

Math Understanding through the Science of Life (MUSCLE)

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Abstract

MUSCLE is an academic enhancement program partnering Duke University's Pratt School of Engineering, Lakewood Elementary School and Rogers-Herr Middle School in Durham, NC. The mission of this program is to promote a passion for understanding and applying math in elementary and middle school students through its application to the science of life. Another goal of the MUSCLE program is to increase Math End-of-Grade (EOG) scores and sustain a high level of math achievement. A specific emphasis is on fostering this passion for math in under-represented minorities. This mission is being realized through multiple program facets including the placement of undergraduate engineering students (GE Engineering Teaching Fellows ETFs) at our partnership schools. The GE ETFs spend 10 hours per week at their partnership school helping teachers develop and execute hands-on activities that integrate meaningful math exercises into the life sciences. The GE ETFs act as role models and sources of expertise in the application of mathematics to fascinating problems in life sciences. This paper summarizes the outcomes and gains made after the first year of the MUSCLE program for the 2001-2002 school year. To date 495 students were served at the middle school and 206 students at the elementary school. Data was collected in the form of teacher, student, and fellow surveys at the beginning and end of the school year to assess the impact of providing hands-on activities in teaching math integrated into a rich life sciences curriculum. We show through statistical measures that improvement in math EOG test scores are significantly greater in classes served by the GE ETFs.

Purpose and basis of study

The vast majority of African American and female students in the inner city schools never make it to taking algebra in the 8th grade. As a result many doors are closed to them in the fields of math, science and technology. It is top priority of the Durham Public Schools to have every student take and pass Algebra by the end of the 8th grade. Unfortunately the students arrive at 6th grade so far behind that it is very difficult for the middle schools to catch them up in time. By starting to accelerate learning in the 3rd, 4th, and 5th grade, and by reinforcing this knowledge in middle schools, we will ensure that the students have every opportunity to pursue a wider range of academic options. In addition there is a high correlation between what children say they like and what they seem themselves as "being good at"^{6,7,17} and children often turn away from math because it is "too hard"^{8,9}. Mathematics has traditionally been taught as a discrete topic.^{1,3,4,5} This can result in children viewing math as a subject separate from other subjects and something to be avoided. It is the goal of MUSCLE to integrate math into all areas of the North Carolina

Standard Course of Study with an emphasis on the life sciences in order to provide meaningful and engaging contexts for learning mathematical concepts by capitalizing on children's natural affinity for plants and animals. It was predicted that teaching mathematics in this hands-on integrated way over the course of this 3 year program would contribute to an increase in the North Carolina Standardized End-of-Grade (EOG) Math Test Scores, an increase in self-reports among children and adolescents of enjoyment of math and science, an increase of self-report in being good in math and science, an increase in viewing math as important to everyone's life, an increase in self-report of a wish to work in a career in math or science, an increase in a wish to do more math, and an increase in the percentage of students eligible to take Algebra by the 8th grade.

Program description

For the 2001-02 school year MUSCLE placed 12 undergraduate Engineering Teaching Fellows from the Pratt School of Engineering in Lakewood Elementary School and Rogers Herr Middle School. These schools were selected as partnership schools since one of the goals of this project was to have a specific focus on fostering an interest in math for underrepresented minority students and each school has a predominantly African-American population. The majority of teaching fellows were also African-American. Fellows assisted teachers in developing and carrying out hands-on learning projects that integrated math into all areas of the curriculum but with a particular emphasis on life sciences. The fellows taught in ways that were fun and exciting to the students and were geared to showing students that math is in everything we do. Teachers and students at Lakewood Elementary School have built a greenhouse and outdoor garden in which they grow flowers and vegetables. The students take pride in their garden and were able to measure plant growth rates, plot this data, and learn probability by tracking characteristics of parent plants and their offspring. A similar program called the Nature Trail exists at Rogers-Herr Middle School. The Nature Trail program also includes raising vegetables and other plants in a school greenhouse followed by subsequent transplantation into one of several gardens. A favorite activity at Lakewood run by the teaching fellows was a problem-solving club where fellows led students in hands-on problem solving which required increasing skills in abstract thinking. Fellows at Rogers-Herr Middle School integrated hands-on lessons into the NC. Standard Course of Study of plate tectonics, for example, by illustrating differences in ductile vs. brittle materials utilizing pretzels vs. tootsie rolls, etc and observing and recording what happened when these materials were compressed or twisted. For an extensive description of the MUSCLE program see Ybarra et al, 2002.¹⁷

Original baseline (status before the program began) and predicted outcomes

Actual End-of-Grade Math Test Scores (%proficiency) for Lakewood (Grades 3-5) and Rogers-Herr (Grades 6-7)					Predicted EOG Scores after MUSCLE		
Grade	1997-98	1998-99	1999-2000*	2000-2001	2001-02	2002-03	2003-04
3	17.8	48.4	53.6	64.3	65.0	74.0	81.0
4	53.8	58.7	64.3	97.0	69.4	75.0	81.0
5	57.1	60.5	55.6	71.4	60.0	64.8	70.0
6	67.0	72.2	72.0	86.7			

7	n/a	n/a	n/a	77.3
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*Note: These 1999-2000 EOG scores were the baseline used in the original proposal as they were the most recent scores available at the writing of the proposal. The predictions made in the original proposal were based on these 1999-2000 scores and are described in the next section. However since the writing of the proposal the 2000-2001 EOG percent proficiency scores were released and are therefore listed above. A revised mathematics EOG test was administered in North Carolina in the spring of 2001 based on a new curriculum in teaching mathematics.

After pulling up the End of Grade Math (EOG's) % proficiencies (passing) from 17.8% in 1998 to 53.6% in 2000 there was minimal significant upward change in Math EOG scores at Lakewood Elementary until 2001 when the Math EOG scores increased dramatically after the renorming of the N.C. Standardized End of Grade Math Test in the spring of 2001 based on a new curriculum in teaching mathematics. Fortunately this revision occurred in the spring of 2001 so we can use the 2000- 2001 baseline data for comparison with the spring 2002 EOG scores since the MUSCLE program was implemented during the 2001-02 school year. Our original predictions based on the 1999-2000 End of Grade Math scores were that by the end of the first year of the MUSCLE program (Spring 2002), the Math EOG scores for 3rd grade would increase to 65% passing, 69.4% passing for 4th grade, and 60% passing for 5th grade.

Our target goals for our middle school partnership were in the area of percent of 8th grade students eligible to take Algebra by fall of 2002. For the 2000 school year only 14 % of the rising 8th graders at Rogers Herr Middle School were eligible to take Algebra. Until 2000-01 there was no 7th grade at Rogers-Herr, and an 8th grade was added for the school year 2001-02. For the first year of the MUSCLE program we predicted an increase from 14% rising 8th graders eligible to enroll in Algebra to 20% by fall of 2002, 35% for 2003, and 50 % by 2004.

For the goal of increasing students' interest in math, no baseline math survey data was available prior to the inception of the MUSCLE program. Since we were unable to administer Students Surveys until approval for the research protocol was received from the public school system, student surveys assessing interest in and enthusiasm for math were administered in the Spring of 2002 only and will serve as a statistical baseline comparison for future years of the MUSCLE program to assess whether or not students with increasing amounts of exposure to the teaching fellows score higher on ratings of interest, enthusiasm and intent to pursue a career in math. The results of these preliminary surveys will be reported here as an indication of students' attitudes towards math at the end of this first year of the MUSCLE program.

In addition we administered Teacher Year-End Surveys to assess impact and satisfaction of the teaching fellows' performance and Fellows Exit Surveys which provided the teaching fellows an opportunity to give feedback on their views of the impact of the MUSCLE program on students, teachers and the fellows' attitudes towards future in teaching. Outcome measures included for the purposes of this first year of the MUSCLE program are:

I. North Carolina Standardized End of Grade (EOG) test scores

II. Student Interest Surveys for Math (assesses students' enjoyment, feelings of competence, and interest in a career in math)

III. POST Teacher Survey on Fellows Performance (provides feedback on helpfulness of Fellows and impact of their teaching strategies/ideas on teachers and students)

IV. **Fellows Exit Surveys** (provides fellows opportunity to give feedback on their views of the impact of the MUSCLE program on students, teachers and their attitudes towards future teaching).

Outcomes

<u>Actual End-of-Grade Math Test Scores (%proficiency) for</u> <u>Lakewood (Grades 3-5) and Rogers-Herr (Grades 6-8)</u>				<u>Predicted EOG Scores</u> <u>after MUSCLE</u>		
Grade	1999-2000	2000-2001	2001-2002	2001-02	2002-03	2003-04
3	53.6	64.3	43.2	65.0	74.0	81.0
4	64.3	97.0	100	69.4	75.0	81.0
5	55.6	71.4	90.6	60.0	64.8	70.0
6	72.0	86.7	84.5			
7	n/a	77.3	87.6			
8			80.0			

Although our predicted increase for Math EOG scores was in the 60's for percent proficiency (passing) for Lakewood Elementary School, the scores for this Spring 2002 for grades 3-5 at Lakewood were in the 90's to 100% vastly exceeding our predicted target goals with the exception of 3rd grade at Lakewood.

It should be noted that with the new norming of the Math EOG test in the Spring 2001, the new statewide math curriculum begun for the academic year 2000-2001, and whatever other factors entered into the increase from Spring 2000 to Spring 2001, there was already an upward trend in place at this school before the MUSCLE program began there. Even so the percent proficiency increased from 97% to a stunning 100% for grade 4 and from 71.4% to a stellar 90.6% for grade 5 from Spring 2001 to Spring 2002, the first year of the MUSCLE program. As noted many factors at this school could have contributed to this increase in math EOG scores. Therefore to further assess the impact of having teaching fellows assigned to specific classes, t-tests were computed to assess the significance of difference in change scores (Spring 2002 Math EOG Scale Score - Spring 2001 Math EOG Scale Score=change score) for classes that had teaching fellows (ETFs) assigned Spring semester 2002 versus a control group of a same grade class that did not have fellows assigned to teach for Spring semester 2002. Separate t-test were computed to evaluate whether or not there was significant difference in the amount of improvement made on Math EOG scores between classes with fellows and classes without teaching fellows for Spring 2002. At Lakewood these analyses of change scores were computed only for grades 4 and 5 since grades 3 and lower did not have EOG Math Scores for the previous year since EOGs are not administered in North Carolina until students are in third grade. Results of these analyses follow:

Comparison of Classes With and Without Teaching Fellows for Change Scores for Math EOG
Scale Scores, Spring 2002 for Lakewood Elementary School

Teaching Condition	N	Mean Change Score	Standard Deviation	t value	probability
Classes with Fellows (Grades 4 & 5 combined)	24	12.58	22.45	-3.93	p< .0002
Classes without Fellows (Grades 4 & 5 combined)	55	-1.16	8.77		
Class with Fellows (Grade 4)	10	14.5	4.20	-3.08	p< .0064
Class without Fellows (Grade 4)	10	8.7	4.22		
Class with Fellows (Grade 5)	14	11.21	29.57	-1.47	p< .1528
Class without Fellows (Grade 5)	16	0.1875	5.17		

Based on comparison of change scores between combined 4th and 5th graders of classes with teaching fellows and those without teaching fellows, the classes with teaching fellows made significantly more improvement on their Math EOG tests from the spring of 2001 to spring 2002 (p< .001). When change scores were compared for 4th graders who had teaching fellows for spring 2002 with 4th graders who did not have teaching fellows assigned to their class, those with teaching fellows assigned to their class also made significantly more improvement on the average than 4th graders without teaching fellows (p< .01). Examination of change score comparison between 5th graders who had teaching fellows assigned to their class with 5th graders who did not have teaching fellows assigned to their class showed a higher mean change score for those with teaching fellows but this score was not statistically significant. Therefore if taken as a combined group, 4th and 5th grade students with teaching fellows assigned to their classes made significantly greater increases in their Math EOG scores than those without teaching fellows assigned to their classes. Due to the small sample size involved in this study, it would be important to replicate these same analyses next year. (Note: These same analyses of change scores as described above will also be computed for grades 6-8 at Rogers-Herr Middle School at a later date due to a school based delay in getting the Math EOG scores from this middle school in time for this current analysis.)

It is further noted that the Percent of Students at Rogers-Herr Middle School who are eligible for Algebra for the fall of 2002 is 25%, representing an increase from 14% at baseline. This increase

in percentage from 14% to 25% exceeds our predicted increase by 5% after only one year of having MUSCLE fellows participating in teaching hands-on mathematics in this partner school.

Results of Student Surveys (Lakewood Elementary)

At the end of this first school year of the MUSCLE program the majority of students in the MUSCLE program at Lakewood Elementary answered the Math Survey positively indicating that they like math, feel they are good in mathematics, feel math is important to everyone's life, would like a job involving using math, and would enjoy doing more math. The results of the Math Surveys follow. (Note: these data are reported separately for K-3 and grade 4 as the Math Survey has 2 forms- one for grades K-3 and the other for grades 4-8). At the time of this analysis, data was available for Lakewood Elementary only.

Percentages of Students Answering Yes or No at Lakewood Elementary School After One Year of the MUSCLE Program to Student Interest Survey

MATH SURVEY K-3

1. I like mathematics.	YES-94.7%	NO-5.26%
2. I am good in mathematics.	YES-73.7%	NO-26.3%
3. Mathematics is important to everyone's life.	YES-76.3%	NO-23.6%
4. I would like a job that involved using mathematics.	YES-60.5%	NO-39.5%
5. Would you enjoy doing more math?	YES- 83.8%	NO-16.2%

Percentages of 4th Grade Students answering in Each Category of Agreement at Lakewood Elementary

MATH SURVEY GRADE 4

	Strongly Agree	Agree	Disagree	Strongly Disagree
1. I like mathematics.	A- 82%	B-18%	C-0%	D-0%
2. I am good in mathematics.	A- 45%	B- 55%	C- 0%	D- 0%
3. Mathematics is important to everyone's life.	A- 55%	B-18%	C -18%	D- 9%
4. I would like a job that involved using mathematics.	A-55%	B-45%	C- 0%?	D- 0%

5. How often do you use math?

100% Every Day ___ Every Week ___ Every Month ___ One Or Two Times A Year

6. Would you enjoy doing more math? 18% No 81% Yes

Findings from teacher end of year surveys

At the end of the first year of the MUSCLE program (Spring 2002), teachers who had fellows assigned to their classes at Rogers-Herr Middle School and Lakewood Elementary School were given end of year surveys. The questions listed below are all of the questions on the surveys on which the teachers could quantitatively rank the fellows performance on a scale of 1 to 5. At Lakewood Elementary and at Rogers-Herr 4 of the 5 teachers for whom fellows were assigned to their classes returned their end of year surveys in time for this analysis. The average rating across fellows by these teachers at Lakewood Elementary was 4.8 (where as a 5 was the highest rating on each question possible) and for Rogers Herr 4.0 indicating that on the average, the teachers gave the fellows excellent ratings on the performance criterion listed below. The majority of ratings on all items were 4's or 5's with the exception of only 2 items for both schools. These items were items #17 and #18 suggesting that that the teachers were neutral with respect to feeling that the fellows enhanced their content knowledge and exposed them to real world applications though they ranked the fellows extremely high with regard to giving them new ideas for hands on teaching activities.

FELLOW'S PERFORMANCE

	Strongly DISAGREE	Disagree	Neutral	Agree	Strongly AGREE
4. Fellow assumed responsibility for planning and executing lessons to my satisfaction.	1	2	3	4	5
5. The overall interaction capitalized on the Fellow's strengths and expertise.	1	2	3	4	5
6. Topics were presented by the Fellow and the teacher as a team.	1	2	3	4	5
7. Presentations covered what I intended.	1	2	3	4	5
8. Material presented was age-appropriate.	1	2	3	4	5
9. Fellow communicated well with the students.	1	2	3	4	5
10. The Fellow improved his/her communications skills in the course of our partnership.	1	2	3	4	5
11. The Fellow responded favorably to suggestions I have made regarding their teaching methods and effectiveness.	1	2	3	4	5
12. Amount of hands-on activities was					

appropriate for the lessons taught.	1	2	3	4	5
13. Students looked forward to/were enthusiastic about visits by Fellows.	1	2	3	4	5
14. Positive image of science and math was presented	1	2	3	4	5
15. I will use ideas gained from my interaction with Fellows in future teaching.	1	2	3	4	5
16. As a result of our interaction, Fellow has benefited for future teaching situations.	1	2	3	4	5
17. Our interaction was beneficial to me in:					
-Enhancing my content knowledge	1	2	3	4	5
18. -Giving me new activity ideas	1	2	3	4	5
19. -Exposing me to real world applications	1	2	3	4	5

Findings from Fellows End of Year Surveys

At the end of the school year, all fellows who taught for the Spring 2002 semester were given exit surveys to convey their impressions of the program and their recommendations for any changes needed. The questions listed below are all of the questions from the fellow surveys that could be ranked quantitatively. The average rating across fellows for Lakewood Elementary for all survey questions was 3.8 at Lakewood Elementary and 3 for Rogers-Herr. Examination of fellows' responses by individual questions indicated that fellows were most satisfied, on the average, with communications with the teachers, feeling that their classroom communication skills improved over the year, feeling the teacher provided adequate direction for planning and executing lesson plans, feeling the classroom experience capitalized on their strengths, feeling the teacher offered helpful advice regarding teaching methods, classroom management, age-level appropriateness, and feeling that they learned effective styles of classroom management. For Lakewood only the fellows strongly agreed that the weekly fellow meetings were helpful. As a group fellows did not feel that administrative expectations regarding their assignments were made clear to them initially. All fellows completing surveys indicated that this experience will motivate them in the future to be an advocate for schools in their community, all stated that at the end of their fellowship they had a better understanding of issues regarding K-12 education, and all said they would recommend participation in this program to upcoming engineering students.

Fellows Exit (End of Year) Survey

Please rate your experience with the teacher and students. We strongly encourage you to elaborate on the back of the sheet to provide fuller responses to any of the questions.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly AGREE
1. The teacher provided adequate direction for planning and executing lessons.	1	2	3	4	5
2. Teacher was actively involved either in planning or executing lessons.	1	2	3	4	5

3. I was satisfied regarding communications with the teacher(s).	1	2	3	4	5
4. The classroom experience capitalized on my strengths and expertise.	1	2	3	4	5
5. My classroom communication skills improved over the course of the year.	1	2	3	4	5
6. The teacher offered helpful advice regarding teaching methods, classroom management, age-level appropriateness.	1	2	3	4	5
7. My understanding of science and math outside my field of expertise improved over the course of the year.	1	2	3	4	5
8. I learned some effective styles of classroom management.	1	2	3	4	5
13. Expectations regarding my assignment were made clear to me. Comment:	1	2	3	4	5
14. The teacher's expectations of my role matched those of the Teaching Fellows Program.	1	2	3	4	5
15. I was adequately supported in obtaining materials.	1	2	3	4	5
16. The work load was reasonable.	1	2	3	4	5
17. I was given adequate training in preparing for my classroom experience.	1	2	3	4	5
18. The weekly meetings were helpful.	1	2	3	4	5
19. There was beneficial exchange of ideas among the fellows.	1	2	3	4	5
20. The Teaching Methods Training was helpful.	1	2	3	4	5

Summary and conclusion

To date the MUSCLE program, partnering Duke teaching fellows with two local schools serving primarily African-American students, has served 495 students for the 2001-02 year at Rogers-Herr Middle School and 206 students for the 2001-2002 school year at Lakewood Elementary School. The program focuses on integrating math into all areas of the curriculum, particularly the life sciences and is designed to engage children in meaningful, hands-on learning activities to inspire and help them experience and "feel" math in their lives and in the world around. After only one year of the program, our predictions of increases in End-of-Grade test scores at both partner schools have been met or exceeded, with the exception of the 3rd grade class at the elementary school. When classes of 4th and 5th graders taught by fellows were compared with classes not taught by Duke teaching fellows, students assisted by teaching fellows made significantly more gains ($p < .01$) on the N.C. Standardized End-of-Grade Math test. Percent of

students eligible to enter Algebra in the 8th grade for the Fall of 2002 increased from 14% to 25% after just one year of this teaching partnership. At a more qualitative level, the fellows were met with enthusiasm and excitement by the children and adolescents, the majority of whom expressed an enjoyment of math and interest in pursuing a job involving mathematics and many of whom asked to visit Duke on field trips and learn more about Engineering and university life. The teaching fellows were highly regarded by their partner teachers as evidenced by high ratings on teacher end of year surveys and informal feedback to the program evaluator. Many stated their intent to use lesson plans developed by teaching fellows for future classes. All teaching fellows completing surveys indicated that this experience will motivate them in the future to be an advocate for schools in their communities, all stated that at the end of their fellowship they had a better understanding of issues regarding K-12 education, and all said they would recommend participation in this program to upcoming engineering students. Web sites are being developed to make available the creative lesson plans of these fellows. End of year program evaluations will continue for the 2002-2004 school years.

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