

## **MUSCLE: Math Understanding through the Science of Life**

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MUSCLE: Math Understanding through the Science of Life is a K-8 academic enhancement program funded by the GE Fund. This program partners the Pratt School of Engineering at Duke University with two schools in the Durham County, NC Public School System (Lakewood Elementary School and Rogers-Herr Middle School). The mission of MUSCLE is to capitalize on children's natural affinity for plants and animals to provide meaningful contexts for learning mathematical concepts. Mathematics in K-8 has been taught traditionally as a discrete topic with contexts fabricated to provide illustrations of applications<sup>1,3,4,5</sup>. This causes children to view math as a subject separate from other subjects and something that can be avoided. Many children develop negative attitudes toward math at early ages. They see math as being too difficult and develop the attitude that they are not good at it. There is high correlation between what children say they like and what they see themselves as "being good at"<sup>6,7</sup>, and children often turn away from math because it is "too hard"<sup>8,9</sup>. The goal of MUSCLE is to integrate math into all areas of the North Carolina Standard Course of Study<sup>1</sup> with emphasis on the life sciences in order to provide meaningful and engaging contexts for learning mathematics.

MUSCLE places 12 undergraduate Engineering Teaching Fellows from the Pratt School of Engineering at our two partnership schools to assist teachers in the creation, development and execution of hands-on learning activities that integrate math into all areas of the curriculum with focus on the life sciences. We strive to show children that math can be fun and exciting, and that math is in everything we do. The teachers and students at Lakewood Elementary School have built a greenhouse and outdoor garden in which they grow vegetables and other plants. All students have a hand in the project and take pride in the plants they grow. The garden project provides us with fertile ground in which to weave the use of math as the universal language of quantification. Children make measurements of plant growth rates and make plots of this data. They learn probability through the law of large numbers by tracking characteristics of parents and their offspring of common garden peas. These are two of many exercises the students perform in the garden.

From the Perspective of the Principal and Curriculum Specialist:

The MUSCLE program brings many exciting possibilities for the students and teachers at Lakewood Elementary School. The five MUSCLE fellows, who each spend 10 hours per week at the school, interact positively with the students. They are excellent role models for the students and even the most reluctant learner is excited about learning math and science with the fellows, particularly since the focus is hands-on. The MUSCLE program has also provided resources

including computer hardware, software, and other electronic devices, resources that the school could not have purchased on its own.

Academically, the fellows are able to target specific skills that students have not mastered. At the end of each nine-week grading period, students take benchmark tests that measure their mastery of specific goals and objectives in reading and math. Class data sheets, as well as individual student data sheets, indicate which goals and objectives students need additional support to attain. For example, a third grade class's benchmark scores may indicate they need targeted instruction with measurement. This type of information allows the MUSCLE fellows to focus their efforts and help students gain mastery through hands-on activities.

Teachers are starting to view the MUSCLE fellows as support for their instructional program. Initially, teachers expressed some reservations, fearing that working with the fellows would mean additional work for them. However, they have found that the fellows provide valuable information and fresh insight when planning lessons for math and science. Teachers have also been more willing to integrate science lessons with math and reading.

One of the major challenges of MUSCLE program has been to find a good match between the fellows and teachers. Initially, each fellow was assigned to work with several teachers, and the group of fellows worked with every teacher in the school. We found that this spread the fellows too thinly as they were not spending enough time with any one teacher. Now each fellow works with only one teacher, and this works very well. One of the factors influencing the match between fellows and teachers is their personality. By having the fellows work with several different teachers initially, we were able to determine the best compatibility. Initially, many of the teachers were intimidated by the "engineering" students. But now a mutual respect has developed between the teachers, fellows and Lakewood students. The fellows bring enthusiasm and technical expertise while the teachers bring experience and expectations and the children bring wonderment and curiosity. Together they are defining the partnership and creating innovative ways to integrate math into the science of life.

Although the MUSCLE program has been a part of Lakewood for only four months, the impact is already visible. Students and teachers are excited about science and its integration. We look forward to even greater possibilities as the fellows target specific grade levels for the second semester and help to plan field trips and interdisciplinary units with teachers and students.

From the perspective of one of the MUSCLE partnership teachers:

We went on walks in the woods and collected leaves and acorns and examined patterns in them. We also examined the patterns of fruits and vegetables in the school garden. Students learned about squares, triangles and circles. They made comparisons in size and shape. We now have a new member of the class. His name is Wuzzlewump, and he is a Dwarf Hamster. The students measured how far he runs on his wheel each night (9 miles!) and then determined how long it would take Wuzzlewump to run to California and back (almost a year!). The MUSCLE fellows help us create innovative ways to work math into all of our lessons.

From the perspective of the Garden Coordinator:

The garden at Lakewood Elementary School has blossomed into a land of opportunity for the youngsters who attend the school. Designed to encourage participation from teachers, students,

parents, administrators and community partners, the garden offers a unique approach to teaching all school subjects on an experiential level. The garden began with the efforts of a few teachers at the school, with participants in the Duke University Retirees Outreach (DURO) coming on board to provide financial and technical support. After a few years, DURO decided to engage another community organization, SEEDS (South Eastern Efforts Developing Sustainable Spaces) in the project. A grassroots community gardening organization that works with groups to develop sustainable green spaces in their communities, SEEDS helped to expand the garden infrastructure, adding several raised garden beds for teachers and several theme areas such as a butterfly garden. SEEDS coordinators then worked with teachers and students to develop lessons that would integrate the garden into the school's curriculum.

Teachers are encouraged to create vocabulary lists and student journals about experiences of working in the garden. Students themselves have created several garden newsletters that have been circulated throughout the school community. For science class, students have learned all about the needs of plants, sowing seeds in their garden and raising them into maturity. They have learned about and practiced the composting of lunch leftovers as part of ecology lessons. Additionally, they have studied animal habitats, insect ecology, weather and climate and more as the curriculum calls for it in a space designed to make learning these concepts fun and purposeful for the children. Teachers have even taught social studies lessons in the garden- the students learned about the symbolism of quilting during slavery and then were given the opportunity to tell their own stories through the creation of a "garden quilt."

The teachers are supported in the teaching of garden-based lessons at the school through the adoption of the Life Lab curriculum. Life Lab's approach is experiential- integrating life, earth and physical science into a garden context. "Through professional development, instructional materials and technical assistance", Life Lab creates garden-centered science programs that reflect the latest findings in child development and national standards in science.

From the perspective of our Lead Teaching Fellow

The main executors of the MUSCLE program are the undergraduate teaching fellows in conjunction with the teachers. The fellows work hand-in-hand with the teachers to develop creative, hands-on garden activities to introduce, teach, or practice an identified math skill. The fellows are predominantly from under-represented minority groups (10 African-American, 1 Asian, 1 Caucasian) as are the children (97% African-American), pursuing either an engineering, science, or math degree. As engineering, science or math based students, the fellows generally have little to no formal or informal training in education. To formally address this deficit, the fellows are required to attend monthly training sessions given by a team of elementary school science teachers, designed to impart fundamental education concepts to bolster the fellows' teaching skills. The majority of the fellows training, however, occurs informally in the daily interaction with the teachers and students of the school.

At Lakewood Elementary School, the introduction and acclimation of the fellows to the school environment followed a funnel-type model. All 12 fellows were first spread out among every classroom, with each fellow assigned to hour-long sessions in multiple classes in different grade levels. After about 4 weeks, seven of the fellows moved on to Rogers-Herr Middle School leaving five fellows at Lakewood, who will stay for the whole year. These five fellows were then re-distributed once again to cover all classrooms. This initial setup allowed each fellow to gain experience with multiple grade levels, different styles of teaching, and large group (classroom)

interaction. All of the students and teachers were exposed to and gained a basic familiarity with the new program. The fellows also facilitated small (3-4 students) "Strategy Clubs" that focused on problem-solving skills, thus gaining experience with small groups. All students in grades 3-5 participated in the clubs, fostering more intimate relationships between the fellows and these students in the target range of the program. This structure was followed for the duration of the fall term, at the end of which each fellow was permanently assigned to one classroom in grades 3-5, with the exception of one fellow who was assigned to both Kindergarten classes. This first introductory term has been one of experiential learning for the fellows. The semester-long school-wide exposure, though somewhat frustrating in its lack of focus, allowed the fellows to gain an understanding of the dynamics of the entire school structure. This established a level of comfort crucial for the successful execution of the program. Most of the fellows came to the program with an interest in math and a fondness for children, but without a concept of how those would translate into the successful and creative teaching of elementary math skills. The training sessions provided materials and instruction on how to create and structure lessons, but the prolonged school interaction was needed to provide practice in executing the lessons. By working with a wide variety of students the fellows were able to identify their own strengths and weaknesses in terms of different grade levels, genders, and teaching styles. Furthermore, the lack of focus of the first term provided a high level of autonomy for the fellows, thus allowing their first lessons to be mostly individual efforts focusing in areas of their own expertise. With the comfort now gained from this first term, the fellows feel more confident in both their relationships with the teachers and students and access to the school's resources. They now find it easier to create, plan, and execute lessons given general competency goals and/or specific directives from the teachers. Weekly meetings of the fellows provide peer support and a forum to develop and maintain school-wide activities such as the Science Box. The Science Box resides in the school's media center and provides all students and teachers an opportunity to write down a science/math-related question and have it answered by the MUSCLE team.

From the perspective of the Training Workshop Lead Teacher

As the Science Specialist at E.K. Powe, an inner city school in Durham N.C., I have had the opportunity to work with Duke Engineering students. I value their contribution and work in our classrooms. They have a positive impact on our students in both helping them understand scientific concepts and promoting a love for the subject.

As the NSF funded Engineering Teaching Fellows program progressed we began to realize that although the Duke students were prepared to teach scientific concepts and had wonderful ideas for lessons and units of study, they had little if any experience in the classroom. They began asking questions about classroom management and learning styles and shared some of the frustrations new teachers always experience. It was at this time that we began to have discussions about developing workshops that would provide information and support for the Teaching Fellows.

I contacted two teachers at Powe, who have clear expectations for their students and who, because of our ethnicity, would personalize the importance of an opportunity to support the teaching of science and math to minority students. We developed a course outline that would provide information as well as create a forum for support through the use of open discussions. We meet once a month with both the NSF Engineering Teaching Fellows and the GE Fund MUSCLE Fellows. These sessions include: a warm up activity that promotes team-building, information requested from previous sessions which is disseminated and briefly discussed such

as Bloom's Taxonomy and the North Carolina Standard Course of Study, a sample lesson based on inquiry learning as a methodology including a rubric for student assessment, open discussion which often leads to role playing and problem solving, and an evaluation. After each session the other teachers and I meet several times to plan the next workshop.

We adhere to our basic course outline, which leaves room for modification dependent on the needs of the Teaching Fellows. For example, we decided to include a discussion on the impact of school, family and community on a child's ability to learn. We hope to uncover through discussion some of the issues plaguing students in our inner city population. Through the evaluations and our lengthy discussions it is apparent that this particular group of students are determined to use all of the tools provided for them to accomplish their goals and the goals of the program.

Science and Math are at the core of what the future promises. A solid foundation leads to understanding and can diminish a fear of these disciplines, for students who may not have had the inclination to embrace them. Students in the MUSCLE program provide the keys to understanding for younger students who one day may take up where they have left off.

I feel comfortable expressing on behalf of my co-teachers and myself the excitement and the pure joy we experience because of our involvement in this program. We are able to share information, ideas, and some of our thirty years of collective teaching experience with students who are energetic, enthusiastic and brilliant. Students who in turn positively impact the lives of many children who will only realize in later years the gifts received from these dedicated young people.

From the perspective of our Child Psychologist Evaluator

The MUSCLE program will be evaluated in the two participating public schools in coordination with Durham Public School teachers, administrators and a Ph.D. psychologist who serves as program evaluator. The following areas will be assessed: (1) mathematics achievement, (2) students' attitudes about math, science and engineering concepts and interest in pursuit of career in science or math, (3) teachers' assessment of impact of employing hands-on activities in the teaching and learning process by the GE Fund Fellows (e.g. how this approach increases learning and encourages student participation as well as the impact of the Teaching Fellows on teachers' attitudes, comfort with, and skill basis for teaching math and science in an integrated format).

The procedure will be as follows. (1) To assess mathematics achievement a pre-post comparison of mathematics achievement will be made utilizing the standardized end-of-grade tests in mathematics (EOG) routinely administered by the Durham Public Schools at the end of each year. Repeated measures design analyses will compare student achievement over the course of 3 years comparing progress of students receiving GE Fund Fellows instruction with a matched control group. (2) To assess students' attitudes about math, science and engineering concepts and interest in pursuit of a career in science or math two sets of questionnaires will be utilized. The first is composed of student attitude questions taken from the National Assessment of Educational Progress and The International Math and Science Study. The second set of questionnaires was developed by our program evaluation team and consists of a pre/post Math and separate Science Survey with separate forms for grades K-4 and grades 5-8 to be administered at the beginning and end of each year for each of the 3 years in the participating elementary and middle schools. For grades K-4, surveys will be administered by reading aloud

to students to insure comprehension. Pre/post comparisons will be made utilizing these instruments at the beginning and end of each school year. (3) To assess students' comprehension, application and assessment of enjoyment of math and science a more comprehensive interview will be given to a small subset of students across grades. (4) Teachers' assessment of impact of employing hands-on activities in the teaching and learning process as well as impact of Teaching Fellows on teachers' attitudes, comfort with, and skill basis for teaching math and science in integrated format will be assessed by administration of three sets of questionnaires at PRE, MID and POST time marks during each year. These surveys were developed by our program evaluation team. A variety of parametric and nonparametric techniques, such as analysis of variance with repeated measures designs and regression analyses, will compare changes in these factors over the three-year period. (5) A summary report will be written at the end of each year of the project incorporating all of the above analyses with goals to provide feedback to Teaching Fellows and public school personnel to optimize use of the Fellows impact.

## Conclusion

The MUSCLE program is a curriculum enhancement program intended to increase the number of students, particularly women and under-represented minorities, who choose science related careers. The program focuses on the integration of mathematics into all areas of study with particular emphasis on the life sciences. Through hands-on projects we engage students' creativity and curiosity. These lessons provide meaningful contexts in which students learn the utility of mathematics as the universal language of quantification. The MUSCLE program is in its first year of funding (GE Fund, three-year grant). Twelve undergraduate engineering (or applied science) students from the Pratt School of Engineering at Duke University spend 10 hours per week at their partnership school delivering hands-on lessons with their partnership teachers. The MUSCLE fellows provide expertise and function as positive role models for the children. Effective program assessment for gauging the impact of the program as well as providing feedback for program improvement is essential to the success of MUSCLE. Plans for the assessment of MUSCLE have been outlined, and we hope to have data available within the next year.

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## Biographies

**Gary A. Ybarra** is an Associate Professor and Director of Undergraduate Studies in the Department of Electrical and Computer Engineering at Duke University. He is the Principal Investigator of the MUSCLE program and has been leading K-12 Engineering outreach programs since 1988. He received a Ph.D. in Electrical and Computer Engineering from North Carolina State University in 1992 and has been on the ECE faculty at Duke University since 1993.

**Martha S. Absher** is Assistant Dean for Education and Outreach Programs at the Pratt School of Engineering at Duke University. She serves as the Co-Principal Investigator of the Muscle Program. She has developed and directed many undergraduate and K-12 education and outreach programs over the past 13 years, and was a 1996 winner of the Presidential Award of Excellence for Mentoring in Science, Engineering and Mathematics.

**Treva Primus Fitts** is a certified K-12 science teacher with a Masters degree in Environmental Science Education. She is the Director of The Science Resource Center at E.K. Powe elementary school. She coordinates the Duke Engineering Teaching Fellows program (funded by the National Science Foundation) at E. K. Powe and leads the MUSCLE Fellows Training Workshops.

**Judith Russell** is the Curriculum Specialist at Lakewood Elementary School. She has a Master's degree in Early Childhood Education with a concentration in Reading. She is the Lead Teacher in the MUSCLE Program at Lakewood Elementary School.

**Susan Wynn** is the Principal of Lakewood Elementary School. She is a doctoral candidate in Educational Leadership at the University of North Carolina at Chapel Hill. She has a Master's degree in School Administration and Education with specialization in English.

**Kristen Ford** is the School Gardens Coordinator for SEEDS (South Eastern Efforts Developing Sustainable Spaces). She has worked with the Lakewood Garden since January 2001, following the completion of her undergraduate degree in Environmental Science and Policy at Duke University.

**Adefolakemi Oni** is a sophomore in the Pratt School of Engineering at Duke University pursuing a major in Biomedical Engineering and a minor in Cultural Anthropology. She serves in the MUSCLE program as the Head Engineering Teaching Fellow at Lakewood Elementary School.

**Glenda Kelly, Ph.D.** is a consulting psychologist for the Pratt School of Engineering at Duke University where she serves as Program Evaluator for the MUSCLE program. She has consulted for the Talent Identification Program at Duke University and was formerly an Assistant Professor in the Medical School at UNC. She has 20 years experience in school consultation, developing individualized instruction to optimize learning in children and adolescents.