Using Field Trips and Hands-on Activities to Improve Middle School Student Achievement in, and Attitude Toward, Mathematics and Science in a Multilingual and Multicultural Environment

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Abstract

An overview of a five-year National Science Foundation Graduate Teaching Fellows in K-12 school/university partnership project to improve the math and science achievement of middle school (grades 6 – 8) students in five New Jersey (USA) districts is presented. All of the districts have a significant number of multilingual and multicultural students. One math and one science research graduate student are paired with one math and one science teacher in the same school for the school year. Four annual field trips that combine math and science experiences are used as catalysts to develop interdisciplinary and hands-on lessons. Graduate students team-teach with each other and with their partner teachers and share information about their research with the middle school students. Project activities are also expected to improve students' attitude towards mathematics and science and thus encourage more of them to continue their academic studies in math and science at the secondary and tertiary levels and to pursue math and science related careers. Examples of lessons and activities are discussed as well as assessment methods and tools, and a summary of preliminary results.
Key words: Field trips, Limited English proficiency (LEP), Specific learning disabilities (SLD), Multilingual, Multicultural, Middle school mathematics and science, Project assessment

Project Overview

The GK-12 Fellows in the Middle: Partnerships for Inquiry and Interdisciplinary Middle School Science and Mathematics project is a five-year project funded by the National Science Foundation (NSF Award Number – 0638708) for the period March 2007 – February 2012. The project is implementing and measuring the educational and attitudinal impact of hands-on interdisciplinary science and mathematics activities, especially those based upon field trip experiences, on the mathematics and science achievement of participating middle school students. The project matches graduate students (Fellows) from the College of Science and Mathematics at Montclair State University with teachers in five local districts. All five districts have a large number of new immigrant families from Central and South America, central and eastern Europe or Asia. The districts were selected based on their specific needs in science and math, and their objectives for recent immigrants, students with Limited English Proficiency (LEP) and students with Specific Learning Disabilities (SLD).

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Each year a pair of math and science graduate students is placed with a pair of grade 6-8 math and science teachers in a middle school in four of the five participating towns. This pairing promotes interdisciplinary efforts, builds a sense of community, and allows for collaborations on projects such as field-experiences and curriculum unit development. The graduate students act as role models for the middle school students by bringing their content and research experiences to the classroom, enhancing instruction and piquing students' interests in science and math.

During the summer, and throughout the school year, teachers and graduate students, guided by the graduate students' research advisors and project personnel, design and deliver interdisciplinary units based on the annual themes of Earth History, Planetary Science, Populations and Ecosystems, and Chemical Interactions. The units engage middle school students in field-experiences, promote the use of scientific processes and make connections to cutting-edge research. The summer institute includes hands-on lessons in both math and science so that the graduate students and partner teachers experience first hand instructional activities that engage middle school students. Additional workshops include suggestions for creating and delivering effective lessons for LEP and SLD students. In addition, project staff, graduate students and partner teachers receive a full day of training at two field trip sites.

Project goals include improved achievement and attitude toward math and science of middle school students in the five school districts, enhanced content and pedagogical knowledge of participating teachers, and improved communication and teamwork skills of the research oriented graduate students. Project goals drive all training, implementation and assessment activities. Throughout the year, graduate students and teachers participate in training activities that promote inquiry- and standards-based teaching, especially as they relate to raising the achievement of LEP and SLD students. Additional information about the project may be found at http://www.csam.montclair.edu/gk12/.

Assessment activities include those that measure the project's short- and long-term impact on the graduate students' communication and team-working skills, and on the teachers' and students' attitudes toward science and mathematics and their understanding of science and math content and research methods. Assessments include both quantitative and qualitative methods.

Field Trips and Related Lessons

Each year, participating students go on four math/science field trips. In October 2007, over four days, more than 300 students plus chaperones went to the Sterling Hill Mining Museum in Ogdensburg, NJ. Details about the site may be viewed at http://sterlinghillminingmuseum.org/. Lessons related to this field trip that engaged the students included a hands-on cookie mining activity and another treating a series of school hallways and staircases as a mining shaft and computing the volume of rock that had to be removed and the associated costs of removing it. Other lessons included the use of right triangle trigonometry to compute the slope of the rock face in the mine, and simulating the economics of running a mine over several years using a container with different colored beans to represent the type of rock removed when a random hand-full of "ore" is removed. Another lesson involved finding information about mine fatalities per year, creating statistical graphs and noting any abnormalities in the data and then investigating what might have caused them.

In February 2008, students from three schools participated in virtual field trips, via Internet pod-casts, and interacted with researchers in the Panamanian Rainforest. Through their conversations with researchers the students learned about such varied topics as how the locks in the canal work and how dung beetles help with the recycling of waste products. In March, the remaining students participated in a similar virtual field trip to Belize and interacted with some of the same research scientists. Additional information about the Rainforest Connection and other virtual field trips may be viewed at the following website http://www.accessnewjersey.net/ that is maintained by Verizon. In May 2008, students will travel to northwest New Jersey and spend the day investigating stream-flow, water pollution, stream deposition, soil strata and related topics at Montclair State University's New Jersey School of Conservation, located in the headwaters of the Flatbrook River watershed. All five of the school districts are located between the lower reaches of the Hackensack and Passaic River watersheds in a densely populated industrial section of New Jersey. Thus this field trip has motivated a number of lessons that compare and contrast the physical characteristics as well as environmental and industrial characteristics of the upper and lower reaches of a watershed. Other lessons use maps to compare and contrast land use along the rivers. By comparing the volume of water passing a point in the lower reaches of a watershed to the volume of water-flow that they measured in the upper reaches of a watershed, students will gain a better understanding of large numbers.

Annually, the fourth field trip for students will be to Montclair State University in June for a Middle School Math and Science Day. In preparation for that day, students will create posters about mathematics and science projects at their schools. Each school will select some posters to be presented at the Math and Science Day. All students will participate in judging posters from schools other than their own school. Additional activities on that day include presentations by research faculty and representatives from industry, a tour of science and mathematics labs, and a campus tour. For example, we have invited veterinarians, medical and dental students, environmental and structural engineers to make brief presentations and then engage in a question and answer session with small groups of students. We expect that this experience, in combination with their interaction with the Fellows, will increase the middle school students' awareness of the post-secondary educational and career opportunities in math and science that are available to them. Thus we hope to counter the documented pressure for minority group students, which include many recent immigrants, to avoid preparing for and selecting a rigorous secondary curriculum (Balfanz & Legters, 2006; Sorge, Newsom, Horton & Hagerty, 2000).

Assessment Methodologies and Tools

Both qualitative and quantitative assessments are employed to measure the effects of the project on middle school students, teachers and graduate students. Participants, and appropriate control groups, completed science and math content and attitudinal assessments prior to their engagement in project activities. Similar assessments will be employed at the end of the school year. In addition, all graduate students and teachers participated in a one-hour interview that will be repeated in June. Each year a representative group of 6 to 8 middle school students from each school will participate in three focus group interviews. Graduate students are observed and videotaped teaching their classes three times during the academic year. They were also videotaped presenting their research and sample lessons during the summer prior to beginning

their work in the schools. In addition to those assessments, the graduate students have also prepared written documents such as letters to personnel at the National Science Foundation and articles for newsletters.

Preliminary Results

Initial quantitative and qualitative data was collected from the teachers and graduate students in May 2007 and from the middle school students in September 2007, before the graduate students joined their class as a visiting mathematician or scientist. Some qualitative data has been collected from the graduate students and middle school students during the middle of the school year. Some preliminary observations about this data is discussed below.

As expected, the math graduate students and partner teachers scored better on the math content assessments than their science colleagues. Similarly the science graduate students and partner teachers scored better on the science content assessments than their math colleagues. However the overall content scores for the math group appears to be slightly higher than those of their science colleagues. All of the graduate students have shown improvement in both their oral presentation, written communication and team-working skills.

The middle school students will not complete all of their post content assessments until April or early May. Since the vast majority (95%) of those assessments will be scored by a state agency, we do not expect to have the results until late June. Similarly, we do not expect to complete the qualitative data collection from the middle school students until mid-June. Some preliminary results form the student focus group interviews indicate that the students enjoy the field trips and related lessons. Comments from teachers and graduate students support the theory that such experiences promote better learning and retention than that achieved by traditional lecture and worksheet classrooms (Bransford, Brown & Cocking, 2000). Perhaps this was best captured by comments overheard at the end of the first field trip when one grade eight student said to several of her companions, “This was the best field trip ever.” Similar comments were made by parent chaperones. Finally, both teachers and graduate students have reported that the middle school students are more aware of college and graduate education and careers in STEMM disciplines.

Relevant Literature and Other Resources

American Association for the Advancement of Science. (1989). *Science for all Americans*. Washington, DC: Author.

Anderman, E. M. (1998). *The middle school experience: Effects on the math and science achievement of adolescents with LD*. Journal of Learning Disabilities, 31, 128-138.

Balfanz, R. & Legters, N. (2006). *Are high schools failing their students? Strengthening academic rigor in high school curriculum.* Washington, DC: The Center for Comprehensive School Reform and Improvement. October 2006 Newsletter.

Berlin, D.F. (1994). *The integration of science and mathematics education: Highlights from the NSF/SSMA Wingspread Conference Plenary Papers*. School Science and Mathematics, 94(1), 32-35.

Bransford, J. D., Brown, A. L. & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

Center for Innovation in Engineering and Science Education. (2001*). Measuring the circumference of the earth - The noon day project.* Retrieved June 2006, from http://www.k12science.org/noonday/.

Committee on Science, Engineering and Public Policy. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future.* Washington, DC: National Academy Press.

Jackson, N.B. (2006, June 6). *A rain-forest census takes shape, tree by tree almost leaf by leaf)*. Science Times, The New York Times, F1, F4.

Lappan, G., Fey, J., Fitzgerald, W. F., Friel S.N., & Phillips, E.D. (2002). *Connected mathematics project.* Retrieved June 2006 from http://www.math.msu.edu/cmp/index.html. (NSF #9150217).

Lawrence Hall of Science. (2005). *Full option science system.* Retrieved June 2006, from http://lhsfoss.org/index.html. (NSF #9553600).

Loucks-Horsley, S. (1999). *Research on professional development for teachers of mathematics and science: The state of the scene.* School Science and Mathematics, 99(5), 258-271.

Merseth, K. (2003). *Windows on teaching math: Cases of middle and secondary classrooms*. New York, NY: Teachers College Press.

Mulhern, F., & Rae, G. (1998). *Development of a shortened form of the Fennema- Sherman mathematics attitudes scale*. Educational and Psychological Measurement, 58(2), 295-306.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Research Council. (2000). *Educating teachers of science, mathematics, and technology: New practices for the new millennium*. Washington, DC: National Academy Press.

Sorge, C., Newsom, H. E., & Hagerty, J. J. (2000). *Fun is not enough: Attitudes of Hispanic middle school students toward science and scientists*. Hispanic Journal of Behavioral Sciences, 22, 332-345.

Strauss, S. M. & Subotnik R. F. (1994). *Gender differences in behavior and achievement*. Association For Women in Mathematics Newsletter 24(3): 12-25.