Report on the Effectiveness of Mathnasium Learning Center Teaching on Middle School Student Performance on Standards-based Mathematics Tests

prepared by

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Summary

In 2004, 38 southern California middle school students participated in a study to determine the effectiveness of the Mathnasium Learning Center program. These students were separated into two groups, middle and upper middle school. A portion of the student in each of these groups attended the Mathnasium Learning Center. This became the experimental group. When the study began, the students were each given a standards-based math test. This test served as a pre-test. All of the students proceeded with the course of study in school, but the experimental group additionally received Mathnasium tutoring as an experimental treatment program for an average period of 3 months. At the end of the 3 month period, all of the students were again assessed using the same instrument, this time serving as a posttest. Analysis of the middle school groups showed a statistically significant improvement, over 10%, in the experimental group's math test scores over the control group.

Introduction

Mathnasium is a learning center where kids go after school to boost their math skills. The center is highly specialized; teaching only math. The program is for students in grades 2 through 8. Students attend the center once or twice a week, for about an hour. Like a gym or health club, members pay a monthly fee and can drop–in anytime. The goal is to significantly increase a student's math skills, understanding of math concepts, and overall school performance, while building confidence and forging a positive attitude toward the subject.

The company sought to determine the effectiveness of its program, and set in motion several qualitative and quantitative studies.

In Fall, 2003, after five months of operations, the parents of the Mathnasium Learning Center in Los Angeles were given a survey in order to gauge their feelings about the impact of the program. Two primary questions were asked: "How did your child's grade in math at school change since enrolment at Mathnasium?" And, "How has your child's attitude towards math improved since enrolment at Mathnasium?" The results of this qualitative study were that 67% of parents reported their children's grades improved, 41% of those "significantly"; and 85% of parents said their children's attitude toward math had improved (Mathnasium, 2004).

In addition to the qualitative study, quantitative studies have been considered. The first, a single group non-experimental pre-posttest design, looked to see if there was a marked improvement in standards-based test scores after students received regular tutoring from the Mathnasium Learning Center. In 2003, 35 elementary and middle school students were involved in the study. All attending the Mathnasium Learning Center, where, on entry into the program, the students were given standards-based placement tests to determine an individual course of action for each student. This placement test served as a pre-test. After an average treatment period of more than 3 months, the students were again assessed, this time with a posttest. Analysis of the 2^{nd} and 5^{th} grade students showed a statistically significant improvement in the Center's math test scores.

The original quantitative study was limited because it was not experimental by design. The goal of this study is to look at whether the positive Mathnasium Learning Center effect can be duplicated in a more robust experimental design. This experimental study has been commissioned to determine whether there exists a positive treatment effect on mathematics testing performance of middle school children as a result of their attending the Mathnasium teaching center for a period of more than 3 months.

Research Method

To see whether the students' skills are improving as a result of Mathnasium teaching, an experimental pre-post study has been designed. A group of southern California middle school students will be separated into two groups, middle and upper middle school. A portion of the students in each of these groups will form an experimental sub-group, and attend the Mathnasium Learning Center.

A middle-school level math test will be given to each student, once at the beginning of the study period (pretest), and once at the end (posttest). The pre and posttests will be matched or paired for each student, so any change in test results can be evaluated individually. The test will test ability in math skills that the treatment program (Mathnasium Learning Center mathematics program) is supposed to enhance. The test will be aligned to California State standards. The test will be validated by an experienced credentialed mathematics teacher, verifying that it really tests competency in the skills intended.

Between the pre and posttest, all students will attend public school and receive math instruction during the normal course of the school day. The experimental group will additionally attend the Mathnasiuum Learning Center approximately once per week for mathematics tutoring. Because of the flexible nature of the Learning Center, the treatment period will vary from 3-4 months depending on when students start with the program.

The design of this statistical study is a non-equivalent quasi-experimental groups design (Figure 1). This study is not true experimental since it does not have randomly assigned groups. The input variable in this design is the Mathnasium Learning Center treatment, received by the experimental group. The output variable will be the change in test score between the pre and posttest. Limitations in this design will be noted in the Conclusions and Recommendations section of this report.

Figure 1. Single Group Research Design based on Kerlinger (1973)

Students at the Mathnasium Learning Center form two groups, experimental and control. Both groups receive math instruction. The experimental group receives the Mathnasium treatment for a minimal period of three months. O represents the pretest and posttest.

N	O	X	O	
N	O		O	

Once the data is collected at the end of the study, the data can be input into a statistics program and *t-tests* can be run to see if there is any difference in performance on tests. The null hypothesis of this study is that those in the experimental group, who attend the Learning Center, will receive no positive effect on posttest performance.

Analysis

Paired pre and posttest data was collected for the four groups: middle school control, middle school treatment, upper middle school control, and upper middle school treatment. Because of attrition in the number of students in the upper middle school groups between the pre and posttest (the treatment group was reduced to 5 students), the upper middle school groups were not advanced to the statistical portion of the study. The statistical analysis was performed on the middle school groups.

The researchers attempted to minimize human input and manipulation of data. This was achieved by the following steps that involved automated computer tools:

1. Use Microsoft Excel to transpose a row per student per test to column format,
2. Export the Excel columns of data to SQL-compatible data structures, and
3. Run a set of Excel macros (query-based scoring algorithm) on the data to calculate final scores (percentage correct) for each test.

Once final percentage scores were calculated, the data from the two grades were imported into SPSS for Windows (version 11), and t-tests were run.

For analysis purposes, it was important to determine whether there was a statistically significant difference between the treatment group and the control group on the overall pre-test score. If there was a significant difference, the final results would be skewed. For this, a *t-test* on the difference between the treatment and control mean pre-test scores was used. Analysis of the mean scores shows there were no significant differences at the starting point of the study (see table below).

Subject	Treatment Mean Pre-test Score	Control Mean Pre-test Score	Absolute difference	*t-value*	Sig (*t-value*)
Math	39.2	23.7	-15.39	-1.59	0.126

Next, a comparison of difference in posttest scores between the groups was performed, and using a *t-test* calculation. A statistically significant difference in the testing scores between group posttest scores is shown at the 95% confidence level (see table below).

Subject	Treatment Mean Pre-test Score	Control Mean Pre-test Score	Absolute difference	*t-value*	Sig (*t-value*)
Math	49.8	23.2	9.6	-2.75	0.013

Further, a Mann-Whitney test was run. Unlike the parametric t-test, this non-parametric test makes no assumptions that the results from the two groups are normally distributed. This test also confirms that the difference in results from the pre and posttest for the

experimental group were significantly different from the control group (see tables below).

Ranks

	GROUP	N	Mean Rank	Sum of Ranks
DIFF	0	13	8.15	106.00
	1	8	15.63	125.00
	Total	21		
PRE	0	13	9.54	124.00
	1	8	13.38	107.00
	Total	21		
POST	0	13	8.42	109.50
	1	8	15.19	121.50
	Total	21		

Results

	DIFF	PRE	POST
Mann-Whitney U	15.000	33.000	18.500
Wilcoxon W	106.000	124.000	109.500
Z	-2.686	-1.380	-2.432
Asymp. Sig. (2-tailed)	.007	.168	.015
Exact Sig. [2*(1-tailed Sig.)]	.006	.185	.013

Conclusion and Recommendations

The statistical results show a positive treatment effect. The mean score for the middle school students between the pre and posttest for the experimental group rose almost 11%, while the mean score between the pre and posttest for the control group remained largely unchanged (-0.5%). The students in the experimental group performed significantly better on a math post-test after receiving instruction through the learning center.

While these results show a positive treatment effect, it is noted that the study groups were relatively small and unbalanced. Preliminary analysis on the upper middle school groups, which contained half as many subjects as the middle school groups analyzed, showed little treatment effect. Also, the selection of students for all groups was not randomized, nor considered normally distributed. While the *t-test* showed no significant difference in the mean variance of the pre-test for both middle school groups, it should be noted that the mean pre-tests scores were higher in the experimental group than those in the control group. This may reflect some aspect of self-selection for the experimental group. It is recommended that a larger scale experimental study be considered within a controlled environment and time frame. The purpose of control is to reduce and bias. Size of sample was very small in this study, and it is recommended that the center conduct additional studies using larger numbers of students where possible. To produce reliable statistics, the minimum size of the groups ought to be a minimum of 20 subjects per group; of course, the larger the group, the better.

An interesting post-hoc finding from the data is the change in attempted test questions between the pre and posttest by students in the different groups. In the pre and posttests, students had a limited amount of time to complete the tests. This time limit caused most students to be selective about the questions they answered, leaving some questions unanswered on the tests. Overall, the students in the control group answered 7 fewer questions on the posttest than they did on the pre-test. The students in the experimental group answered 102 more questions on the posttest than on the pre-test. One possible explanation for the difference may be that receiving tutoring from the Mathnasium center increases a student's knowledge of math topics and problem solving techniques. With more knowledge, these students can tackle more problems. Another explanation is that students who attend the center may become more at ease with math subject matter. This is echoed by feedback from parents who have stated that their student's attitude toward learning math has become more positive as a result of attending the Mathnasium program. Regardless of the reason for the large difference, it is an interesting finding that merits additional attention in future studies.

Despite the limits encountered in this study, when coupled with previous quantitative and qualitative studies of the Mathnasium Learning Center's effectiveness, the results of this study further demonstrate a positive effect on performance as a result of receiving math tutoring from the center.

References

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Appendix A. Mathnasium Corporate Information

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Appendix B. Mathnasium Teaching Philosophy, Method, and Curriculum

Philosophy

The key to understanding math is Number Sense. Number Sense does not develop by accident. It is the result of a process of encounter and interaction with a specific set of concepts and skills presented in a way that makes sense to the learner. The Mathnasium Method is the life's work of Larry Martinek, Mathnasium's Chief Education Officer and a teacher and math teaching consultant in the Los Angeles area for the past 30 years. It's the best there is: a time-tested, personalized program, that employs diagnostics, instruction, worksheets, manipulatives, and the latest computer software to build Number Sense, and with it, confidence and a deep understanding and lifelong love of mathematics.

Strategy

Learning from the successes and failures of other approaches, and from the teaching experience of its creator, The Mathnasium Method uses a unique combination of mental, verbal, visual, tactile, and written techniques to help children learn math.

MENTAL

Students are taught how and when to use mental math techniques. This enables them to dispense with needless paper–and–pencil work and focus on the task at hand.

Example: 99 + 99 + 99 = _____

Instead of setting this problem as a vertical addition problem, students are taught to think, "100 + 100 + 100 – 3 = 300 – 3 = 297."

VERBAL

Language is used as an integral part of the program. Students are taught the meaning of root words in the mathematics context. Students are also taught how

to explain their thought process and reasoning verbally.

Example: Percent

Percent is taught as meaning per CENT, “for each 100.” Using this definition, “7% of 300” is easily seen to be, “7 for the first 100, 7 for the second hundred, and 7 for the third hundred = 7 + 7 + 7 = 21.”

VISUAL

Meaningful pictures, charts, and tables are used to explain ideas and concepts.

Many of the problems in the workbooks are “pictured–based,” providing students with insights into problems that transcend the written words.

Example: If each circle in the picture is a dime, how much money is shown in the picture?

Many of the problems in the Mathnasium program feature pictures as prompts for problem solving.

TACTILE

When appropriate, manipulatives are used to introduce, explain, and/or reinforce concepts and skills.

The transfer of knowledge from manipulatives to other aspects of learning is carefully monitored.

Examples: Counting chips are used to facilitate learning the principles of addition, subtraction, multiplication, and division. Dice and cards are used in studying Probability.

WRITTEN

Written practice with computation (“drill”) is a necessary component of mathematics education. Mathnasium provides for abundant practice.

In addition, our workbooks and other printed material provide a framework for the orderly development of mathematical thought and skills.

Examples: Our worksheets cover the entire spectrum from practicing “1 + 1” to solving linear equations. In addition, our printed materials cover all aspects of Problem Solving.

ATTITUDE and SELF-ESTEEM

Many students come through our doors with an “I’m no good at math…I hate math” attitude. Kids don’t really “hate math.” What they hate is being, frustrated, embarrassed, and confused by math.

Being successful is the best way to over–come these problems.Mathnasium

provides for success by finding the right starting point (through diagnostic testing) and building confidence and self–esteem through successful encounter and interaction with carefully selected materials.

IN ADDITION

The Mathnasium Method also provides: enrichment at all levels of the curriculum, advanced work, including topics not usually introduced in the classroom, for students who are ready, and intensive remediation, as needed.

Method

EVALUATE

Mathnasium students are given a two-part diagnostic test. The first is a written test designed to assess the student's weakness with respect to grade-level material. The second part is a series of oral questions, designed to assess the depth of the student's understanding of key math concepts and skills. We use the results to assign a learning plan tailor-made for your child.

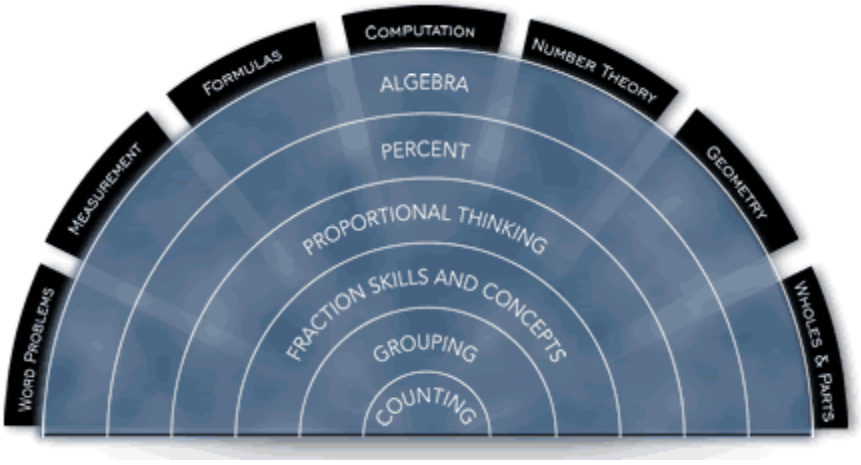
EDUCATE

- Customized Program for your Child
- Highly trained instructors
- Guided practice
- The latest computer software
- Manipulatives
- Periodic assessment to keep students on track
- Kids workout once or twice a week, or as often as they like, just like a gym.

RESULTS

Your child's progress is measured by his or her grades, third party assessment (ERB, CTBS, ISEE, SAT9/6, CAT), and love of mathematics.

Curriculum



The heart of the Mathnasium curriculum is comprised of:

COUNTING
Counting is "the ability to count from any number, to any number, by any number."

WHOLES & PARTS
Knowledge of Wholes and Parts is “the ability to ‘see’ wholes and parts in a given question, and to utilize the idea the ‘The whole equals the sum of its parts,’ and ‘Each part equals the whole minus all of the other parts’ to answer the question at hand.”

PROPORTIONAL THINKING & CHANGE
Proportional Thinking and Change is “the ability to compare numbers by division and by subtraction, and to use this knowledge to solve problems by ‘reasoning in groups.’”

These categories are further subdivided into the following 20 curricular areas.
1. Counting
2. Percent
3. Number Facts
4. Measurement
5. Half
6. Geometry
7. Computation
8. Wholes and Parts
9. Proportional Thinking
10. Money
11. SAMEness, Quantity, Value
12. Data Analysis
13. Laws of Mathematics
14. Patterns
15. Negative Numbers
16. Algebraic Thinking

17. Fraction Concepts
18. Problem Solving
19. Number Theory
20. Math Vocabulary

Appendix C. Mathnasium Internal Pre-Tests used in this Study

Appendix G. Test Result Data

Student		Pre-Test						Posttest					Comparision		
Grade	ID	Total #	TotCorr	Tot Wrg	Tot NA	TotAttmt	PctCorr	TotCorr	Tot Wrg	Tot NA	TotAttmt	PctCorr	IncInPct	ChgCorr	ChgAttmt
Middle School Control Group (5-6)															
6	8	91	7	38	46	45	7.7%	6	26	59	32	6.6%	-1.1%	-1	-13
6	10	91	20	15	56	35	22.0%	14	15	62	29	15.4%	-6.6%	-6	-6
6	11	91	12	18	61	30	13.2%	35	45	11	80	38.5%	25.3%	23	50
6	20	91	49	32	10	81	53.8%	26	10	55	36	28.6%	-25.3%	-23	-45
6	22	91	43	32	16	75	47.3%	26	2	63	28	28.6%	-18.7%	-17	-47
6	25	91	36	19	36	55	39.6%	47	23	21	70	51.6%	12.1%	11	15
6	31	91	6	6	79	12	6.6%	5	19	67	24	5.5%	-1.1%	-1	12
6	32	91	8	7	76	15	8.8%	8	14	69	22	8.8%	0.0%	0	7
6	33	91	4	1	86	5	4.4%	9	14	68	23	9.9%	5.5%	5	18
6	34	91	7	7	77	14	7.7%	8	8	75	16	8.8%	1.1%	1	2
6	36	91	40	39	12	79	44.0%	39	37	15	76	42.9%	-1.1%	-1	-3
6	38	91	45	14	32	59	49.5%	47	12	32	59	51.6%	2.2%	2	0
6	39	91	4	2	85	6	4.4%	5	4	82	9	5.5%	1.1%	1	3
			281			511	23.8%	275			504	23.2%	-0.5%		-7
Middle School Experimental Group (5-6)															
6	6	91	22	21	48	43	24.2%	46	29	16	75	50.5%	26.4%	24	32
6	7	91	26	11	54	37	28.6%	28	11	52	39	30.8%	2.2%	2	2
6	9	91	4	9	78	13	4.4%	9	9	73	18	9.9%	5.5%	5	5
6	18	91	59	22	10	81	64.8%	74	16	1	90	81.3%	16.5%	15	9
6	19	91	36	13	42	49	39.6%	48	40	3	88	52.7%	13.2%	12	39
6	21	91	71	17	3	88	78.0%	80	11	0	91	87.9%	9.9%	9	3
6	23	91	22	53	16	75	24.2%	26	61	4	87	28.6%	4.4%	4	12
6	24	91	45	46	0	91	49.5%	52	39	0	91	57.1%	7.7%	7	0
			285			477	39.1%	363			579	49.9%	10.7%		102