Supporting Mathematical Proficiency through Computational Fluency: Assessing the Impact of the E.nopi MATH Program

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Summary

- Like, when I got into it it (math) was like kinda hard, but now it's like, it's easier than you think it is. It's much easier, and it makes me feel good. *(Interview with Don)*
- I'd say it's (E.nopi MATH) helped me with my multiplication and subtraction……… But with the Enopi it showed me step by step, and I got it. I can do math faster. ……I've learned it so well what I like is when your doing it, when you first do it, like what I said the directions. …… And like, when you do that, when you do it step by step you'll learn it and when you do more problems you'll get faster and faster at it. *(Interview with Miki)*
- Um, it helped me learn how to not go so fast. To not make so many mistakes. Um, it makes me feel better about myself. I don't make as many mistakes. *(Interview with Lisa)*

The E.nopi MATH program aims at building computational skills for elementary and middle school students. The purpose of this study is to examine the impact of *E.nopi MATH*, a program that supports students' computational fluency, on students' mathematical proficiency and on the development of students' positive attitudes to learning mathematics.

91 students, 44 experimental and 47 control group students were recruited for the study. In the fall of 2004, 4 teachers from upstate New York volunteered for the study. One teacher was assigned to the experimental group and the other three teachers were assigned to the control groups.

Intervention was provided for the school year of 2004-2005 using E.nopi MATH as a supplementary program in addition to regular textbook. Control group teachers were instructed to follow their usual method instruction without employing E.nopi MATH program.

Students completed the grade appropriate District Math Inventory Test and New York State Math Test as pre and post tests at the beginning and end of the year. A Simplified

Fennema-Sherman Mathematics Attitudes Scale was used to test the students' attitudes towards math learning.

. Results showed that the fourth grade students who had used E.nopi MATH for a year showed statistically significant scores on the New York State Math Test and scored higher on attitudes toward math than the control group.

Supporting Mathematical Proficiency through Computational Fluency: Assessing the Impact of the E.nopi MATH Program

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Introduction

Improving students' mathematical fluency has been a major concern for American educators during the past years. Several international and national assessments have revealed a low level of performance in mathematics of American students. Results from assessments, such as the Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA), conducted over the past 10 years indicate that American students tend to have a limited understanding of fundamental mathematical concepts and have trouble applying mathematical skills even on simple problems (National Research Council, 2001, p. 55).

Mathematics educators, guided by the National Council of Teachers of Mathematics (NCTM), expect students to become mathematically proficient; they should to be able to go beyond the mastery of disconnected facts and procedures, to learn conceptually, to problem solve and to apply their mathematics knowledge to new situations (NCTM, 2000). This approach requires mathematics educators to move away from placing a heavy emphasis on computation, rote memorization and repeated practice of procedures.

What is mathematical proficiency? The National Research Council (2001) theorized that mathematical proficiency is composed of five strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. These strands are intertwined and influence each other. Yet, American educators tend to highlight the importance of computational proficiency over the other strands in primary grades (NCTM, 2000).

America has a long history of alternating between teaching procedurally and teaching conceptually, although concepts and procedures are closely interrelated (Griffin, 2003). In the 1950s and 1960s, the "back-to-basics" movement overemphasized computational competency which was already a major focus during the first half of the twentieth century (National Research Council, 2001, p.115). In response to this movement, a new reform movement of the 1980s and 1990s pushed the direction toward conceptual learning and the development of thinking processes such as reasoning, solving problems, connecting mathematical ideas and communicating ideas of mathematics with others (National Research Council, 2001). According to Loveless (2003), prioritizing conceptual understanding while reducing the attention on computational skills has lead to an imbalance in students' mathematics education.

The emphasis on conceptual understanding has proved to be somewhat more effective than the traditional emphasis on computational proficiency in terms of students' performance in the TIMSS and PISA studies. However, the increase in scores has been minimal.

We believe that it is relevant to investigate the effect of computational fluency on overall mathematical proficiency. The purpose of this study is to examine the impact of *E.nopi MATH* (a program that supports students' computational fluency) on students' mathematical proficiency and the development of students' positive attitudes toward learning mathematics.

Review of the Literature

Current state of students' mathematical proficiency. Reports from international assessments of students' mathematics competency have shown that the performance of American students is low compared to that of students from other developed countries. For example, the results of the Trends in International Mathematics and Science Study (TIMSS) in 2003 reported that students from Singapore, Hong Kong, Japan and Chinese Taipei received the top four rankings while the students from the U.S. were ranked as 12^{th} out of 25 participating countries (TIMSS, 2004). American fourth graders scored, on average, 518 points while their counterparts from leading countries scored between 564 and 594 points.

Another important international study on mathematical achievement, Programme for International Student Assessment (PISA), reported similar results in 2004. The U.S. performance in mathematics literacy and problem solving was lower than the average performance among most Organisation for Economic Co-operation and Development (OECD) countries and below average on each mathematics literacy subscale representing a specific content area, space and shape, change and relationships, quantity, and uncertainty (2005, April 19).

National assessments show that a great number of American students perform below national standards. In the past 30 years a series of national assessments have been implemented to observe American students' achievement in mathematics. The overall level of achievement in mathematics has increased during that period. Between 1990 and 2005, the Nation's Report Card, the National Assessment of Educational Progress (NAEP), reported that the percentage of fourth graders performing at or above Basic level increased from 50 to 80 percent, and the percentage performing at or above Proficient level increased 13 to 36 percent. However, it is of great concern that 20 percent of students are still at or below Basic level in math achievement nationwide (NAEP, 2005).

At the state level, the results of the 2005 New York State Mathematics Test issued by The New York State Education Department report that 77.4 percent of fourth grade students attained the grade level standards (Levels 3 and 4) (2005, November). While this is a large percentage of success, it also means that 22.6% of fourth graders in the State of New York failed the expectations for the target grade level mathematics fluency.

Conceptual and Procedural Understanding. The relationship between computational proficiency and mathematical proficiency is well theorized in the National Research Council's report in 2001. The council describes mathematical proficiency as composed of five intertwined and interdependent strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (p. 116).

The National Research Council suggests that procedural fluency is the basis for developing strong conceptual understanding of mathematical ideas. Computational skills such as knowledge of procedures, knowledge of when and how to use them appropriately, and skill in performing them flexibly and efficiently, are especially needed to support conceptual understanding (p.121). The council specifically states that students need to be efficient and accurate in performing basic computations with whole numbers without needing to refer to a table or other visual aides (p.121). The council also recommends that students reach an automatization level of proficiency in computational skills in order to achieve a higher level of overall mathematical fluency.

National and state learning standards for mathematics suggest that computational fluency is a major component of the mathematics curriculum in grades 3rd to 5th (NCTM 2000, National

Research Council 2001, New York State Learning Standards, 2005). The NCTM's Principles and Standards of School Mathematics (PSSM) claims:

> A major aim in 3-5 grades is the development of computational fluency with whole numbers. Fluency refers to having efficient, accurate, and generalizable methods (algorithms) for computing that are based on well-understood properties and number relationships. Some of these methods are performed mentally, and others are carried out using paper and pencil to facilitate recording of the thought process. Students should come to view algorithms as tools for solving problems rather than as the goal of mathematics study (NCTM, 2000, p.143).

For grade levels three to five, NCTM recommends spending a significant amount of instructional time on conceptual understanding rather than on developing computational fluency (NCTM, 2000, p.153). The council emphasizes the importance of mastering computational skills in primary grades although it maintains that computational skills are *tools* rather than a goal for mathematics education. The NCTM recommends the use of calculators to support students' computational abilities in enhancing the learning of math (NCTM, 2000, p.153). The use of calculators can enhance students' ability to perform computations and to extended problem accessibility while enabling them to execute routine procedures quickly and accurately.

The New York State Learning Standard 3-Mathematics (2005) aligned with the NCTM standards and the National Research Council recommendations also identifies computational fluency as a major component in developing mathematical proficiency.

Critics of the NCTM's vision consider that recommendations such as those described in the previous paragraphs send mixed messages concerning the importance of mastering computational skills in primary grades. Some organizations such as the Honest Open Logical Debate on math reform (H.O.L.D.) and Mathematically Correct (as cited in Ross, 2001) are the most active in opposing the NCTM's position of emphasizing conceptual learning over computational skills. These organizations believe that de-emphasizing accuracy and competence in computational skills will produce students who simply cannot do the math that they need to do. They insist on teaching computational skills in tandem with conceptual learning in math and have pressed school boards to adopt curricula that stress competence in basic computational skills. H.O.L.D. and Mathematically Correct believe that unless students are taught traditional algorithms, they will not be able to develop their full potential for learning mathematics (Ross, 2001).

Employing multiple representations in teaching and learning mathematics. Cognitive theories of learning claim that young students learn mathematics through physically manipulating objects and reflecting on their actions. In order to help young students internalize and generalize their knowledge, teachers play the role of facilitators while scaffolding their students' work as doers of manipulation. Bruner and Piaget (as cited in Burris.2005, p.9) argued that knowledge can be represented in three ways: concrete, pictorial and symbolic. For primary grade students, educators are encouraged to understand the importance of conducting lessons with hands-on experiences. It is common to observe students in the early grades manipulating blocks to develop the concept of numbers and counting strategies. Afterward the teachers may use pictorial representations to show, for example, the addition of "2 dots plus 3 dots" as a total of 5 dots. Pictorial representations support the transition from concrete to symbolic representations. Symbolic representations are apparent in number sentences such as 3+2= [ ] which are usually introduced after concrete and pictorial presentations.

In order to attain conceptual understanding, students should be exposed to the three forms of representation until they are able to fluently move back and forth between them. The use of multiple representations is strongly supported by the NCTM particularly for the primary grade students to make mathematical ideas more concrete and available for later reflection (NCTM, p.137).

Ross (2001) argued that the construction of concepts is an abstract-cognitive process. To learn number operations meaningfully, the students should be able to move from the concrete level to the pictorial and symbolic levels, while developing computational algorithms. The teachers should evaluate students' work, helping students recognize efficient algorithms, and provide sufficient and appropriate practice so that the students become fluent and flexible in computing.

The time spent in the mathematics classroom may not provide opportunities for students to develop conceptual and procedural understanding and for the practice of the procedures. One possible approach to solve this situation is the implementation of a supplementary program to help students develop computational competency. As students may differ in the level of computational abilities, the material provided in a supplemental program should be individualized to meet each student's need. The E.nopi MATH program is one of a number of specially designed programs whose intent is to provide conditions to develop and increase procedural competency.

E.nopi MATH

E.nopi MATH was established in 1975 in Korea as a program to teach mathematics to students from kindergarten to 8th grade. Currently, it is the most widely used program to supplement after-school math instruction in Korean homes. By the year 2004, more than 2.4 million students were enrolled in the E.nopi program in Korea.

Parents enroll their child in the program on a monthly basis to support their child's mathematics competency. The student works on the E.nopi MATH booklets for 10 to 30 minutes each day. A tutor visits each student once a week. During each visit, the tutor revises and grades the work the student has done during the week. The tutor helps the student with math problems that the student struggles with and lets him/her do the revision work on their own.

There are basically two aspects of mathematics knowledge reflected in the content of the E.nopi MATH booklets: Basic Thinking Math and Critical Thinking Math. Basic Thinking Math, which supports the foundation of a student's computational competency, is a core program to learn computational skills. It teaches numbers, number operations, and application of arithmetic and equations. Critical Thinking Math was designed for students to develop the ability to recognize patterns, utilize reasoning and perform relational analysis. The program is composed of 23 levels from pre-kindergarten to the end of elementary grades (5th or 6th), and 9 levels for middle school students. Each level consists of 24 sets making a total of 690 sets**.**

E.nopi Math can be characterized as individualized learning and student initiated learning. E.nopi was designed to fit each individual student's level regardless of age or grade. During instructional time in the mathematics classroom, it is not easy to give students individualized support. It is envisioned that a teacher could effectively instruct students with diverse math ability levels teaching in large or small groups, while E.nopi would support students individually, at their own levels.

The E.nopi MATH curriculum is developed based on small steps, prompt responses, and self checking. Students' progress is based on small steps which allow students to proceed to the next level without the teacher's direct instruction. Each finished booklet is graded and returned to the student so that the student can check his/her mistakes and make corrections.

E.nopi MATH emphasizes computational skills and pursues the automatization level of carrying out computations. McDevitt and Ormrod (2005, p.193) define the automatization level as when a procedure can be carried out rapidly and efficiently while mentally processing or physically performing tasks. It is expected that with proper practice of E.nopi MATH, students can perform mathematics computations with minimal effort and high levels of accuracy. Psychologists believe that the activities that become automatized take up very little space in working memory. Thus, students can devote available working memory capacity to other more complex or higher levels of tasks and problems (McDevitt & Ormrod 2005, p.193). Without mastering basic computational skills, students' mathematical problem solving performance can be slowed down because they use their cognitive ability to review computational procedures

In order to begin using the E.nopi program, an initial diagnostic test is given to each student. Then, based on the results of the test, the student is provided with a booklet at a level where s/he may feel comfortable. It may sometimes be a little lower than the student's actual capabilities but it helps students to learn the format of the program. Students are expected to make only a few mistakes in order to proceed to the next booklet. With successful mastery of each level, students are expected to build confidence and develop a positive disposition toward mathematics.

When a student completes a booklet with few mistakes and within an assigned time, s/he is given the next level booklet. The process continues in this manner, dealing with new concepts after mastering previous ones. In this way, each student can progress at his/her own pace and level. E.nopi MATH emphasizes slow but steady progress and values practice as an important component that supports student's progress.

Methodology

Research Design [1]

Setting. The study was conducted at Hanes, a public Intermediate school, located in upstate New York. The school serves approximately 600 students at grade levels 3 to 6. The majority of students (97%) are Caucasian. Approximately 25% of the school children receive free or reduced-priced lunch. (New York State Education Department, 2004, 2005)

The performance of the Hanes students on the New York State 4th grade Mathematics test is higher than the average of the state level. For the year of 2003-2004, 77% percent of Hanes 4th graders passed the state test while the New York State's average passing rate was 68.1%.

Participants. A teacher from Hanes Intermediate School volunteered to participate in this study. Miss Fisher has taught in elementary and intermediate schools for 28 years. The year this study took place (2004-2005) Miss Fisher taught two 4th grade math classes. Three other 4th grade teachers joined the study to provide control groups. Table 1 provides information on how the groups were selected.

Table 1

Participants

Experimental (E.nopi) Group	Control Group
2 classes taught by Miss Fisher	3 classes taught by 3 different teachers
44 students	47 students

Due to the exploratory nature of applied educational research and the fact that this was a pilot study of the E.nopi MATH program, this study involved a restricted rather than random assignment. We do not believe that it changes the direction of results as we discuss later in this report.

In order to control for selection bias, we verified that both groups of students were selected randomly when they were originally assigned to their classes in September 2004. All five participating classes were inclusive classrooms. Miss Fisher and the other control group

[1] Note that names of people and places have been changed to preserve anonymity.

teachers were invited to the introduction of the E.nopi MATH program presented by an E.nopi MATH specialist.

Miss Fisher did team teaching with a colleague, Ms. Jones, for two classes. Ms. Jones taught social studies while Miss Fisher provided mathematics instruction. Miss Fisher volunteered to be in the experimental group and to use E.nopi MATH in her two 4th grade math classes. The parents of participating students from both classes signed a permission slip prior to the onset of the study.

Implementation. E.nopi MATH was originally developed to be used for after-school home use. For the purpose of this study, however, we used it within the school setting. E.nopi MATH was implemented for the entire school year of 2004-2005 with the experimental group of students using part of their daily time allocation of 45 minutes for the math class.

Ninety one students, 47 in the experimental and 47 in the control groups, were identified. In Miss Fisher classes (experimental group) of the 45 minutes assigned for math, the first 20 minutes were allocated for implementing E.nopi MATH with the remaining 25 minutes for regular classroom instruction, using the curriculum of Klein, Starkey and Ramirez's (2004) Scott Foresman Mathematics textbook. The students in the three control groups were also taught with the Scott Foresman textbook. The control group received the regular instruction, based on the SF textbook for the entire 45 minutes lessons.

A research assistant was hired to be present on a daily basis to help implement the program and to grade the booklets. Later, a second assistant joined the project because the first assistant was not able to be at the class every day due to scheduling conflicts.

To determine the initial computation level for each student in the experimental group, Miss Fisher's students took a diagnostic test developed by the E.nopi MATH specialist. The test was scored and sent to E.nopi Headquarters. Initial booklets, adequate for a one month supply of E.nopi Math for each student, were then delivered by E.nopi America to begin the research in September 2005.

Based on the initial diagnostic test, every student in the experimental group was assigned a booklet appropriate to his/her level. When E.nopi MATH booklets were introduced in class, the students were very excited due to the novelty of the interesting and fancy booklets. It was a new experience for all of them.

Initially, it was expected that the students would complete 8 pages per day within 25 minutes. However, during the first week, many students finished 16 pages at a time. The students rushed to complete the booklets. The finished booklets were graded by the teacher assistant and returned to the students to make corrections. Instead of correcting their mistakes they wanted to go on to new questions. The classroom teacher explained to the class that they needed to correct the mistakes before they started on the next level of booklets. This is an important feature of the E.nopi MATH method.

After the initial excitement faded away, it was observed that many students spent the E.nopi MATH time to talk with classmates or to draw pictures on the booklets. In the end, they only finished one or two pages during the assigned time. Their concentration levels declined and the students often made many careless mistakes on the booklets. The high number of mistakes restricted them from progressing to the next level. Developing concentration and working efficiently are two other goals of the E.nopi program. At the beginning of the study, this was harder to attain in the classroom setting.

After a month, the research team thought that some changes were necessary to ensure the implementation E.nopi in an appropriate manner. At this moment, we need to re-determine the students' mathematical abilities and reevaluate their diagnostic test. How long should it take to solve 8 pages? The E.nopi MATH specialists visited Hanes Elementary School to check the students' progress. They found that the students *were* able to solve the assigned one-day amount of 8 pages within 8 minutes. We needed to help students improve their concentration.

Starting in January 2005, the research team along with Miss Fisher decided to shorten the time allotted for E.nopi in order to increase the concentration level and help students focus better. E.nopi MATH time was drastically reduced from 25 to 12 minutes. Students were then encouraged to finish their required 8 pages on time. The reduced and more focused time helped the students finish more pages within 12 minutes. Later on, in March, the E.nopi MATH time was reduced to 10 minutes so that Miss Fisher would have more teaching time to preparing the students for the New York State 4th grade Math Test.

Table 2

Time Line for E.nopi. MATH Study

Date	Description	E.nopi MATH
September 2004	E.nopi MATH	25 /45 minutes
September 2004	Pre tests taken	
January 2005	E.nopi MATH	12/45 minutes
March 2005	E.nopi MATH	10/45 minutes
May, June 2005	Post tests taken	

In addition to the E.nopi diagnostic test and the follow up of students' progress in their booklets, other assessment tools were used to collect data about students' knowledge of mathematics and their progress throughout the year as well as the students' attitude towards mathematics. Pre-tests, inventory and math attitude tests were given to both experimental and control groups in September 2004. Post-tests, the New York State Math Test and the same math attitude test were given in May and June of 2005.

For all participating students two pre and post tests were administered. Table 3 shows the list of pre and post tests. All of the pre tests were administered in September 2004 and the post tests in May of 2005. Grade level appropriate District Inventory Test and the New York State Math Test were used to measure mathematical fluency and a Simplified Fennema-Sherman Mathematics Attitudes Scale was used to measure pre and post attitude changes.

Table 3

Pre and Post Tests

Pretest	Posttest
Mathematics Inventory Hanes District Test (Sept. 2004)	New York State 4th grade Mathematics test (May 2005)
Math Attitudes Test (Sept. 2004)	Math Attitudes Test (June 2005)

Throughout the school year, the research assistants and the researchers observed the students when they were working on E.nopi MATH booklets. The observations revealed that many of the fourth graders were using inefficient strategies to solve addition, subtraction, and multiplication problems. Many students used their fingers to count up, count back, and skip count. They mechanically counted with fingers and wrote the answers on the paper. The students not only spent a great amount of time solving the problems, but they were not aware of possible mistakes they were making.

After talking to the students in order to investigate their understanding of the operations and their awareness of inefficient strategies, the research team decided to make an important intervention. We held two lessons with the students in which we discussed addition and subtraction strategies. These strategies were not mastered by the students in previous grades. We thought that there was no purpose in having students practice with E.nopi booklets if they were just using finger counting to solve the problems. This path would not be conducive to an automatization level of computation. Our intervention, however, did not come soon enough to produce long term results. Only a few students began using the strategies taught, and some students created strategies of their own. Most of the students, however, tended to rely on their previous inefficient strategy of finger counting.

Results

The experimental design for this research study was a two group pretest-posttest design with an experimental and control group. The dependent variables utilized in this investigation were fourth grade scores on the New York State Math Test and scores on a math attitude test. The independent variable was instructional strategy employing either traditional textbook instruction supplemented by E.nopi MATH (experimental group) or traditional textbook instruction alone (control group).

Preliminary analyses indicated that each data set had an approximately normal distribution with homogeneity of variance. Therefore, data were analyzed using analyses of variance (ANOVA) and analysis of covariance (ANCOVA). Each ANOVA had 1 df associated with the test for differences between the groups. (Note that an ANOVA with 1 df is the same as a *t*-test with the calculated *F*-value being equal to t^2.) There were 89 df associated with the error term in each ANOVA and 88 df associated with the error term in each ANCOVA.

Analysis of pretest math scores and pre-attitude scores showed no statistical differences between the two groups. For the Pre-Inventory math test ($F = 2.135$, $p = .147$, df = 1/89), the mean and standard error (SE) for the E.nopi group were 21.72 and 1.05, respectively. For the control group the mean and SE were 23.85 and 1.01. For the pre-attitude test ($F = .205$, $p = .652$, df = 1/89), the mean and SE for the E.nopi group were 118.2 and 2.25, and for the control group 116.8 and 2.18. Therefore, ANOVAs were appropriate to examine posttest differences between the E.nopi math group and the control group.

The analyses showed significantly higher posttest means for the E.nopi group than for the control group on the math posttest (NYS scores) and on the math attitude posttest (see the tables below for means and SEs). The results also showed significantly higher means on all math subtests with the exception of the Uncertainty subtest. To be complete, we included results from Analysis of Covariance (ANCOVA) for the Uncertainty subtest as well as for all other comparisons. The ANCOVA for the Uncertainty subtest was statistically significant with higher means (adjusted for the covariate) for the E.nopi group. Otherwise, the two sets of analyses yielded the same results and conclusions.

Table 4 summarizes all statistical results of pre- and posttest math comparisons between the experimental and control groups. The mean posttest score of the experimental group students who received E.nopi MATH as well as Scott Foresman math instruction was 679.2; the control group which received traditional Scott Foresman math instruction had a mean score of 656.8. The students in the experimental group who received lessons using E.nopi showed greater achievement gains than did students who received the same content without E.nopi MATH exercise.

Table 4

Statistics for Math Achievement

	Statistical	E.nopi	Control	Difference	E.nopi	Control	F ratio
	Test	Mean	Mean	Probability	Std. Error	Std. Error	
Pretest	ANOVA	21.72	23.85	.147 (ns)	1.05	1.01	2.135
NYSscores	ANOVA	676.6	659.2	.001	3.57	3.45	12.275
NYSscores	ANCOVA	679.2^	656.8	.000	2.64	2.55	36.632

^ means adjusted for covariate.

Statistical results on the seven sub key areas of the New York Math Test (Mathematical Reasoning, Number and Numeration, Operations, Modeling/Multiple Representation, Measurement, Uncertainty and Patterns/functions) are summarized in Table 5. For each subtest the E.nopi group had statistically significant higher means than the control group except for the ANOVA involving Uncertainty.

Table 5

Statistics for Math Achievement-Subscales

	Statistical	E.nopi	Control	Difference	E.nopi	Control	F ratio
	Test	Mean	Mean	Probability	Std. Error	Std. Error	
Mathews	ANOVA	77.2	64.0	.000	2.61	2.53	13.099
Number	ANOVA	83.8	75.0	.001	1.92	1.86	11.049
Operas	ANOVA	84.2	73.9	.009	2.66	2.75	7.190
Model	ANOVA	79.0	70.6	.008	2.24	2.17	7.363
Mesa	ANOVA	79.3	69.8	.002	2.17	2.10	9.863
Uncut	ANOVA	81.2	73.7	.056*	2.77	2.68	3.759
Pattern	ANOVA	80.6	70.1	.002	2.21	2.14	10.285
Mathews	ANCOVA	78.9	62.4	.000	2.08	2.01	31.957
Number	ANCOVA	85.1^	73.8	.000	1.53	1.48	27.607
Operas	ANCOVA	85.9	72.3	.000	2.24	2.17	18.820
Model	ANCOVA	80.2	69.4	.000	1.95	1.89	15.511
Mesa	ANCOVA	80.6	68.5	.000	1.77	1.71	23.769
Uncut	ANCOVA	83.1	72.0	.000	2.16	2.09	13.372
Pattern	ANCOVA	81.7	69.8	.000	2.00	1.93	18.153

* near significance at the .05 level of significance, but technically not significant.

^ means adjusted for covariate whenever analysis of covariance was used.

Table 6 summarizes pre- and post-math attitude differences between the two groups. The students in the experimental group achieved a mean score of 138.5 , and those in the control group achieved a mean score of 115.1 , showing the E.nopi MATH group had better math attitudes after the study.

Table 6

Statistics for Math Attitude

	Statistical	E.nopi	Control	Difference	E.nopi	Control	F ratio
	Test	Mean	Mean	Probability	Std. Error	Std. Error	
Preattitude	ANOVA	118.2	116.8	.652 (ns)	2.25	2.18	0.205
Mathatt	ANOVA	138.5	115.1	.000	1.81	1.75	87.059
Mathatt	ANOVA	138.2^	115.4	.000	1.46	1.41	125.997

^ means adjusted for covariate.

The analyses indicate that the data are consistent with the hypothesis that E.nopi MATH group produces better math performance and attitudes. Detailed analysis is presented in Appendix B.

To see the influence of teacher's variable previous school years 2002-2003 and 2003-2004 New York State Math test results were examined. The conclusion is that, on the basis of the 2002-2003 and 2003-2004 New York State Math test scores, there is no evidence of differences among teachers in the different groups.

Analyses of NYS scores for the years 2002-2003 and 2003-2004 for the teachers involved in the study showed no statistically significant differences among teachers, years, or the interaction between teachers and years. A similar analysis by group (i.e., the E.nopi teacher vs all control teachers) yielded no significant differences for group, year, or the interaction between group and year (shown in Table 7 and Table 8).

Table 7

Summary for teacher analysis

Teacher	2002-2003 mean	2002-2003 SE	2003-2004 mean	2003-2004 SE
1 (e. nopi)	659.00	5.98	669.23	5.84
2 (e. nopi)	654.55	6.13	660.27	5.84
3 (control)	657.95	6.13	650.14	5.84
4 (control)	650.14	5.98	651.95	6.13
5 (control)	661.73	5.84	654.45	6.13

No differences are significant.

Table 8

Summary for group analysis

Group	2002-2003 mean	2002-2003 SE	2003-2004 mean	2003-2004 SE
E. Nopi	656.83	4.26	664.75	4.11
Control	656.67	3.43	652.11	3.46

No differences are significant.

Discussion

The data in this investigation yielded evidence to support the two initial hypotheses that E.nopi MATH would support higher gains in achievement of mathematical fluency and better attitudes towards mathematics. This study is the first to report the effectiveness of the E.nopi MATH program on improving mathematical performance and attitudes among fourth grade students in America..

Schools that provide a symbolic level of computational skills exercises, such as E.nopi MATH, may offer greater opportunities for students to succeed than do schools that do not provide it. The results of this study support the position of the National Research Council that improving computational skills improves general mathematical fluency.

This research suggests that providing appropriate computational skills exercises to master the major mathematical concepts in primary grades is essential. The exercises for building mathematical fluency should not be mere repetition. Instead they should be self-progressing, educationally meaningful practice.

Limitations of the Research. Despite the positive results of this study, we need to point out several limitations. Because education is a complex practice, it is not easy to control all variables in order to draw causal conclusions. Though the E.nopi MATH group achieved more and demonstrated a better attitude toward mathematics, alternative variables. Also, the participants in the study were volunteers rather than randomly selected teachers and students. To the extent that the volunteers differ from the target population, results may not be generalizable to that population. Despite these limitations, the present study constitutes a first look at the effectiveness of E.nopi Math as a supplementary to traditional strategies of teaching.

The sample size was large enough to do a statistical analysis, but was not large enough to generalize the results. Replications and extensions of this research could clarify the current findings and extend them with the use of a larger, randomly selected sample.

Final Comments

Considering that this was a pilot study, the results were highly successful in terms of our goals. First, we found that the E.nopi MATH program can positively affect students' mathematical fluency and attitudes toward mathematics. Based on other observations made during the study, such as students' lack of efficient strategies for computations, we believe that the implementation of E.nopi MATH program would have a major impact if it is done in first or second grade. Researching the implementation of E.nopi in a school for two or more consecutive years would also provide information about long term impact of the program. In addition to the positive findings already presented, we have gained practical information about changes we can make to implement the program during classroom time. For example, we have learned when and how long the students should work on E.nopi booklets in order to concentrate and be productive. We have learned that the differences between E.nopi and regular lessons should be discussed with the students. We learned that the students should know mental, efficient strategies before doing repeated practice. Although it was the first time the program was implemented in an American classroom, the experience gave us insight on how to implement it more effectively.

References

Allen F.B. A new mission for NCTM –Save our schools-. Retrieved November 18, 2005, from http:www.mathematicallycorrect.com/mission.htm.

Boser, U. Revised mathematics standards provide more guidance. Educational Week, April 19th, 2000 (Online). http:www.edweek.org/ew/ewstory.cfm?slug=32nctm.h19.

Brownell, W.A. (1987). Meaning and skill-Maintaining the balance. *Arithmetic Teacher* 3129-36. Reprinted in Arithmetic Teacher 34 (April): 18-25.

Burris, A. C. (2005). Understanding the math you teach. Pearson/Merrill Prentice Hall, Upper Saddle River, New Jersey.

Doepken, D., Lawsky, E., Padwa, L. (2004). Modified Fennema-Sherman Attitude Scales. Retrieved September 15th 2004 from http://www.woodrow.org/teachers/math/gender/08scale.html.

Griffin, S. (2003). Laying the foundation for computational fluency in early childhood. *Teaching Children Mathematics* (February) 306-309

Griffin, S., Case, R. (1996), Number worlds: Kindergarten level. Durham, N.H: Number Worlds Alliance.

Griffin, S., Case, R. (1997). Rethinking the primary school math curriculum: An approach based on cognitive service. Issues in Education 4:1-51.

Highlights from the trends in International Mathematics and Science Study (TIMSS) (2003). Retrieved November 18th 2005 from http://nces.ed.gov/pubs2005/timss03/summary.asp.

Hoff, D.J. (2000). Math revisions add emphasis on basic skills. Educational Week, April 12th, 2000 (Online). http:www.edweek.org/ew/ewstory.cfm?slug=32nctm.h19.

Klein, A., Starkey, P., Ramirez, E. (2004). Scott Foresman Mathematics: Level 4. Scott Foresman & Co.

Loveless, T. (2003). Trends in math achievement: The importance of basic skills. Speech presented at the Secretary of Education's Mathematics Summit in Washington. Retrieved November 18th 2005, from http://www.brook.edu/views/speeches/loveless/20030206.htm.

McDevitt, T.M., Ormrod, J.E. (2004). Child Development: Educating and working with children and adolescents. Pearson/Merrill Prentice Hall, Upper Saddle River, New Jersey.

National Assessment of Educational Progress. (2005). The nation's report card: Mathematics 2005: National Center for Educational Statistics.

National Council of Teachers of Mathematics (NCTM) (2000). Principles and standards for school mathematics. Reston, Va: NCTM.

National Research Council (2001). Adding it up: Helping children learn mathematics. Kilpatiric, J., Swafford, J., and Bradford F.

New York State Education Department (2004). Retrieved November 29, 2005 from http://www.nycenet.edu/daa/2005Math38/pdf/2005_NYS_NYC_Highlights.pdf

New York State Education Department (2005) Retrieved November 29, 2005 from http://www.emsc.nysed.gov/repcrd2004/overview-analysis/110701060000.pdf

Oakley, B. A., Lawrence, D., Walter, L.B., Boxley, B., Kobus. C.J. (2003). Using Kumon method to revitalize mathematics in an inner-urban school district. Proceedings of the 2003 American society of Engineering Education Annual Conference & Exposition.

Ross, D. (2001). The math wars. Retrieved November 18th 2005 from http://www.ios.org/articles/dross_math-wars.asp

Appendixes

Appendix A

Name______________________

Simplified Fennema-Sherman Mathematics Attitude Scale Short Form

(Adapted from Mulhern & Rae, 1998)

Instructions:
Example: I like mathematics.
As you read the sentence, you will know whether you agree or disagree. Do not spend much time with any statement, but be sure to answer every statement. Work fast, but carefully. There are no “right” or “wrong” answers. The only correct responses are those that are true *for you.* Whenever possible, let the things that have happened to you help you make a choice.

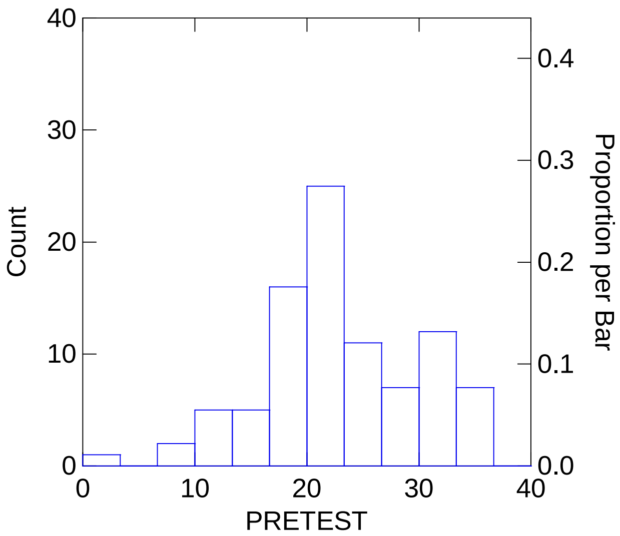
		Strongly Agree	Agree	Not so Sure	Disagree	Strongly Disagree
1	**Generally, I have felt secure about attempting mathematics.**	5	4	3	2	1
2	**I am no good at math.**	5	4	3	2	1
3	**For some reason even though, I study, math seems unusually hard for me.**	5	4	3	2	1
4	**Most subjects I can handle OK, but I have a knack for messing up math.**	5	4	3	2	1
5	**I usually have been at ease in math class.**	5	4	3	2	1
6	**Mathematics usually makes me feel uncomfortable, and nervous.**	5	4	3	2	1
7	**Mathematics makes me feel uncomfortable, restless, irritable, & impatient.**	5	4	3	2	1
8	**I get a sinking feeling when I think of trying, math problems.**	5	4	3	2	1
9	**Mathematics makes me feel uneasy and confused.**	5	4	3	2	1
10	**I study mathematics because I know how useful it is.**	5	4	3	2	1
11	**Knowing mathematics will help me earn a living.**	5	4	3	2	1
12	**Mathematics is a worthwhile and necessary subject.**	5	4	3	2	1

13	**I’ll need a firm mastery of mathematics for my future work.**	5	4	3	2	1
14	**I will use mathematics in many ways as an adult.**	5	4	3	2	1
15	**Mathematics has no relevance to my life.**	5	4	3	2	1
16	**Mathematics will not be important to me in my life’s work.**	5	4	3	2	1
17	**I see mathematics as a subject I will rarely use in daily life as an adult.**	5	4	3	2	1
18	**I’d be proud to be the outstanding student in math.**	5	4	3	2	1
19	**I am happy to get good grades in mathematics.**	5	4	3	2	1
20	**It would be really great to win a prize in mathematics.**	5	4	3	2	1
21	**Being first in a mathematic competition would make me happy.**	5	4	3	2	1
22	**Being regarded as smart in mathematics would be a great thing.**	5	4	3	2	1
23	**If I got the highest grade in math I’d prefer no one knew.**	5	4	3	2	1
24	**It would make people like me less if I were a really good math student.**	5	4	3	2	1
25	**I don’t like people to think I am smart in math.**	5	4	3	2	1
26	**My teachers think I’m the kind of person who could do well in mathematics.**	5	4	3	2	1
27	**My teachers have made me feel I have the ability to go on in mathematics.**	5	4	3	2	1
28	**My teachers have been interested in my progress in mathematics.**	5	4	3	2	1
29	**I have found it hard to win the respect of math teachers.**	5	4	3	2	1
30	**Getting a mathematics teacher to take me seriously usually has been a problem.**	5	4	3	2	1
31	**I have had a hard time getting teacher to talk seriously with me about mathematics.**	5	4	3	2	1

Appendix B

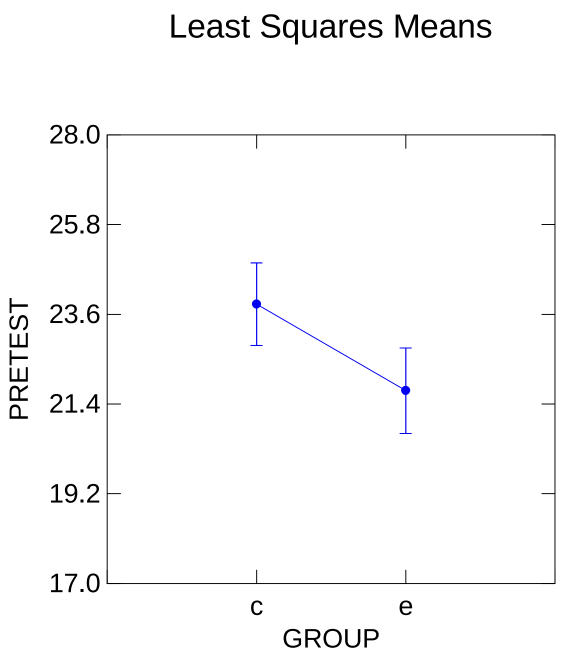
Detailed analyses:

1. **Are the pretest scores approximately normal. Yes.**



2. **Are there statistical differences between the groups on the pre-test? No.**

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: PRETEST   N: 91   Multiple R: 0.153   Squared multiple R: 0.023


                             Analysis of Variance

Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

GROUP$                  102.502     1      102.502       2.135       0.147

Error                  4272.685    89       48.008

Least squares means.
                                LS Mean           SE       N
  GROUP$      =c                  23.851        1.011      47
  GROUP$      =e                  21.727        1.045      44
-------------------------------------------------------------------------------
```



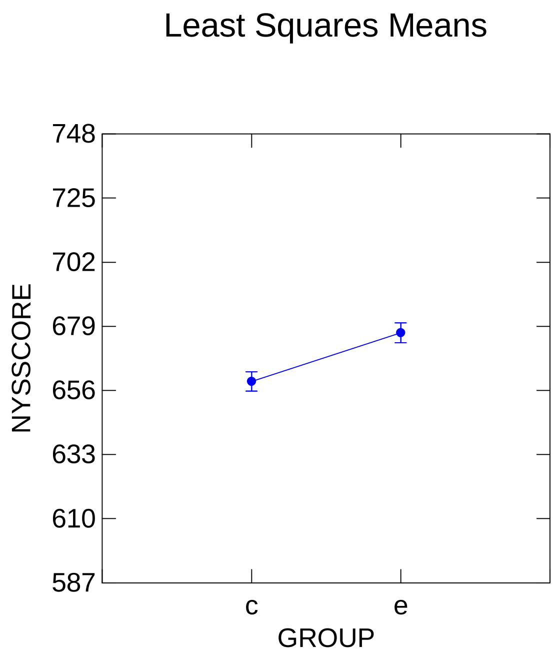

```
-------------------------------------------------------------------------------
Durbin-Watson D Statistic     1.671
First Order Autocorrelation   0.161
-------------------------------------------------------------------------------
```

3. Are the NYS scores approximately normal and have homogeneity of variance? Yes.

4. Are there differences between the E. nopi groups when pretest differences are not removed? Yes, the E. nopi group scores higher than the control group.

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: NYSSCORE   N: 91   Multiple R: 0.348   Squared multiple R: 0.121

                             Analysis of Variance

Source              Sum-of-Squares   df  Mean-Square     F-ratio       P

GROUP$                   6882.140     1     6882.140      12.275       0.001

Error                   49898.607    89      560.659
```

```
Least squares means.
                                      LS Mean          SE       N
  GROUP$       =c                      659.234        3.454      47
  GROUP$       =e                      676.636        3.570      44
-------------------------------------------------------------------------------
```




```
-------------------------------------------------------------------------------
Durbin-Watson D Statistic     1.382
First Order Autocorrelation   0.284
-------------------------------------------------------------------------------
```

5. Is there evidence for homogeneity of slopes? Yes. (This is a necessary condition for doing an analysis of covariance.)

6. Are there differences between the E. nopi groups when pretest differences are removed even though they pretest differences are not significant? Yes. The E. nopi group does significantly better than the control group.

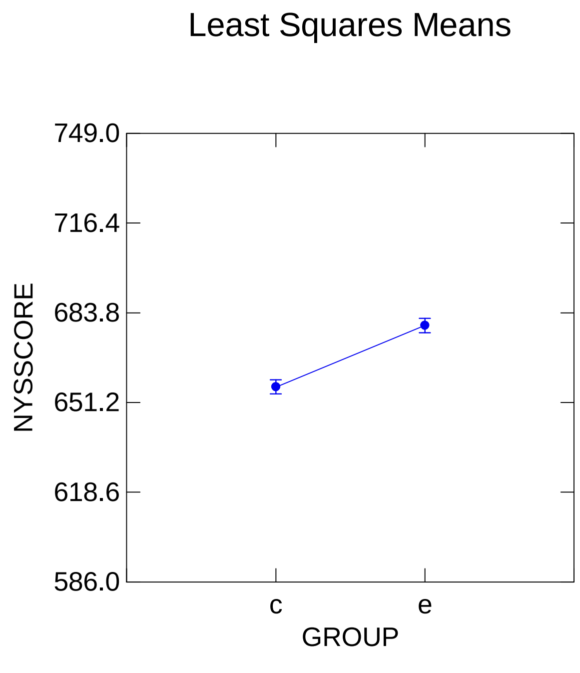
```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: NYSSCORE   N: 91   Multiple R: 0.728   Squared multiple R: 0.531
```

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GROUP$	11092.463	1	11092.463	36.632	0.000
PRETEST	23251.555	1	23251.555	76.787	0.000
Error	26647.052	88	302.807		

Adjusted least squares means.

		Adj. LS Mean	SE	N
GROUP$	=c	656.839	2.553	47
GROUP$	=e	679.195	2.640	44




```
Durbin-Watson D Statistic     1.380
First Order Autocorrelation   0.284
```

7. Analyses of variance for subtests. All subtest show higher means for E.nopi groups.

Mathematical reasoning

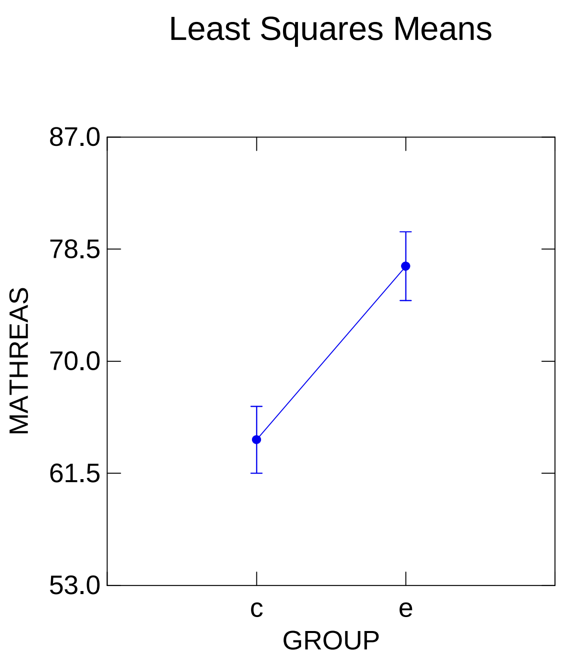
```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: MATHREAS   N: 91   Multiple R: 0.358   Squared multiple R: 0.128
```

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GROUP$	3936.882	1	3936.882	13.099	0.000
Error	26749.074	89	300.551		

Least squares means.

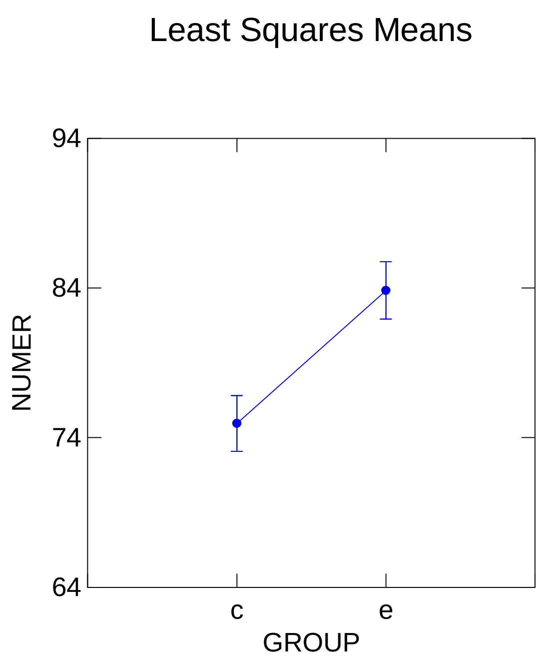
		LS Mean	SE	N
GROUP$	=c	64.043	2.529	47
GROUP$	=e	77.205	2.614	44



```
--------------------------------------------------------------------------------
Durbin-Watson D Statistic     1.323
First Order Autocorrelation   0.314
```

Number and numeration

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: NUMER   N: 91   Multiple R: 0.332   Squared multiple R: 0.110

                              Analysis of Variance

Source              Sum-of-Squares    df   Mean-Square     F-ratio       P

GROUP$                    1793.386     1      1793.386      11.049       0.001

Error                    14445.801    89       162.312

--------------------------------------------------------------------------------

Least squares means.
                                LS Mean           SE       N
  GROUP$      =c                  74.957        1.858      47
  GROUP$      =e                  83.841        1.921      44
--------------------------------------------------------------------------------
```




```
--------------------------------------------------------------------------------
```

```
Durbin-Watson D Statistic     1.424
First Order Autocorrelation   0.258
```

Operations

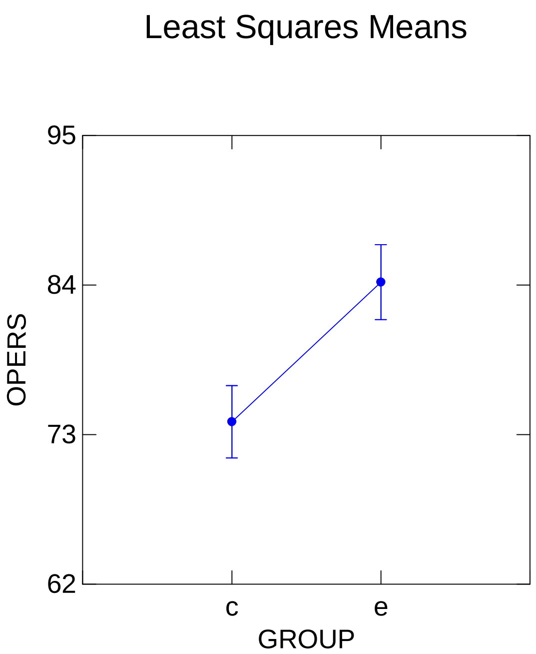
```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: OPERS   N: 91   Multiple R: 0.273   Squared multiple R: 0.075
```

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GROUP$	2396.142	1	2396.142	7.190	0.009
Error	29659.968	89	333.258		

Least squares means.

		LS Mean	SE	N
GROUP$	=c	73.936	2.663	47
GROUP$	=e	84.205	2.752	44



```
Durbin-Watson D Statistic     1.241
First Order Autocorrelation   0.343
```

Modeling/Multiple representation

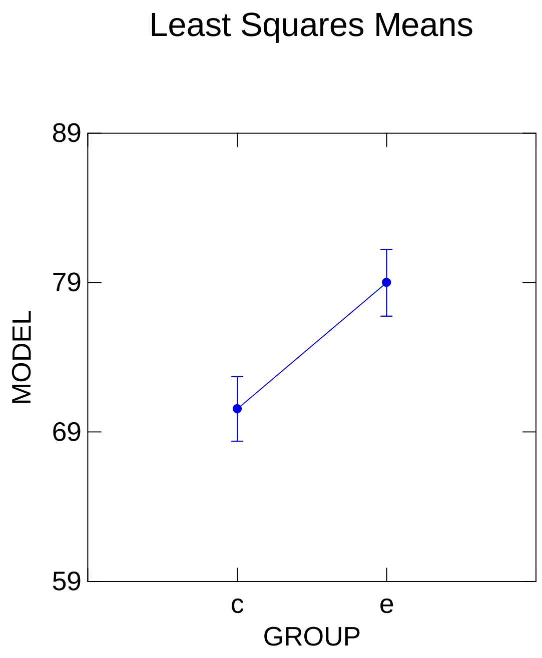
```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: MODEL   N: 91   Multiple R: 0.276   Squared multiple R: 0.076
```

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GROUP$	1621.416	1	1621.416	7.363	0.008
Error	19597.617	89	220.198		

Least squares means.

		LS Mean	SE	N
GROUP$	=c	70.553	2.165	47
GROUP$	=e	79.000	2.237	44



```
*** WARNING ***
```

```
Case            28 is an outlier        (Studentized Residual =       -3.387)
 Durbin-Watson D Statistic     1.521
First Order Autocorrelation   0.208
```

Measurement

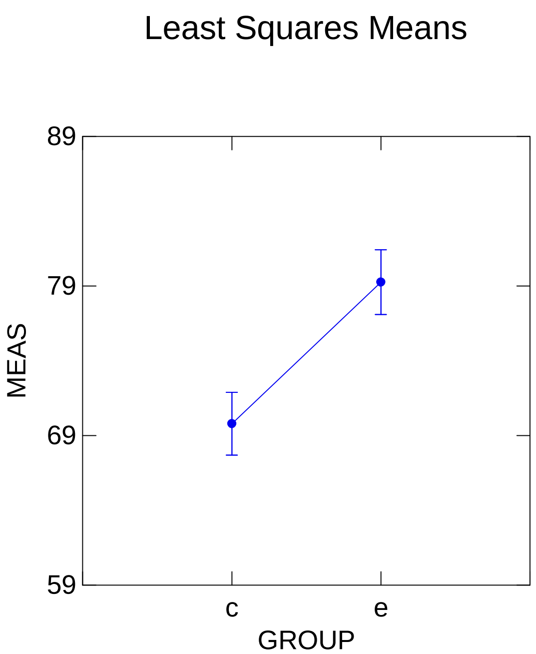
```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: MEAS   N: 91   Multiple R: 0.316   Squared multiple R: 0.100
```

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GROUP$	2034.911	1	2034.911	9.863	0.002
Error	18362.122	89	206.316		

Least squares means.

		LS Mean	SE	N
GROUP$	=c	69.787	2.095	47
GROUP$	=e	79.250	2.165	44

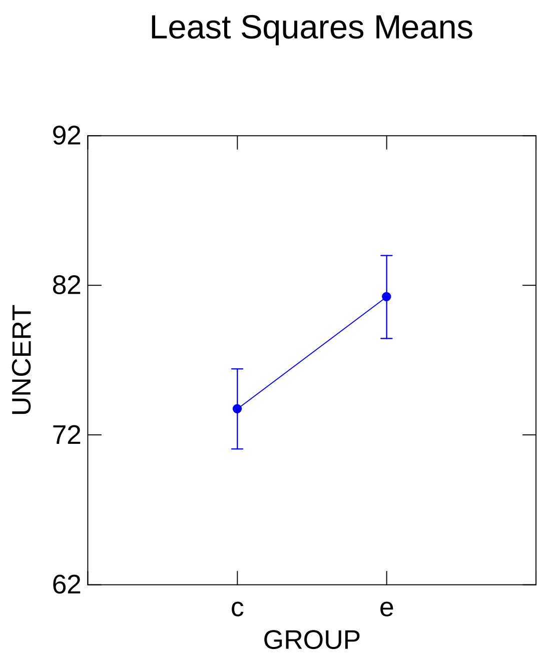



```
*** WARNING ***
```

```
Case            28 is an outlier        (Studentized Residual =       -3.451)
Durbin-Watson D Statistic     1.318
First Order Autocorrelation   0.303
```

Uncertainty

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: UNCERT   N: 91   Multiple R: 0.201   Squared multiple R: 0.041

                             Analysis of Variance

Source              Sum-of-Squares   df  Mean-Square     F-ratio       P

GROUP$                   1272.370     1     1272.370       3.759       0.056

Error                   30122.663    89      338.457
 ------------------------------------------------------------------------------
-
Least squares means.
                               LS Mean           SE       N
  GROUP$      =c                 73.745        2.684      47
  GROUP$      =e                 81.227        2.773      44
-------------------------------------------------------------------------------
```



```
--------------------------------------------------------------------------------
*** WARNING ***
Case            7 is an outlier        (Studentized Residual =       -3.787)

Durbin-Watson D Statistic     1.492
First Order Autocorrelation   0.229
```

Patterns and Functions

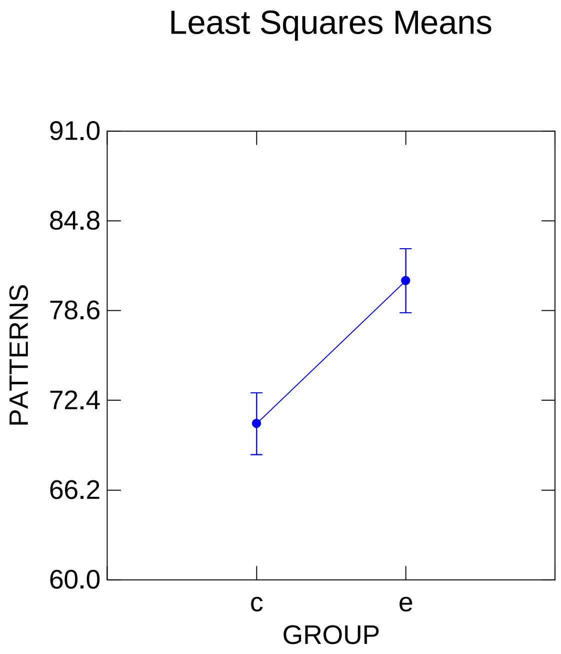
```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: PATTERNS   N: 91   Multiple R: 0.322   Squared multiple R: 0.104
```

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GROUP$	2214.659	1	2214.659	10.285	0.002
Error	19163.759	89	215.323		

Least squares means.

		LS Mean	SE	N
GROUP$	=c	70.787	2.140	47
GROUP$	=e	80.659	2.212	44



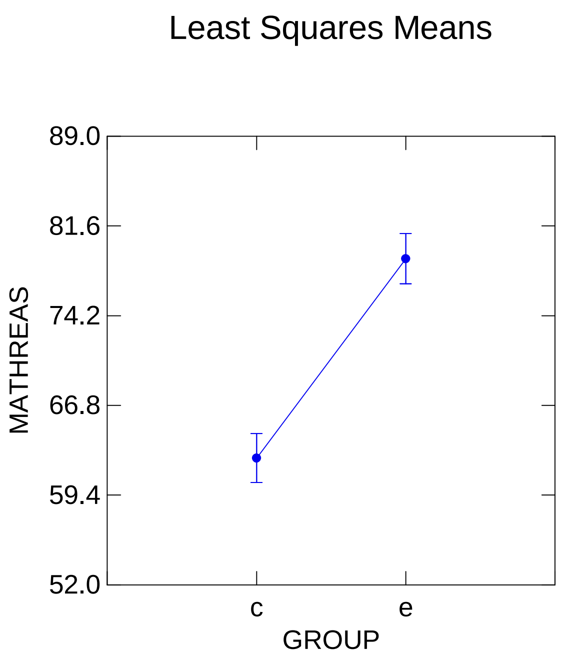

```
--------------------------------------------------------------------------------
 *** WARNING ***
Case            69 is an outlier        (Studentized Residual =       -3.576)

Durbin-Watson D Statistic     1.745
First Order Autocorrelation   0.097
```

8. Analyses of covariance for subtests.

Mathematical Reasoning

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: MATHREAS   N: 91   Multiple R: 0.679   Squared multiple R: 0.461

                              Analysis of Variance

Source              Sum-of-Squares   df  Mean-Square     F-ratio       P

GROUP$                   6002.859     1     6002.859      31.957       0.000
PRETEST                 10218.959     1    10218.959      54.402       0.000

Error                   16530.115    88      187.842
 -------------------------------------------------------------------------------
-
 Adjusted least squares means.
                           Adj. LS Mean           SE       N
```

GROUP$	=c	62.454	2.011	47
GROUP$	=e	78.901	2.079	44



```
Durbin-Watson D Statistic     1.632
First Order Autocorrelation   0.159
```

Number and numeration

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
c, e

Dep Var: NUMER   N: 91   Multiple R: 0.668   Squared multiple R: 0.446

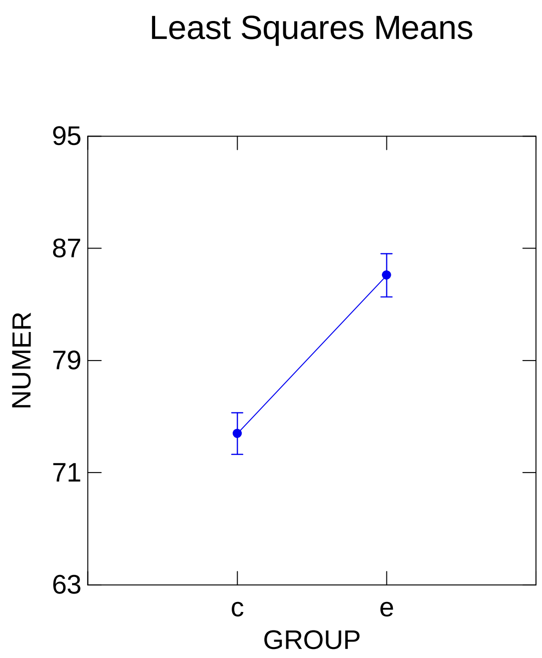
Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GROUP$	2824.131	1	2824.131	27.607	0.000
PRETEST	5443.728	1	5443.728	53.215	0.000
Error	9002.073	88	102.296		

Adjusted least squares means.

		Adj. LS Mean	SE	N
GROUP$	=c	73.798	1.484	47

GROUP$	=e	85.079	1.534	44



Durbin-Watson D Statistic   1.583
First Order Autocorrelation   0.178

Operations

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: OPERS   N: 91   Multiple R: 0.634   Squared multiple R: 0.402

Analysis of Variance

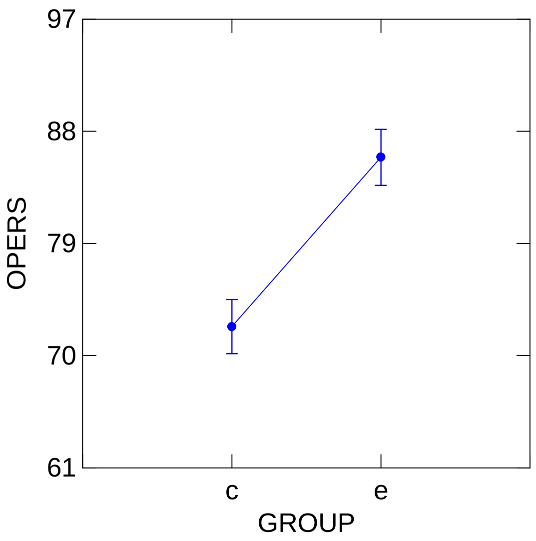
Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GROUP$	4101.606	1	4101.606	18.820	0.000
PRETEST	10481.224	1	10481.224	48.092	0.000
Error	19178.743	88	217.940		

Adjusted least squares means.

	Adj. LS Mean	SE	N

GROUP$	=c	72.328	2.166	47
GROUP$	=e	85.923	2.239	44

Least Squares Means



Durbin-Watson D Statistic	1.481
First Order Autocorrelation	0.221

Modeling/Multiple representation

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
c, e

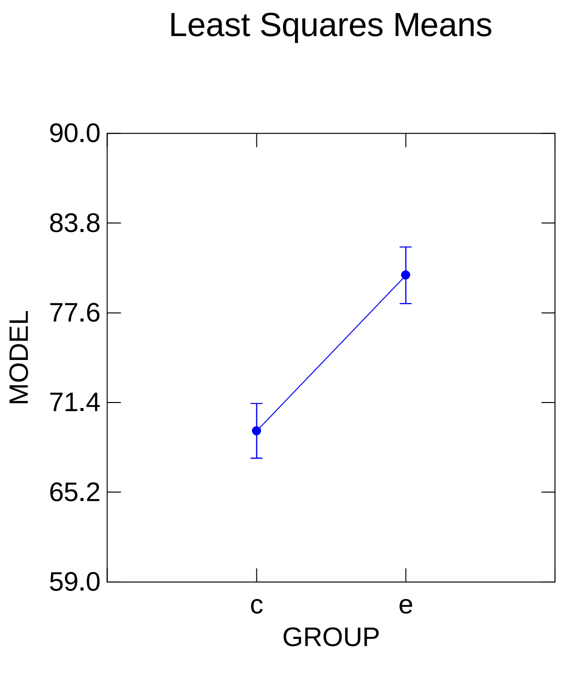
Dep Var: MODEL   N: 91   Multiple R: 0.560   Squared multiple R: 0.314

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GROUP$	2566.149	1	2566.149	15.511	0.000
PRETEST	5038.615	1	5038.615	30.455	0.000
Error	14559.002	88	165.443		

Adjusted least squares means.

		Adj. LS Mean	SE	N
GROUP$	=c	69.438	1.887	47
GROUP$	=e	80.191	1.951	44



Durbin-Watson D Statistic   1.548
First Order Autocorrelation   0.197

Meaurement
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
c, e

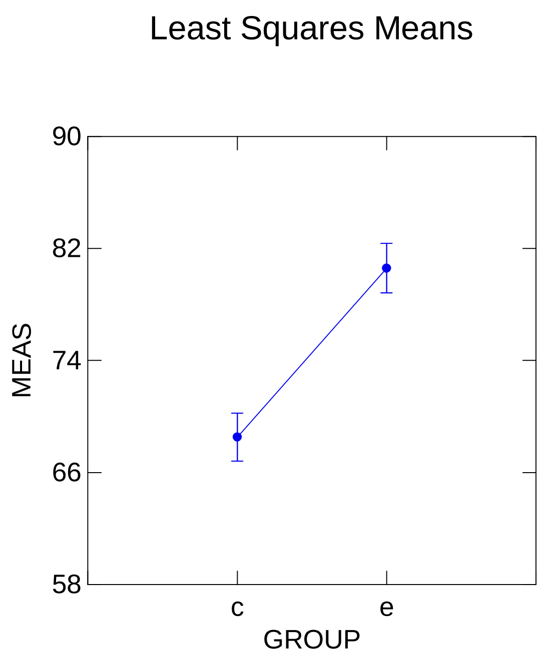
Dep Var: MEAS N: 91 Multiple R: 0.643 Squared multiple R: 0.414

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GROUP$	3229.499	1	3229.499	23.769	0.000
PRETEST	6405.505	1	6405.505	47.144	0.000
Error	11956.617	88	135.871		

Adjusted least squares means.

		Adj. LS Mean	SE	N
GROUP$	=c	68.530	1.710	47
GROUP$	=e	80.593	1.768	44



Durbin-Watson D Statistic 1.454
First Order Autocorrelation 0.234

Uncertainty
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
c, e

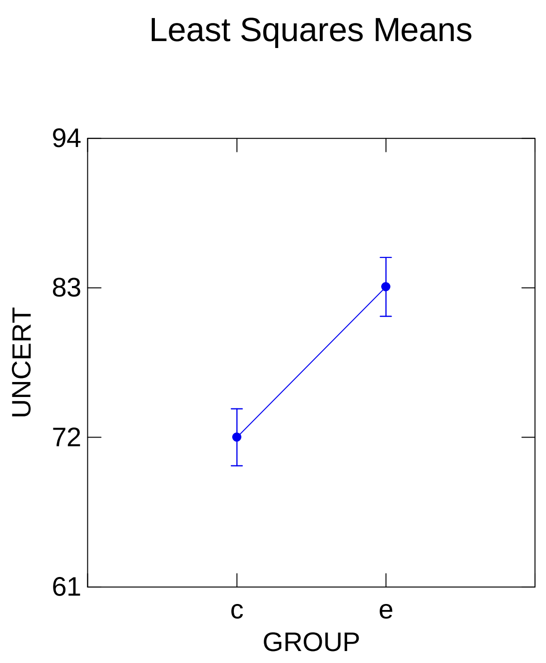
Dep Var: UNCERT   N: 91   Multiple R: 0.655   Squared multiple R: 0.430

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GROUP$	2721.264	1	2721.264	13.372	0.000
PRETEST	12213.705	1	12213.705	60.015	0.000
Error	17908.959	88	203.511		

Adjusted least squares means.

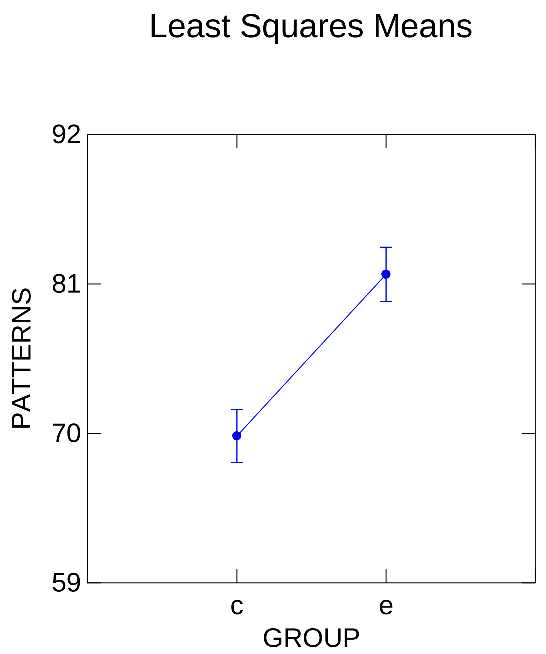
		Adj. LS Mean	SE	N
GROUP$	=c	72.008	2.093	47
GROUP$	=e	83.082	2.164	44



Durbin-Watson D Statistic   1.598
First Order Autocorrelation   0.175

Patterns and functions

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: PATTERNS   N: 91   Multiple R: 0.536   Squared multiple R: 0.287

                             Analysis of Variance

Source              Sum-of-Squares   df  Mean-Square     F-ratio       P

GROUP$                   3145.400     1     3145.400      18.153       0.000
PRETEST                  3915.930     1     3915.930      22.600       0.000

Error                   15247.829    88      173.271
-------------------------------------------------------------------------------
Adjusted least squares means.
                           Adj. LS Mean           SE       N
  GROUP$      =c                  69.804        1.931      47
  GROUP$      =e                  81.709        1.997      44
-------------------------------------------------------------------------------
```

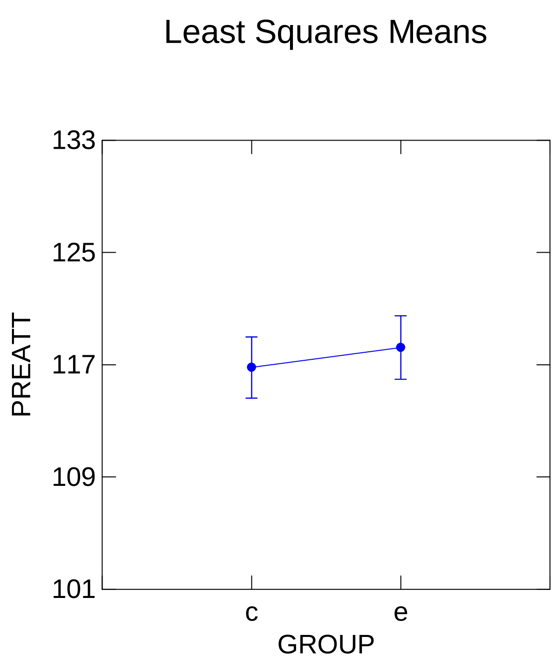



```
-------------------------------------------------------------------------------
*** WARNING ***
Case              69 is an outlier        (Studentized Residual =       -4.374)
```

```
Durbin-Watson D Statistic     1.776
First Order Autocorrelation   0.083
```

9. Preattitude analyses. There is no difference between the two groups.

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: PREATT   N: 91   Multiple R: 0.048   Squared multiple R: 0.002

                            Analysis of Variance

Source              Sum-of-Squares   df  Mean-Square     F-ratio       P

GROUP$                     45.743     1       45.743       0.205       0.652

Error                   19901.004    89      223.607
-------------------------------------------------------------------------------
Least squares means.
                                   LS Mean           SE       N
  GROUP$      =c                    116.809        2.181      47
  GROUP$      =e                    118.227        2.254      44
-------------------------------------------------------------------------------
```

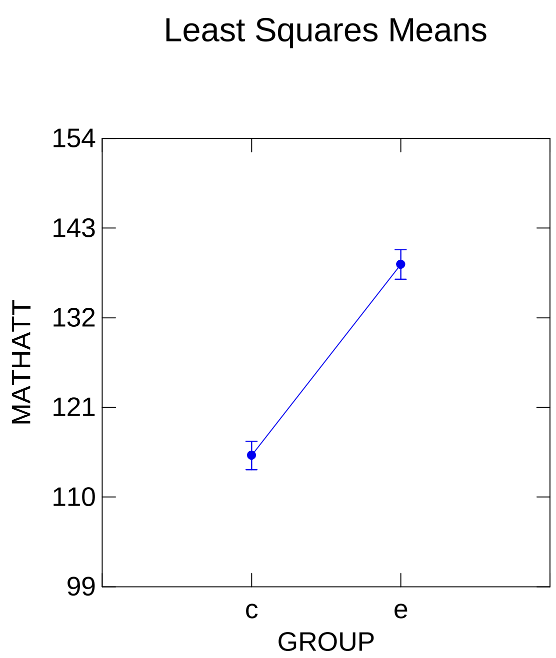



```
-------------------------------------------------------------------------------
 *** WARNING ***
Case           35 is an outlier        (Studentized Residual =       -3.457)
Durbin-Watson D Statistic     1.489
```

```
First Order Autocorrelation   0.253
```

10. **Math attitude analyses. ANOVA. The E. nopi group has significantly higher scores.**

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: MATHATT   N: 91   Multiple R: 0.703   Squared multiple R: 0.494


                             Analysis of Variance

Source              Sum-of-Squares   df  Mean-Square     F-ratio       P

GROUP$                  12485.040     1    12485.040      87.059       0.000

Error                   12763.377    89      143.409

-------------------------------------------------------------------------------

Least squares means.
                                LS Mean           SE      N
  GROUP$      =c                 115.106         1.747     47
  GROUP$      =e                 138.545         1.805     44
-------------------------------------------------------------------------------
```



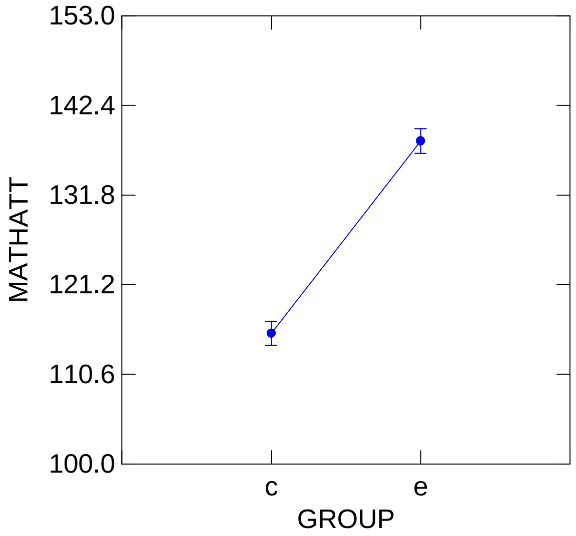

```
-------------------------------------------------------------------------------
```

```
*** WARNING ***
Case           35 is an outlier        (Studentized Residual =       -3.655)
Durbin-Watson D Statistic     1.908
First Order Autocorrelation   0.046
```

11. **Math attitude analyses with preattitude as covariate. The E. nopi group has higher scores.**

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
GROUP$ (2 levels)
   c, e

Dep Var: MATHATT   N: 91   Multiple R: 0.822   Squared multiple R: 0.675

                             Analysis of Variance

Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

GROUP$                 11745.011     1    11745.011     125.997       0.000
PREATT                  4560.285     1     4560.285      48.921       0.000

Error                   8203.092    88       93.217
-------------------------------------------------------------------------------
Adjusted least squares means.
                           Adj. LS Mean           SE      N
  GROUP$      =c                 115.435        1.409      47
  GROUP$      =e                 138.195        1.456      44
-------------------------------------------------------------------------------
```

Least Squares Means




```
--------------------------------------------------------------------------------
Durbin-Watson D Statistic     1.886
First Order Autocorrelation   0.056
```

Preliminary considerations

NYS scores are approximately normal by teacher and by year.
Variances are homogeneous.
Teachers 1 and 2 are E.nopi teacher, Miss Fisher.

ANOVA by teacher and year

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
YEAR (2 levels)
       2002-2003,     2003-2004
TEACHNUM (5 levels)
          1,        2,        3,        4,        5

Dep Var: NYS   N: 210   Multiple R: 0.210   Squared multiple R: 0.044
```

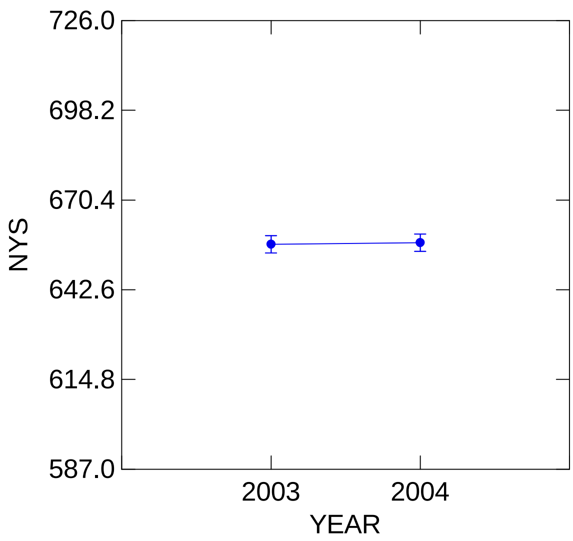
Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	14.901	1	14.901	0.020	0.888
TEACHNUM	4050.284	4	1012.571	1.349	0.253
YEAR*TEACHNUM	2677.302	4	669.326	0.892	0.470
Error	150145.553	200	750.728		

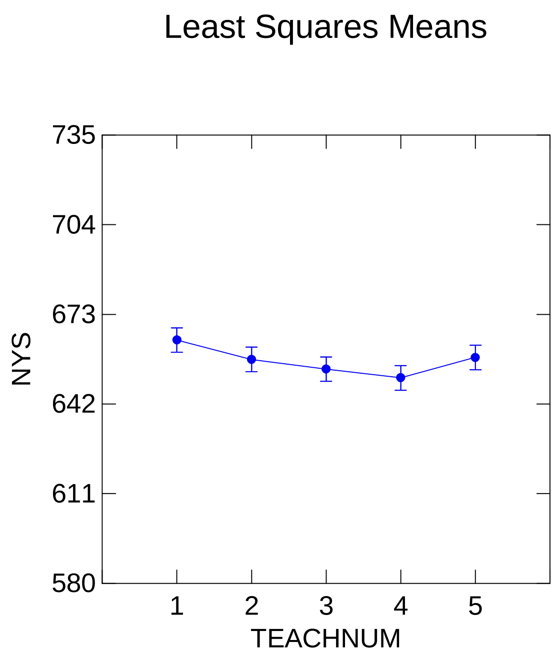
Least squares means.

		LS Mean	SE	N
YEAR	=2003	656.674	2.688	104
YEAR	=2004	657.207	2.664	106

Least Squares Means

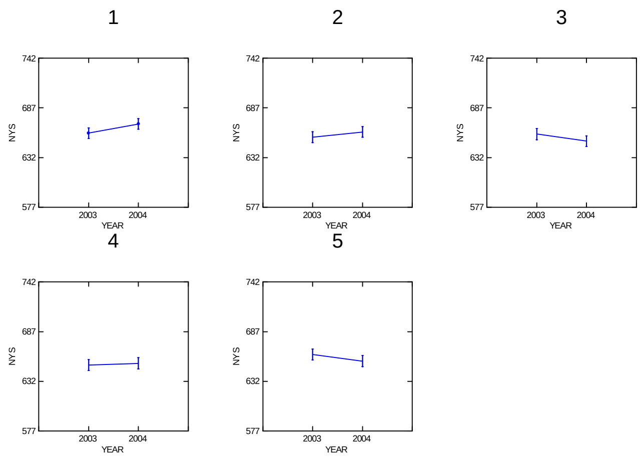


TEACHNUM	=1	664.114	4.180	43
TEACHNUM	=2	657.411	4.233	42
TEACHNUM	=3	654.043	4.233	42
TEACHNUM	=4	651.046	4.280	41
TEACHNUM	=5	658.089	4.233	42



YEAR	=2003			
TEACHNUM	=1	659.000	5.979	21
YEAR	=2003			
TEACHNUM	=2	654.550	6.127	20
YEAR	=2003			
TEACHNUM	=3	657.950	6.127	20
YEAR	=2003			
TEACHNUM	=4	650.143	5.979	21
YEAR	=2003			
TEACHNUM	=5	661.727	5.842	22
YEAR	=2004			
TEACHNUM	=1	669.227	5.842	22
YEAR	=2004			
TEACHNUM	=2	660.273	5.842	22
YEAR	=2004			
TEACHNUM	=3	650.136	5.842	22
YEAR	=2004			
TEACHNUM	=4	651.950	6.127	20
YEAR	=2004			
TEACHNUM	=5	654.450	6.127	20

Least Squares Means



Durbin-Watson D Statistic 1.958
First Order Autocorrelation 0.009

ANOVA by group and year

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
YEAR (2 levels)
2003, 2004
GROUP$ (2 levels)
control, enopi

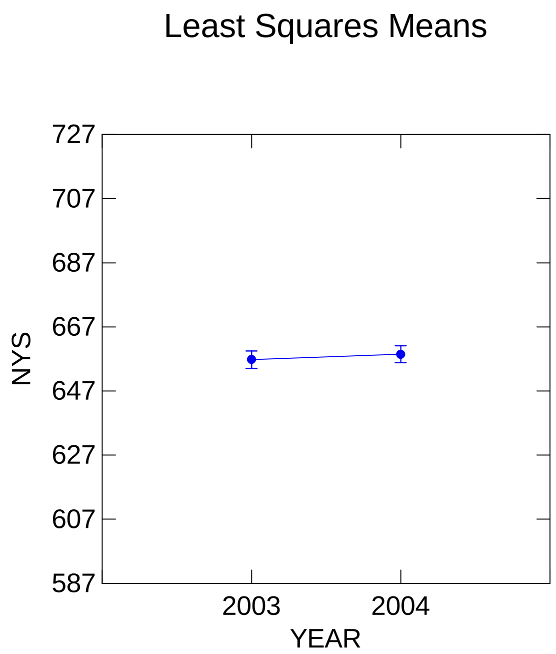
Dep Var: NYS N: 210 Multiple R: 0.162 Squared multiple R: 0.026

Analysis of Variance

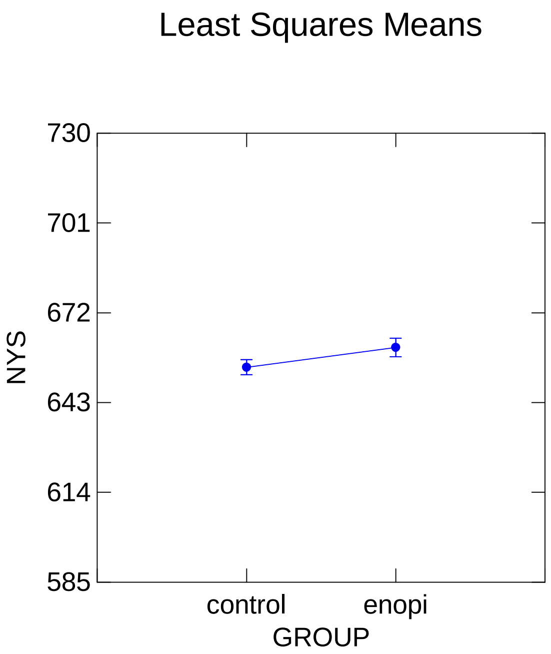
Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	143.283	1	143.283	0.193	0.661
GROUP$	2070.692	1	2070.692	2.790	0.096
YEAR*GROUP$	1966.808	1	1966.808	2.650	0.105
Error	152916.265	206	742.312		

Least squares means.

		LS Mean	SE	N
YEAR	=2003	656.748	2.733	104
YEAR	=2004	658.431	2.685	106

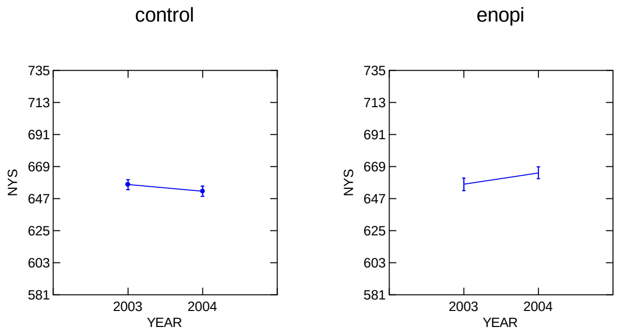


GROUP$	=control	654.390	2.437	125
GROUP$	=enopi	660.790	2.957	85



```
YEAR         =2003
  GROUP$       =control          656.667        3.433       63
YEAR         =2003
  GROUP$       =enopi            656.829        4.255       41
YEAR         =2004
  GROUP$       =control          652.113        3.460       62
YEAR         =2004
  GROUP$       =enopi            664.750        4.107       44
-------------------------------------------------------------------------------
```

Least Squares Means




```
-------------------------------------------------------------------------------

Durbin-Watson D Statistic     1.940
First Order Autocorrelation   0.017
```