate that the Vedic

method of instruction was worthwhile teaching.

Table 17

Instructor Feedback: Help Needed by Students

1.How much help was necessary for students to compete the lesson?

Topic	Minimal	Moderate	Constant/1:1
Digit Sums	7	0	0
Subtracting	6	0	0
Multiplying	4	1	0
Divisibility checks	0	5	0
Fractions: Adding	0	5	0
Fractions: Subtracting	0	5	0

Table 17 showed that students required minimal help during the first three topics and

then moderate help for the last three topics. As with any course, as the complexity of the

material increased so did the need for support. However, there are no reports of students

requiring constant or one-on-one support.

Question two asked what percentage of students completed each of the lessons. The

instructor reported that one hundred percent of students attending were able to complete the

series of lessons within the classroom time or in the moments after.

Question three asked the instructor to pick two words that best describe how she felt

about teaching this lesson. Of the two or three words chosen, *Happy* and *Satisfied* were the

most common words picked. From these responses it can be deduced that overall the

teaching experience was positive. The instructor also added the word "surprised" twice. This word indicates the teaching experience was outside of the expected and was more positive than expected.

Table 18

Instructor Feedback: Teaching Descriptors

3. Pick two words that best describe how you felt teaching this lesson

Topic	FR	CF	IN	ST	HP	SF	Other?
Digit sums					✓	✓	
Subtracting				✓	✓	✓	'Surprised' that they all caught on quickly
Multiplying				✓	✓	✓	
Divisibility checks					✓	✓	
Fractions: Adding					✓	✓	
Fractions: Subtracting							'Surprised' that borrowing was so easy to teach

Note: FR = Frustrated, CF = Confused, IN = Indifferent, ST = Satisfied, HP = Happy, and SF = Successful

Question four asked the instructor to rate the level of observed frustration the students' experienced with each lesson. If the teacher believes the class is frustrated by the way a topic is being taught she or he will intuitively change course. If this happens, it could indicate a problem with that particular Vedic topic. The following table illustrated that the instructor observed minimal or no frustration for the first two to three topics. Then a slightly higher level of frustration was observed for the last three topics. This result concurs with question one which asked the instructor what level of support students needed. As the instructor perceived class frustration level inching up, she reported an increased need to provide support.

Table 19

Instructor Feedback: Class Frustration Level

4. Using a ratio please rate the level of frustration the class experienced with this lesson

Topic	Minimal/No 1	2	Moderate 3	4	Very Strong 5
Digit sums	7/7				
Subtracting	6/6				
Multiplying	3/5	2/5			
Divisibility checks		5/5			
Fractions: Adding		5/5			
Fractions: Subtracting		5/5			

Question five asked the instructor for additional comments or ideas. Instructor comments illustrate the pros and cons on a topic by topic basis. Suggestions for changes are made, as well as comments about what worked well. These recommendations can be incorporated into future Vedic math classes. The observations are listed below starting from the first topic covered.

Topic 1 Digit Sums from lessons one and two:

- Practice digit sum checks more. Have students check their own work more often using digit sum checks.

- Students had no problem applying their knowledge of digit sums to divisibility tests a month later.

Instructor wrote down the following comments from students:

- *"That's crazy – it worked" (while checking addition sums with digit sum checks)*

- *"This is so awesome"*

- I [instructor] asked the students at the beginning of their first class. *"Who is feeling a little nervous – any sweaty palms*?" lots of hands went up. At the end of class, a student that had so much anxiety about being in class (the instructor who walked her to class mentioned to me she was almost crying in the hall) said loudly after completing her assignment, *"I got it and I don't have sweaty palms!"* She had a huge smile on her face.

- *"I started doing [digit sums] at home with birthdates for fun."*

- While doing a review of adding/subtracting/ multiplying/dividing with digit sums checks one comment was, *"It's two o'clock? Time flies when you're having fun!"* Students wouldn't leave until all of their homework was done.

Topic 2 Subtraction from lessons three and four.

- One student was very unsure of the digit sums subtraction check. I spent an extra fifteen minutes at the end of class until she got it.

- I [instructor] was really nervous going into lesson four (borrowing) because everyone knew how to subtract. The students caught on to the borrowing method after just two questions! One student with a significant brain injury caught on the quickest.

- A few students needed a reminder to subtract one from the initial number before applying the "All from nine the last from ten" rule. For example:
$$^4\!5000 - 3456 =$$

- This is a very easy method for students to learn. The question will be if they can remember this method in the future when doing mixed subtraction problems.

  Instructor recorded additional comments from students:

- One student working on subtracting and checking with digit sums said, *"Oh God, this is so fun!"*

- One student commenting to another instructor who walked in the class, *"I think I found that really fun."*

- Students talking about Vedic subtraction in general:
  - *"For some reason it feels like a game"*
  - *"We are in there for a full hour but it just goes so fast"*

- Student talking with her support worker: *"Math is so fun. And I have homework. I'm so excited. It will be so fun. I can't believe this is coming out of my mouth!"*

Topic 3: Multiplication.

- It would be beneficial to have the time to teach this method for the multiplication tables up to fifteen. The concept of "bar" numbers would have to be taught. It might be worthwhile to teach this in the regular MA015 curriculum to measure students' confidence around multiplying.

- Students were very excited to hear that there was a method for "the block" other than memorizing. The "block" are those times tables ranging from six 6 x 6 to 9 x 9. They are difficult to impossible for some students to memorize. A discussion started during the lesson about times tables phobias. Many stories surfaced about not having memorized "the table". Students shared their fear, anxiety, and embarrassment about times tables. One student disclosed having a childhood illness in grade 4 which wiped out all her memory and confessed that she never relearned the times tables. Another student shared that she had been in a car accident and had sustained a brain injury which erased her memory of times tables. Another, "Just never learned them."

- Class time was over at 1:50pm but students refused to leave until we did <u>all</u> the facts. We were there until 2:10pm. One student wouldn't leave until I showed her all the tables once again so she could go home and show her children.

- There were lots of smiles throughout class and lots of "WOWs."

- Students were <u>eager</u> to come to the board to do questions.

- *"It seems like a game"* stated a student while working on problems.

Topic 4: Divisibility Tests.

- Students needed reminders to reduce fractions.

- There were not any overt signs of frustration – all the students were very happy. They all needed clarification or a little help getting through the assignments. They all felt comfortable asking questions when help was needed.

- Divisibility testing was found easier to teach than common factors. Divisibility testing has a list of concrete rules while with common factors, factors can be missed. This is especially true with the higher numbers. Finding factors takes a higher level of concentration, more time, and thus the level of frustration can be higher. With divisibility rules there wasn't any frustration.

- Finding a three as a factor (divisibility test for three) was exciting to teach because the students were so good at digit sums already. They were very happy to be learning something so simple, yet no other student in MA015 knew. Students did a lot of smiling during these classes. This reaction was much more positive than teaching common factors in preparation for reducing fractions.

- This skill of factoring through divisibility testing is the only concept needed to do adding/subtracting/multiplying/dividing fractions using the Vedic method. Finding the lowest common multiplier (common denominators) for adding/subtracting is not used; therefore, less teaching time is required.

- Students came up with a new name for divisibility testing, "Divisibility Checks" (they hated any reference to *tests)*.

Topic 5: Adding Fractions.

- The initial teaching of the concept was completed in only twenty minutes. However, students needed to review the steps the next day. If Vedic fractions were to be taught in the MA015 classroom, extra practice time would be beneficial. While more time is needed to solidify the method into long term memory, teaching time is drastically reduced!

- One student realized (on her own) that you could continue to reduce the "bubbles." This was going to be the next day's lesson. For example:

$$\frac{1}{50} \quad + \quad \frac{1}{100}$$

$$(5) \qquad (10)$$

$$(1) \qquad (2)$$

- One student kept working on adding fractions even after class. She wanted to stay all afternoon.

- After three hours of class time, students took MA015 M4 unit 5 test and scored 92%, 92%, 92% and 100% (one student didn't write). They did extremely well; much better than I had anticipated.

- It would be beneficial to have two weeks (4-6 classes) of review to practice all the new methods. It has been one new thing after another with very little time to go over and review the learned material.

- Comment made by one student to another: *"I used to hate math, now I love math."*

Topic 6: Subtracting Fractions.

- The Vedic math borrowing technique was much easier to teach than the traditional method.

- If the first number is a whole number, students found it easy to add 0/1 to make it a mixed number and to continue as with the other questions.

- Students would have benefited from more practice time. Unfortunately, with Christmas break looming there was only enough time for two hours of subtracting before the review started and post test given. Ninety minute lessons might be better. Students were never ready to leave after one hour.

- One student missed three lessons during the adding/subtracting fractions lessons. She was able to catch up, but it would be really helpful to have a MA015 textbook! The research students recognize the need for a Vedic Math 015 textbook and they often ask when one will be printed. The students want to see it in a workbook format because they believe it will help other fellow students.

  Additional Instructor Comments

- I [instructor] have overheard many times the students talking with fellow struggling students, "That unit is really a lot easier the Vedic way." As a result, many students who were not able to participate in research want to learn the "new" way next year with the new textbooks.

- One student actually had the opportunity to teach an ABE substitute teacher how to do Vedic subtraction. The instructor later told me how excited the student was to teach her. The substitute was surprised that the student could remember the method well enough to teach the method to someone else, especially since the student had been taught this method four months prior.

The instructor, who has been teaching fundamental math for over twelve years, reflected that there was a new, positive atmosphere in the math class which demonstrated to her that these new methods work. The overall demeanor of the students changed dramatically. An excitement to learn replaced their usual anxiety and frustration. The structured methods, with their clear and simple rules, allowed the students to be successful,

which led to building their confidence and motivation. Students learning Vedic methods were able to grasp concepts more quickly and with more ease than with traditional methods. The students recognized they were learning more quickly than before and knew they were able to complete units faster than students not in the research.

Post Vedic Math Interview

Three months after the Vedic class was over, three students were available for interviews. When asked if they would recommend Vedic math to other students they replied:

- *Yes I would, there was nothing I didn't like; It was way easier and way faster. And it was fun. And I'm a person that did not like math.*
- *Yes, I liked that it was easier to solve questions than normal math.*
- *Yes, it narrowed down the questions to a short way of answering.*

When asked if they had other comments, the replies received were:

- *Sometimes in class I would get it right and I would say out loud, "Whoo Hoo! I got it!"*
- *And I even use it at work on inventory nights when I have to add stuff up. Its way faster.*
- *I'm just in the middle of teaching my son multiplication using Vedic math.*
- *If given two choices I would choose Vedic math. My daughter saw me solving math problems and she said, "That's not how we do it at the high school. It looks like a short way to solve the questions."*
- *The other way of math we had to use a lot more scrap paper to come up with the answers.*
- *It feels like you're an investigator solving questions in a different way.*

The students who succeeded at the Vedic math class are very positive. From their perspective, the class was worthwhile, fun, and the skills learned were transferrable to their everyday life.

Discussion

The instructors of fundamental level one math have observed students struggle with the same math concepts year after year, and have witnessed how that struggle wears on their confidence and self-worth. Despite trying many different strategies and environmental supports (adjusting the learning environment) over the years, no obvious improvements appeared in either their ability to succeed, or how they felt about learning math, until the Vedic math program was implemented. Even though the number of participants was low (ten), and the numbers of successful completions lower (four), their dramatic shift in how they perceive learning math and their much improved sense of achievement indicates further success for greater numbers of students may be possible. This opens the door to the possibility that the depth and breadth of the usefulness of Vedic methods may continue to be revealed. Vedic math uses a different set of steps to achieve the correct answers, and the students in the program excelled where in the past, with conventional methods, they have stumbled. For even a small group of learners to fundamentally change how they think about learning math is remarkable, and the hope is that more students will be able to experience this.

In summary, the Vedic math project was a very useful endeavor. It began with an extensive search of available resources on Vedic math. A single book containing all the topics needed for Fundamental Math 015 does not exist, and the strategies described in this project were chosen, analyzed and compiled from a variety of sources. The standard Math 015 workbook was used, but the methods for solving questions evolved from a compilation of Vedic methods found in a number of books and sources. Now that a specific set of materials has been gathered for fundamental level math students, it is hoped this information

can be utilized by other centres interested in trying a different way of teaching math, and will eventually be integrated into a workbook.

The first research question asked: if teaching Vedic math methods would improve student completion rates. A cohort of Math 015 students was enrolled and the program ran for ten weeks for a total of thirty hours. Given that a typical Math 015 course is allocated between 80 and 120 hours to complete, and students very often do not complete in that time frame, even the instructor and I were surprised that four of the ten Vedic students completed Math 015. A 40% completion rate compared to the average for typical Math 015 classes of approximately 8% is impressive, but results have to be interpreted with this small sample size in mind. Being able to measure and confirm the Vedic students had improved completion rates was gratifying for the students, the instructor and the researcher. The students themselves continue to be ambassadors for Vedic math. They recommend it to friends and are confident enough in their skills to teach others.

This is all the more remarkable considering they were students with a history of difficulty completing Math 015 using typical methods. They were returning students whose pre-test Math 015 assessments demonstrated they had problems learning and retaining math skills. Their Vedic math post-test and three month post-test showed they were able to gain math skills and keep them.

What was different about this class was that they were taught to solve equations using Vedic math methods and that they were a cohort of students who were able to commit to the ten week period. This group of students developed an excitement about learning math which was indicative about the subject they were learning and not the cohort environment.

The other research question asked how the instructor rated the teaching experience. For example, the instructor rated the class frustration level (Table 19), as "Minimal/No" for the first three topics and then slightly higher for the remaining topics. This is a very good result compared to the level of frustration a typical Math 015 class would present. Instructors constantly monitor their students' progress, emotions, and abilities. They strive to push students to the edge of their capacity while building up their belief that they can do more. Instructor feedback was critical to knowing whether Vedic math is a method worth pursuing.

Overall, the teaching experience was very highly rated and teaching fundamental math using Vedic methods will continue at this campus for future students. In fact, the instructor has begun developing a math workbook for students to use. It cannot be overstated that from the perspective of the instructor, the effect of Vedic math on student success and demeanor is profound. When you observe students enjoying what they are learning you know you are on the right track. Students who learn with confidence and eager anticipation are destined to experience feelings of success. When the instructor is enjoying teaching, it is a win-win on all counts.

From this foundation, it would be preferable to have these methods used in a broader context and with a wider array of students, to expand the base of evidence. The results are intriguing and hopeful. The more students that are taught Vedic mathematics, the clearer the picture will be about how useful these methods are. If results can be measured compared to previous classes, all the better. In essence, this is a preliminary project that was encouraging enough to promote future investigation and exploration.

With non-formal information sharing, the Vedic math project is generating interest. Along with being asked to provide a three-hour Vedic math class at a recent CNC

Professional Development Day for college instructors, general inquiries about the project have been received. The instructor and I have been invited to speak at the 2012 ABEABC conference in Harrison Hot Springs, BC. This is the very same conference that ignited Waneta's interest in 2010.

For the students, Vedic math did not stop when the project ended. Not only did they rate their learning experiences with Vedic math positively, some signs of math momentum can be found in the students. Even when the classes were over and students were back in their regular math class – the new math permeated throughout their school experience. Two students have recently completed the difficult algebra section of Math 020. Both used their Vedic knowledge of subtraction and fractions to complete the units. This is suggestive that their knowledge was transferable and not restricted to just Math 015.

Limitations of Design

The most obvious limitations are the small sample size and the use of a cohort rather than ongoing enrollment. With time constraints always present, and a desire to see if there could be an effect in a proportionally small period of time, a fixed cohort class was chosen rather than ongoing enrollment. There were fewer students, and it was easier to keep track of them. As we move forward in teaching Vedic methods to students we will be keeping a close eye on completion rates. Ideally, other institutions might implement Vedic methods, and they too can add to the body of knowledge. Another limitation is the ability to truly assess the students' level of mastery of the math principles over an extended period of time.

Recommendations for future research

There are many avenues for future research. By chance we only had females in this study. We would like to see further studies with both genders. As this project focused on

struggling learners, we would recommend studies that involve typical learners. We suspect these methods would be successful if measured using typical learners and would like to see this done.

Another area of interest beyond the scope of this study would be to examine the role of Vedic math and motivation. It was apparent from their responses that students were motivated and engaged with learning Vedic math. It is asserted that this motivation and engagement influenced their completion rates, and studying how Vedic math affects motivation would be very interesting to study.

As with any study, a certain level of trust is required on the part of the reader. When deciding if an article has potential we assess how we would use it in our own lives. This is what I encourage all to do. Even if readers are not in a position to replicate or expand on this project, they can take the methods described and use them in their everyday life.

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Appendices

Appendix A: Informed Consent
              REB

Appendix B: Student Selection Questionnaire
              Intake Interview
              Student Feedback Questionnaire
              Instructor Feedback Questionnaire
              CNC Math Placement Assessment
              CAAT Math Assessment

Appendix A: Vedic Math: A New Approach for Math 015 Students: Letter of Invitation
Dear College of New Caledonia Math 015 student,

I would like to invite you to be part of a research project I am conducting. My name is Barb Durban-Wilson and I work for the College of New Caledonia (CNC) and I am completing a Master's Degree in Education with the University of Northern British Columbia (UNBC). My supervisor at UNBC is Dr. Peter MacMillan and you can contact him with any questions you may have about this project at 250.960.5828.

The objective of my research is to work collaboratively with CNC Math instructor, Waneta Nealis, and with Math 015 students to learn what affect teaching Vedic Math methods has on student ability to progress through and complete Math 015 and to record the instructor and students' perceptions on the process of learning.

The Vedic Math approach is a very different way of problem solving which holds promise for anyone who has difficulty with traditional math. Math is a subject that many people find intimidating and challenging. This study will collect demographic information of typical CNC Math 015 students to illustrate the need to create a foundation to accommodate differences in learning styles.

As part of this investigation, I am inviting all interested Math 015 students to attend math classes using the Vedic approach. The lessons will provide a demonstration of some of the techniques as well as ample opportunity to practice what has been learned.

The potential benefits of participating in this study are learning some techniques that might make math easier for learners and may result in less math related anxiety and frustration. If you participate and meet the outcomes associated with Math 015, you will progress to Math 020. There are minimal risks to this study.

All students will be doing the following tasks as part of the class, but only those students who have completed and signed an informed consent form will have their data used by Barb Durban-Wilson. These lessons are completely voluntary and as a participant you will be asked to:

- Review and sign the consent form
- Complete the Math only portion of the standardized English and Math Achievement Test (EMAT)
- Complete a Student Selection Questionnaire to ensure suitability for the project
- Complete an Intake Interview Questionnaire asking demographic and prior math experience questions
- Attend Vedic math classes from October to December, 2011
- Complete feedback questionnaires
- Retake the Math portion of the EMAT placement (January 2012) assessment

The following guidelines will be followed:

- Only Barb Durban-Wilson will have access to your informed consent form.
- Only Barb Durban-Wilson and Waneta Nealis will have access to your data and responses.
- Anonymity and confidentiality will be addressed by not including names on any reports.
- If you are unable to maintain regular attendance (defined as two out of three classes per week), we will offer support (as we would any student who is

struggling to attend). Support is defined as services provided by a College employed Support Worker whose role includes helping students find and maintain adequate housing, food security, and other barriers to attendance. You will have the option to withdraw from the research project and enroll in a non-structured, modulized Math 015 class where regular attendance is not necessary.

- As there is minimal risk to participants we may ask if you would be agreeable to a follow up interviews, and if so you will be directed to place your name on the feedback form.
- You may withdraw from this process at any time and your information will be withdrawn and destroyed as well.
- Information will be stored and locked in a college filing cabinet, raw data will be destroyed after one year in December of 2012, hard copies shredded and/or electronically deleted from a password protected computer.
- All responses will be compiled and a copy of the findings will be available upon request once completed.
- Results will be shared with CNC and UNBC.
- If you have any questions please contact Barb Durban-Wilson (250-692-1743) or Waneta Nealis (250-692-1700 712).

You are not obligated to participate in this research project. If you choose to participate, you are free to withdraw at any time without prejudice. If you decide to change to the non-Vedic Math 015 class you may do so at any time without consequence. All of your completed forms will not be used in the study and will be destroyed. Similarly, if you choose to participate in this research project this information will also be held in confidence.

Thank you very much for your time, consideration and willingness to support this research project.

Barb Durban-Wilson
College of New Caledonia
Lakes Campus
durban@unbc.ca

Appendix A: Vedic Math: A New Approach for Math 015 Students – Informed Consent

My name is Barb Durban-Wilson and I work for the College of New Caledonia (CNC) and I am completing a Master's Degree in Education with the University of Northern British Columbia (UNBC). My supervisor at UNBC is Dr. Peter MacMillan and you can contact him with any questions you may have about this project at 250.960.5828.

This document constitutes an agreement to participate in my research project, the objective of which is to work collaboratively with CNC Math instructor, Waneta Nealis, and with Math 015 students to learn what affect teaching Vedic Math methods has on student ability to complete Math 015 and to record the instructor and students' perceptions on the process of learning.

The Vedic Math approach is a very different way of problem solving which holds promise for anyone who has difficulty with traditional math. Math is a subject that many people find intimidating and challenging. This study will collect demographic information of typical CNC Math 015 students to illustrate the need to create a foundation to accommodate differences in learning styles.

In addition to submitting my final report to the University of Northern British Columbia I will also be sharing my research findings with the College of New Caledonia and the Institute for Teaching, Learning and Research. All participants will be given an electronic copy of the final report as well.

The potential benefits of participating in this study are learning some techniques that might make math easier for learners and may result in less math related anxiety and frustration. If you participate and meet the outcomes associated with Math 015 you will progress to Math 020. There are minimal risks to this study.

All students will be doing the following tasks as part of the class, but only those students who have completed and signed an informed consent form will have their data used by Barb Durban-Wilson. These lessons are completely voluntary and the study participants will be asked to complete the following process:

- Review and sign the consent form.
- Complete the Math only portion of the standardized English and Math Achievement Test (EMAT).
- Complete a Student Selection Questionnaire to ensure suitability for the project.
- Complete an Intake Interview Questionnaire asking demographic and prior math experience questions
- Attend Vedic math classes from October to December, 2011.
- Complete feedback questionnaires after completion of each Vedic component.
- Retake the Math portion of the EMAT placement assessment in January 2012.

The following procedures will be followed:

- Only Barb Durban-Wilson will have access to your signed consent forms.
- Only Barb Durban-Wilson and Waneta Nealis will have access to your responses.
- Information will be gathered by the completion of interviews and questionnaires.
- Each participant's contributions will be kept private and anonymous.
- You may withdraw from this process at any time and your information will be withdrawn as well.
- If you are unable to maintain regular attendance (defined as two out of three classes per week), we will offer support (as we would any student who is struggling to attend). Support is defined as services provided by a College employed Support Worker whose

role includes helping students find and maintain adequate housing, food security, and other barriers to attendance. You will have the option to withdraw from the Vedic math class and/or the research project and enroll in a non-structured, modulized Math 015 class where regular attendance is not necessary.

- Anonymity and confidentiality will be addressed by not including names on any reports. As there is minimal risk to participants we will ask them if they would be agreeable to follow up interviews, and if so they will be directed to place their name on the feedback form.
- Information will be stored and locked in a college filing cabinet, raw data will be destroyed after one year in December of 2012, hard copies shredded and/or electronically deleted from a password protected computer.
- All responses will be compiled and a copy of the findings will be available upon request once completed.
- Results will be shared with CNC and UNBC.
- If you have any questions please contact Barb Durban-Wilson (250-6921743) or Waneta Nealis (250-692-1700 712).

You are not obligated to participate in this research project. If you choose to participate, you are free to withdraw at any time without prejudice. If a student decides to change to the non-Vedic Math 015 class he or she may do so at any time without consequence. All completed forms will not be used in the study and will be destroyed. Similarly, if you choose to participate in this research project this information will also be held in confidence. An any concerns or complaints about the project should be directed to the Office of Research at UNBC (reb@unbc.ca or 250.960.6735)

☐ Check here if you would like to receive results of study and please add email address below

By signing this letter you give free and informed consent to participate in this project. Thank you for your time and consideration.

Name (Please Print): _____

Contact information: _____

Email address: _____

Signed:_____ Date: _____

Barb Durban-Wilson durban@unbc.ca
College of New Caledonia – Lakes District Campus

Appendix A: Vedic Math: Script for Research Project

As the language in the letter of invitation and informed consent form is relatively complex, the following script will be followed to explain each of the paragraphs. The entire class will be lead through the process. The concern we will to ameliorate here is students' who test at the Math 015 level may also test low on the English, making the complex language of the forms difficult to understand.

Script

Thank students for being there, introduce self (Barb Durban-Wilson), where I am from, who I work for and who this study is in conjunction with (CNC and UNBC).

Discuss Vedic math and why the college is offering this unique program. Discuss that we hope that is makes learning math easier and we want to study the process to see if it actually does. Students in this class have an opportunity to be part of this research project. There will be no difference in the class for student who do or do not participate in the study. The only difference is that students who do not participate will not have their data included in the report. Their data will be destroyed instead.

Discuss that there are minimal risks to the study, the process is very similar to what would happen in a regular class with the exception that a questionnaire will be completed by students after each Vedic topic which is similar to evaluation forms for courses that they may have used before. Also we will retest the EMAT math portion one month after the completion of the course to check for retention of methods.

Read and discuss bullets that exist on the letter of invitation and the informed consent form.

Stress that there is no penalty for not taking part in the study, and that their instructor will never know which students have signed this form or not.

Appendix A

UNIVERSITY OF NORTHERN BRITISH COLUMBIA

RESEARCH ETHICS BOARD

MEMORANDUM

To: Barbara Durban-Wilson
CC: Peter MacMillan

From: Henry Harder, Chair
Research Ethics Board

Date: October 6, 2011

Re: **E2011.0912.092.00**
Vedic Mathematics in the ABE Fundamental Classroom

Thank you for submitting amendments to the above-noted proposal to the Research Ethics Board.

These amendments have been approved for a period of 12 months from the date of this letter. Continuation beyond that date will require further review and renewal of REB approval. Any changes or amendments to the protocol or consent form must be approved by the Research Ethics Board.

Good luck with your research.

Sincerely,

Dr. Henry Harder
Chair, Research Ethics Board

Appendix A

College of New Caledonia
SCHOOL OF ACADEMIC STUDIES

August 15, 2011

Barbara Durban
Burns Lake Campus
College of New Caledonia

Dear Barbara,

Re: Research Ethics Approval

Please accept this letter as confirmation of ethics approval by the Chair of the CNC
Applied Research Ethics Board. We understand that your research project "Vedic
Mathematics in the ABE Fundamental Math Classroom" is being used as your thesis for
your Master's degree at the University of Northern British Columbia.

We look forward to seeing the results of your research.

Sincerely,

Don Precosky
Chair
Applied Research Ethics Board

/lb

Appendix B: Vedic Math: Student Selection Questionnaire

Student Name: _____ Date: _____

Interviewer Name: _____

Question	Yes	No	Comments
1. Do results of EMAT indicate student is at a Math 015 level?			
2. Does student have one or more year s of previous Math 015 experience?			
3. Does student have a history of good attendance, or have circumstances changed to allow for good attendance? (please explain any change in circumstances)			
4. Is student able to attend three classes per week?			
5. Is student employed?			
6. If yes, will the employer allow student to attend 3hours/week?			
7. Does student express a desire to learn new things in general?			
8. Is student willing to try a new way of doing math?			
9. Ask student, *"If you know how to do fractions already, are you willing to learn fractions in a new way?"*			

A student will be selected if the following criteria are met:
- ☐ Able to commit to three classes/week
- ☐ Genuinely interested in learning a new way to do math
- ☐ Tests at a Math 015 level and has 1+ years experience with Math 015

Student has been selected to continue with the research Project. Please circle:

YES   **NO**

Appendix B – Vedic Math: Intake Interview

Student Name: _____   Date: _____

(Names will not be used in any report).

Interviewer Name: _____

Demographic Information

What year were you born?: _____

Gender: M or F   What town do you live in or near? _____

Which ethnicity are you? Please circle: Aboriginal   White   Other: _____

How do you support yourself? Please circle:

Employment Insurance   Employed   Self-employed   Social Assistance/Band
                                                              Assistance

Other: _____

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To be filled out by student:

Please take a moment to remember your experiences with math in the past and answer the following questions:

1. In school, up until which grade did you take math? _____

2. What did you like about learning math?

3. What did you NOT like about learning math?

4. On a scale of 1 to 4 rate how your previous **grade school** math experiences made you feel?

Not successful	Somewhat **un**successful	Somewhat successful	Successful
1	2	3	4

5. On a scale of 1 to 4 describe how your previous **CNC math** experiences made you feel?

Not successful	Somewhat **un**successful	Somewhat successful	Successful
1	2	3	4

6. On a scale of 1 to 4 describe how **angry** math can make you feel?

Hardly ever angry	Somewhat angry	Occasionally angry	Often angry
1	2	3	4

7. On a scale of 1 to 4 describe the level of **happiness** you have experienced with math?

Hardly never happy	Somewhat happy	Occasionally happy	Often happy
1	2	3	4

8. Circle words that describe how you feel about math.

frustrated   **angry**   **happy**   **successful**
        confident

Other: _____

9. Other comments? If you need more room, please turn over and write on back.

Appendix 4 – Vedic Math: Intake Interview
Completed by previous instructor: Name: _____

Student Name: _____

On a scale of 1 to 4 please assess student's progression rate through Math 015?

Quicker than average	**Average**	**Slower than average**	**Not at all**
1	2	3	4

On a scale of 1 to 4 please rate the level of frustration this student experienced with math:

None	**Minimal**	**Moderate**	**Strong**
1	2	3	4

Note to instructors: Please try to objectify the student's level of frustration by checking applicable bullets found in the categories below. If a student displays behaviours from more than one category please choose either 2 or 3 above.

1 Quicker than average/None	2 -3 Average/Moderate	4 Not at all/Strong
☐ Smiles throughout the lesson	☐ Smiles occasionally ☐ Displays unhappiness occasionally	☐ Does not smile even if something is funny in class ☐ Displays flat affect or unhappiness throughout the lesson
☐ Comments positively throughout lesson "Oh, this is neat!"	☐ May utter a positive comment	☐ Comments negatively, may swear/yell ☐ Is heard saying things like "I hate math"
☐ Able to work through problems on own ☐ Needs little or no help ☐ Needs very little extra clarification	☐ Frequently needs clarification of concepts but is able to understand with the extra help	☐ Needs constant 1:1 ☐ Unable to complete one or two questions on own
☐ Able to complete the in class assignment ☐ Able to complete the homework assignment	☐ Is able to complete 60% of the in class and homework assignments	☐ Cannot complete the class/homework assignments
☐ Understands mistakes he/she has made ☐ Wants to know why mistakes were made	☐ Sometimes does not know why an answer is wrong	☐ Does not care to know why an answer is wrong
☐ Able to achieve 80-100% on tests	☐ Able to achieve 60 – 80% on tests	☐ Consistently does not pass tests
☐ May help other students ☐ Looks "at ease" ☐ Participates in discussions and asks questions	☐ Understands most concepts but usually asks for help when doesn't ☐ May look uncomfortable	☐ May get completely overwhelmed, put head on desk, or walk out

Other comments on student's past Math 015 experience. For example, any Math015 concepts that were exceptionally difficult or easy?

Appendix B – Vedic Math: Student Feedback Questionnaire

Student Name: _____   Date: _____

Vedic Topic:_____

Please take a moment to answer the following questions:

1. Were you able to complete assignments during class time?   YES   NO

2. Were you able to complete the homework assignments?   YES   NO

3. Circle the sentence that best describes how many assignment questions you understood.
    a. I understood **none** of the questions
    b. I understood **some** of the questions
    c. I understood **most** of the questions
    d. I understood **all** of the questions

4. Circle words that best describe how you felt about this Vedic topic.

    frustrated   **angry**   **confused**   **indifferent**

    happy   **successful**   **confident**

5. Do you have other comments? If you need more space, please use the back of this page.

Appendix B: Vedic Math: Instructor Feedback Questionnaire

Date: _____   Vedic Topic: _____

To be filled out by instructor at the end of every Vedic topic:

1. How much help was necessary for students to complete the lesson? Please give a **ratio** and **percentage** for students needing the following help: (#needing help/whole class = %)

minimal/no help	**moderate**	**constant/1:1**

2. What percentage of students completed the lesson? **0%   20%   40%   60%   80%   100%**

3. Pick two words that best describe how you felt about teaching this lesson.

   frustrated   **confused**   **indifferent**   **satisfied**
                        happy   **successful**

   other?_____

4. Using a ratio please rate the **level of frustration** the class experienced with this lesson (see back):

1	**2**	**3**	**4**	**5**
minimal/no		**moderate**		**very strong**

5. Do you have any other comments or ideas? Please use the back of this page if you need more room.

Appendix B: Vedic Math – Instructor Feedback Questionnaire

Note to instructors for question 4:

Please try to objectify the student's level of frustration by using the guidelines below. If a student displays behaviours from more than one list then please choose 2 or 4.

1 **Minimal or none**	3 **Moderate**	5 **Very Strong**
☐ Smiles throughout the lesson	☐ Smiles occasionally ☐ Displays unhappiness occasionally ☐ May look uncomfortable (squirm)	☐ Does not smile even if something is funny in the class ☐ Displays flat affect or unhappiness throughout the lesson
☐ Comments positively throughout lesson "Oh, this is neat!"	☐ May utter a positive comment	☐ Comments negatively, may swear/yell ☐ Is heard saying things like "I hate math"
☐ Able to work through problems on own ☐ Needs little or no help ☐ Needs very little extra clarification	☐ Frequently needs clarification of concepts but is able to understand with the extra help	☐ Needs constant 1:1 ☐ Unable to complete one or two questions on own
☐ Able to complete the in class assignment ☐ Able to complete the homework assignment	☐ Is able to complete 60% of the in class and homework assignments	☐ Cannot complete the in class/homework assignments
☐ Understands mistakes he/she has made ☐ Wants to know why mistakes were made	☐ Sometimes does not know why an answer is wrong	☐ Does not care to know why an answer is wrong
☐ Able to achieve 80-100% on tests	☐ Able to achieve 60 – 80% on tests	☐ Consistently does not pass tests
☐ May help other students ☐ Looks "at ease" ☐ Participates in discussions and asks questions	☐ Understands most concepts but usually asks for help when doesn't	☐ May get completely overwhelmed, put head on desk, or walk out

CNC Math Placement Assessment

Math Placement

1.
$$61$$
$$+\ 23$$

2.
$$457$$
$$+\ 36$$

3.
$$400$$
$$-\ 225$$

4.
$$738$$
$$\times\ 24$$

5. $29\overline{)406}$

6. $23.05 + 0.67$

7. $74.57 - 31.4$

8. 0.24×4.2

9. $23.52 \div 4.2$

10. $40 - 8 + 10 \times 2$

Math Placement #2

1. Find the average of these numbers: 8, 12, 24, 32

2. $\dfrac{3}{4} + \dfrac{5}{6}$

3. $9\dfrac{1}{10} - 4\dfrac{1}{4}$

4. $\dfrac{3}{10} \times \dfrac{5}{7}$

5. $\dfrac{4}{5} \div 1\dfrac{1}{5}$

6. Solve: $x - 0.7 = 6$

7. Rewrite 0.009 as a percent.

8. Rewrite $\dfrac{5}{8}$ as a percent.

9. $400 \text{ cm} = \underline{\hspace{1cm}} \text{ m}$

CAAT

CANADIAN ADULT ACHIEVEMENT TEST

Test Booklet

LEVEL B