

“DISCOVER MATH” AT THE READING FOUNDATION

by

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Teachers in regular and special classrooms across Canada and the United States are confronted with students who have persistent difficulties with math concepts. In the sixteen years that I was a school psychologist, I received many referrals on students who did not “get” the idea of what adding and subtracting was, for example. The student might come up with random responses (pure guesses) to adding/subtracting questions. Such students typically relied on something very concrete, such as their fingers, for any sort of accuracy at all. The usual recommendation was to provide more practice with concrete objects (coins, counters, chips, etc.) with lots of review and repetition. Typically such “skill and drill” activities, while providing some measure of relief, still do not address the problem these students have. And given the sequential nature of mathematics instruction, the difficulty can pose a very severe challenge for the student within a very few years of schooling. Overall, it was my experience that math difficulties are likely as prevalent and problematic as reading difficulties in the population at large. In a review of some of the research on this topic, Parmar and Cawley (1997) state that students in the general category of learning disabilities:

- function two to four grades below expectancy across mathematics topics
- demonstrate growth patterns in mathematics of 1 year of grade equivalent for every 2 or more years of school
- attain grade-equivalent levels approximating fifth to sixth grade at the time they are leaving school
- achieve about 1 year of grade-equivalent growth from the 7th through 12th grades
- demonstrate only limited proficiency on tests of minimum competency toward the end of secondary school and
- show strange habitual error patterns.

Other studies (Cawley, Parmar and Smith, 1995) show that the trend for such students is to fall further and further behind their peers as time goes on.

Any teacher who has spent any length of time working in this area can attest to the reality of these studies.

Is there anything that can be done?

The rest of this article provides information on a program called “Discover Math,” developed at The Reading Foundation in Calgary, which has been clinically tested and has provided a good measure of relief to students who, for the most part, have had long-standing difficulties with mathematics.

I opened The Reading Foundation in Calgary, a private clinic which specializes in the assessment and treatment of learning difficulties in 1990. (A Vancouver Reading Foundation clinic was started in 1994.) The clinic began offering remedial programs for students in basic reading/spelling and comprehension from its inception and obtained excellent results using an “immersion” approach (Truch, 1990, 1994). Students who come to the clinic are first assessed for their needs and then attend remedial sessions each day for four hours. They come either in the mornings or afternoons and receive one-on-one assistance the whole time.

The average stay is four weeks if the difficulty is restricted to one area, such as reading. Students with multiple difficulties (eg. both reading and math) will need additional time.

In 1992, two years after the clinic opened its doors, I saw the need for a remedial math program. I noticed the Lindamood-Bell organization, where I was first trained in basic reading processes, was offering a workshop in math. I and some of my staff members attended the two hour workshop, which provided some of the ideas we needed to get started. When we returned from the conference, I and the staff members created a math program based on some of the principles learned in the workshop. However, some additional and important features were added. At about the same time we were developing the math program, the western provinces were developing the Western Canadian Common Curriculum Framework in mathematics. We made our program consistent with those

objectives at each grade level (1 to 9). The intention of the program is definitely to provide students with an *understanding* of basic math concepts for each of the major strands of the curriculum. In the end, our program covered the major objectives of each of the major strands in mathematics from grades 1 to 9. We also developed a unique scope and sequence chart which allows us to easily track the progress of a student through the program. In this way, when a student completed the program at The Reading Foundation, there was a much greater guarantee that the outcomes were closely matched to what they were being taught in their classrooms. We also developed a curriculum-based assessment which allows us to see where the student is having difficulty.

In terms of methodology, a number of features are incorporated into the program based on the following general principles:

- understanding of math concepts, operations and processes is paramount for the student
- understanding math concepts in turn is promoted by
- discovery through concrete experiences and extensive use of manipulatives
- internalization of those experiences through discussions (language) and through mental imagery
- to develop good number sense, students need to experience and internalize how numbers relate to each other. In this way they can begin to estimate in all their arithmetic processing
- application to problem solving situations is important at all age levels
- repetition and reinforcement play an important role once a concept, operation or process is understood. Basic arithmetic operations eventually need to be “automatic” for the student.

Adherence to these principles keeps the program in line with not only the Western Canadian Protocol but also with the professional teaching standards of the National Council of Teachers of Mathematics (1991). It is also consistent with a more “constructivist” approach to the teaching and learning of mathematics (Cobb and Bauersfeld, 1995) but does not deny the importance of learning basic operations together with some repetition to achieve automaticity in those areas *once the process or operation is understood*.

The program took several months to write. All staff were then trained in the program and we began accepting referrals for students in the spring of 1993. Since then, we have put many students through the intensive one-on-one program with consistently positive outcomes. Last year, I summarized the overall results, which are presented for you in Table 1.

Before trying to interpret Table 1, let me explain how our assessment works. When a student comes to the clinic and difficulties in math are listed as part of the presenting concerns, then the student is given our math screening tests as part of the overall assessment. Level I of the test covers the math objectives in grades 1, 2 and 3. There are 8 objectives sampled in grade 1, 12 in grade 2 and 17 in grade 3 for a total of 37 objectives. Level II covers the objectives in grades 4 to 6. There are 11 objectives sampled in grade 4, another 13 in grade 5 and 24 in grade 6 for a total of 48 objectives at Level II. Level III covers the grade 7, 8 and 9 objectives. There are 23 objectives sampled in grade 7, 23 in grade 8 and 19 in grade 9 for a total of 65 objectives at Level III. So, for example, if the student is in early grade 6, he would be asked to complete the grade 4 and 5 objectives from Level II. If he was very weak at those items, he would also be asked to complete the Level I portion of the test. This kind of testing quickly reveals where the breakdown is occurring for the student. Students are post-tested once they have completed the scope and sequence of the program. It should also be noted that clinical students may be doing the math program in combination with other programs, such as reading comprehension.

For purposes of this analysis, the number of objectives at each grade level is cumulative to the end of grade 6. At the grade 7 level, the total number of objectives was reduced because those from Level I were not included (they were usually too easy by then for the older students).

For students who are in high school, the Discover Math program may or may not be appropriate for them. If a grade 10, 11 or 12 student (or an adult for that matter) has difficulty in math and if our assessment shows that the need goes down to the level of our program, then that student may be accepted into The Reading Foundation’s program. There were a number of older high school students taking math whose needs could be met through our program. The scope and sequence of the program is carefully explained to the parents. If the student does not present with any serious difficulties at lower math levels, then a recommendation for tutoring from other agencies is made. With those explanations in mind, here is the overall-summary of results for the students who took the clinical program.

Table 1

SUMMARY TABLE OF MATH RESULTS

Grade	N	#Obj	X Pre	X Post	% (Obj)	% (Base)	X Hours
2	7	20	7.28	15.85	42.8%	217%	27.40
3	19	37	16.00	29.05	35.3 %	181%	39.78
4	21	48	24.09	37.70	30.3%	156%	39.19
5	12	61	33.50	53.40	33.0%	159%	37.60
6	25	85	39.48	65.32	30.4%	165%	47.56
7	16	71	23.31	50.18	39.1%	215%	56.38
8	10	94	37.40	58.90	22.9%	157%	46.10
9	10	113	47.10	86.30	35.0%	183%	57.00
10-12	17	113	50.90	83.50	29.0%	164%	53.29

A total of 137 students were used in this analysis. This does not represent every student who took the program, but it does represent the majority.

You can see from Table 1 that the increase in performance at each grade level is very encouraging. For example, at the grade two level, we found that in average time of 27.4 hours of instruction, we were able to increase the math performance on the cumulative grade 1 and 2 objectives very substantially from pre to post-testing. A total of 20 objectives are tested to the end of grade two (8 for grade 1 and 12 for grade 2). These objectives cover adding and subtracting (with and without regrouping), basic fraction concepts, understanding the effect of "0" in an equation, counting by 2's and 5's, the commutative property, counting money, estimating, understanding place value and seeing patterns in geometric arrays. In the program, students also apply their skills to solving problems at each grade level.

The first X%GAIN score was calculated as follows: $15.85 - 7.28 = 8.57$. The 8.57 was then divided by the number of objectives at this level (20). This gives an increase of 42.8% in the number of objectives learned compared to the cumulative number for that grade. The second % GAIN score was calculated simply by dividing the mean post score by the mean pre score and multiplying by 100. The latter gain is much more impressive! These calculations were performed in the same manner for all grade levels.

I also did a more in-depth analysis at each grade level, but I will present the information for the grade 4 level only in this article. This information appears in Tables 2, 3, and 4.

In addition to the concepts from the previous three grades, students at the grade 4 level are introduced to more advanced work in decimals and fractions, multiplying and dividing and measurement and geometry. From Table 1, here are the over-all grade 4 scores. (A total of 21 students at the grade 4 level did the *Discover Math* program.)

X Pre Score	X Post Score	X % Gain	%GAIN	X Hours	(Range)
24.09 (48)	37.7 (48)	30.3%	156%	39.19	(20-69)

Students at the grade 4 level spent an average of close to 40 hours in the program with a range of as little as 20 hours and as many as 69 hours for a couple of students. Their over-all gains after this period of time were significant and are illustrated in the next three tables.

Table 2

Number of students who achieve 50% or more on all 48 objectives:

Pre	Post
11/21	21/21

Table 2 simply looks at the number of students who were able to score 50% or more (i.e, 24 or more correct on the 48 items sampled from grades 1 to 4 inclusive). Table 2 shows a substantial improvement for all the students.

Table 3

Number of students who achieve 50% or more on the grade 4 objectives only:

Pre	Post
1/21	12/21

Table 3 shows that when we look at the test items at the grade 4 level only (there were 11 such items) then the number of students who are able to achieve 50% or more on the post-test is significantly more than the number who were able to achieve such a score when they were pre-tested. This calculation was done so as not to paint a false picture of grade-level gains. Even so, the outcomes are still compelling.

Table 4

Grade 4 items only (X scores)

Pre	Post
1.38 (11)	5.85 (11)

Table 4 simply presents the average score on the 11 items from the grade 4 test from pre to post-test levels.

The outcomes at each of the other grade levels covered by the program were very similar but are not presented in this article because of limitations of space.

In summary, while statistics can and do lie, the results presented here together with our clinical experience with the program, are very encouraging.

The Reading Foundation's math program was strictly an internal one until the summer of 1999. To that point, it had been used exclusively as a one-on-one program and no external training had been offered. That is about to change because of our experience with the program in California.

In 1998, the state of California adopted a new Framework for Mathematics. The Reading Foundation was invited to further develop its math program using the new California Framework in a joint project that involved the MESA organization, a private company called Enriched Learning Solutions, California State University at Sacramento and the Intel Corporation (who provided a grant which covered part of the costs).

Preparing for the summer project meant an extensive rewriting of the program to meet the new and rigorous California standards. Hundreds of hours were spent revising the various facets of the program.

The intention was to first train some local teachers in the program. Training time was one week. The training was followed by a five week intervention period during which the newly trained teachers had an opportunity to implement the program with minority students in grades 7 through 12 from the Sacramento area. The teachers were assisted by experienced clinicians from The Reading Foundation.

What we learned from the project was that the program could be taught in small groups (there were an average of 25 students in each of the classes). The students were able to break into smaller groups once the concept was presented by the Reading Foundation's instructor. The small groups were led by the newly trained teachers and overseen by the clinical staff.

There were a total of 126 student who went through the program. Actual instructional time was about 3 hours each day for a total of 75 hours of instruction over the five week period for each group of students.

Results were again encouraging and presented in Tables 5, 6 and 7.

Table 5

Average Scores

Pre	Post
33.64/82	43.70/82

There were a total of 82 objectives use in the test that was devised for the project. The test items covered the objectives of the new California Framework from grades 3 through 7. I should mention that the new Framework is extremely ambitious and perhaps unrealistic. In any event, the pre to post-test results show an increase of 30%. This is lower than the average figures obtained from the one-on-one clinical intervention, but nevertheless still very promising.

Table 6

Students with a Grade of 50% or More

Pre	Post
40/125	72/126
(32%)	(57%)

Table 6 shows that the number of students who would receive a passing grade of 50% or more on the test increased substantially. I should also mention that the test used was a very rigorous one. A passing grade on this test should transfer in very positive ways to actual classroom performance.

Finally, we can see the trend towards increasing scores at each grade level in the frequency analysis presented in Table 7.

Table 7

Number of Students in Each Category of Scores (Pre to Post)

	0-20%	21-30%	31-40%	41-49%	50-59%	60-69%	70-79%	80%+
Pre	7	27	34	17	23	11	6	0
Post	6	11	11	25	31	16	9	7

The trend is definitely fewer students with lower scores and more students with higher scores on the post-testing.

Collectively, our clinical and small-group results using Discover Math shows it as a program with promise. Comments from parents, students and the teachers in California who received the initial training in the program have been uniformly positive.

To that end, The Reading Foundation will soon begin offering training to teachers who are interested in becoming certified in our program. We see it as a program that will be a useful adjunct to any teacher or tutor who is teaching math in grades 1 to 9 and particularly useful as a remedial program for students either in one-on-one, small- group or classroom settings.

We will be sending a brochure to schools notifying them of training dates and locations. We will also be able to offer "on-site" training to school districts who are interested.

If you want to be on our professional mailing list, please contact us by mail, phone, e-mail or fax:

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