GHOST Program
Georgia High School Outreach for Science and Technology Program

Submitted by:

Material Advantage Student Chapter
Georgia Institute of Technology
Atlanta, GA

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Motivation and Inspiration

The K-12 education system in Georgia is suffering greatly in STEM (science, technology, engineering, and mathematics) areas as indicated by statewide performance testing in general science and math. This is a significant problem in grades 6-8 as well as grades 9-12, where Georgia is shown to be clearly below the national average in terms of progress towards achieving students with at least a basic proficiency in both science and math. Several statistics portraying Georgia's recent educational standing with respect to the rest of the nation are shown for both 8th grade and SAT scores in Figure 1 and Figure 2 respectively [1, 2]. This data indicates that some progress is being made with respect to science and math education by the 8th grade (does not take into account the possible lowering of standards), but no progress has been made at improving SAT scores. On average, Georgia students consistently score lower than the national average.

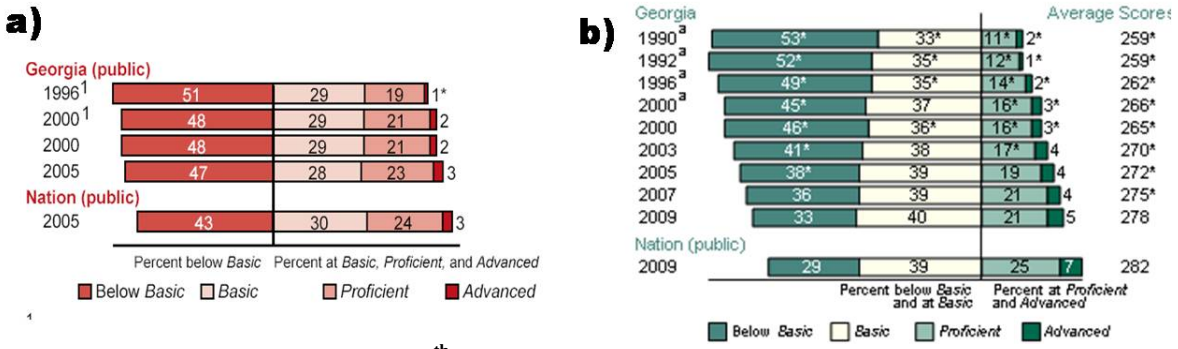

Figure 1: Georgia 8th graders' progress in a) science and b) math [1].

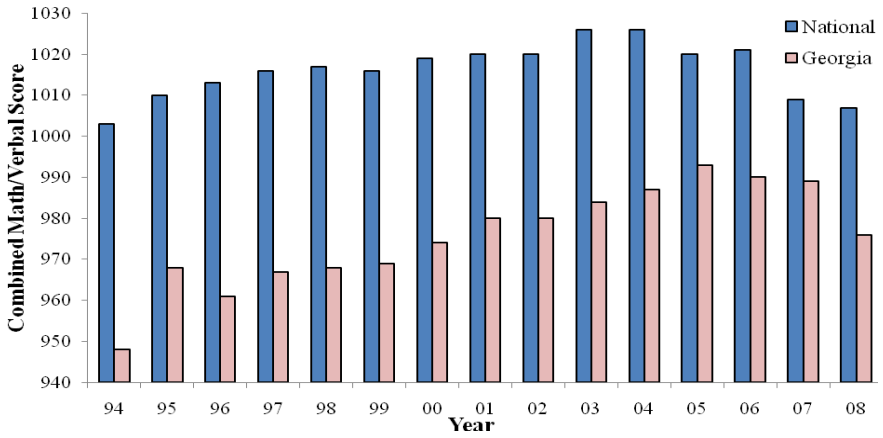

Figure 2: Average National and Georgia combined math/verbal SAT scores.

Economics may play a significant role in the below average values for Georgia middle and high school students. Currently, an average of 51% of Georgia high school students are on a free or reduced lunch program; an 8% increase from nine years ago. This percentage is as high as 65-70% in some school districts within Atlanta and the surrounding area [2]. These numbers indicate the relative economic position of those students attending the public schools, but can also be indicative of the amount of funding available for a particular school district. According to the Georgia Budget and Policy Institute (GBPI), funding for K-12 education will be 10.9% lower in the proposed 2011 fiscal year state budget than it was in 2009 with further reductions in funding continuing for at least the next five years. The proposed 2011 FY education budget also

proposes the elimination of state support for Education Technology Centers as well as the National Science Center and Foundation, which currently offers programming to encourage student interest in math and science [4]. In response to the below national average K-12 science and math performance of Georgia students and the increasingly constrained school budgets, volunteers can play a significant role in generating further interest and proficiency in both science and math.

Materials Science and Engineering (MSE) based outreach to K-12 students is an ideal way to create and develop student interest in technical fields as well as inform those that will soon be entering college or are undecided about college about the existence of and opportunities within the MSE profession. As of 2009, MSE undergraduates totaled only 1.6% of the undergraduate engineering student body at Georgia Tech thus making it the smallest major within the school of engineering [5]. Consequently, it is not only important that interest in science and engineering be developed among K-12 students, but that the students realize that MSE includes a variety of topics and that the future of technology rests upon the development of new materials. In particular, it is important to target students who do not display motivation or interest in science and math curriculum, but who also may not have had the opportunity to explore the possibilities in studying science or engineering.

GHOST Part I (2008-2010)

Over the past two years, the GHOST program at Georgia Tech has achieved many successes and realized a number of goals with respect to forming the foundation for an MSE K-12 outreach program. The initial phase of GHOST resulted in the acquisition of demonstration related materials, development of a flexible MSE classroom curriculum, and the establishment of a network of student volunteers and faculty support within the Georgia Tech MSE department as well as Atlanta area high school (public, private, and homeschool) teachers. The resulting support network has produced a highly successful, adaptable, and influential program that has positively affected many K-12 students as well as MSE student volunteers.

Demonstrations and Presentations

An initial MSE PowerPoint presentation, which will soon be available on the Georgia Tech MSE website (www.mse.gatech.edu), along with a variety of MSE related demonstrations (Table 2) and take-home experiments were developed to exhibit to high school students by GHOST presenters. Both the initial PowerPoint presentation and associated demonstrations were organized so that they could be easily modified to meet specific curricula as appropriate for the particular classroom ie. biology, chemistry, physics, or any combination of subjects. The curriculum could also be easily tailored to address six or seven 50 minute classes or three or four approximately two hour classes for each school visit. This amounted to presenting to 100-200 students per school visit.

Table 2: List of MSE demonstrations used in high school classrooms.

Demonstration	Lesson	Wow (1-10 scale)	Education (1-10 scale)	Interactive (1-10 scale)
Pictures of Twin Towers	Materials in history	6	8	4
Pictures of Liberty Ships	Materials in history	6	8	3
Pictures of Aloha Airlines airplane	Materials in history	8	8	4
Pictures of space shuttle disasters	Importance of using the right materials	6	7	4
Pictures of meteorite impact	Strain rate controlled material synthesis	7	6	3
Shape memory alloy	Shape memory effect	8	5	5
Shape memory polymers	Shape memory effect	8	5	8
Kevlar	Defense applications of materials	6	5	4
Boron carbide plates	Hard materials	7	7	5
Composite body armor	Defense applications of materials	4	5	5
Videos of projectile impact simulations	Computational materials science	6	6	4
Biomaterials (stent, hip implant)	Biological/medical applications	7	7	7
Integrated Circuit	Miniaturization	5	6	7
Carbon nanotubes	Example of useful nanostructure	5	7	5
Quantum dots	Quantum Confinement	7	7	6
Fuel Cell	Energy materials	6	7	7
Synthetic Opal	Optical materials	5	5	7
Gemstones/quartz	Crystals/band gaps	7	7	7
Morphos butterfly and jewel beetle shells	Biomimetic materials	7	7	5
Space shuttle tile	Insulating materials	8	7	6
Racquet balls / Flowers in liquid N_2	Glass transition temperature	9	6	7
Old v. new penny	Insulating materials, metal melting temps.	8	7	7
Amorphous v. crystalline metal	Crystallinity effects on mechanical properties	7	8	7
Super conducting (levitating) magnet	Super conductive materials	9	6	6

All PowerPoint presentations began with a brief description of the foundation of Materials Science: metals, ceramics, and polymers and their inherent atomic structure/property relations. The presentations proceed into more specific fields of materials research: electronic, structural, biological, biomedical, biomimetic, nano-, and others. After several school visits, it became apparent that the students were highly interested in not only the subjects of MSE but also the more personal side of pursuing an MSE or other technical degree. Consequently, time was always reserved at the end of the presentations to address questions about the transition from high school to college, the nature of academic research, and life as an undergraduate or graduate student in MSE. Several of the slides used in the GHOST presentations are shown in Figure 2. A photo from one of the visits is shown in Figure 3.

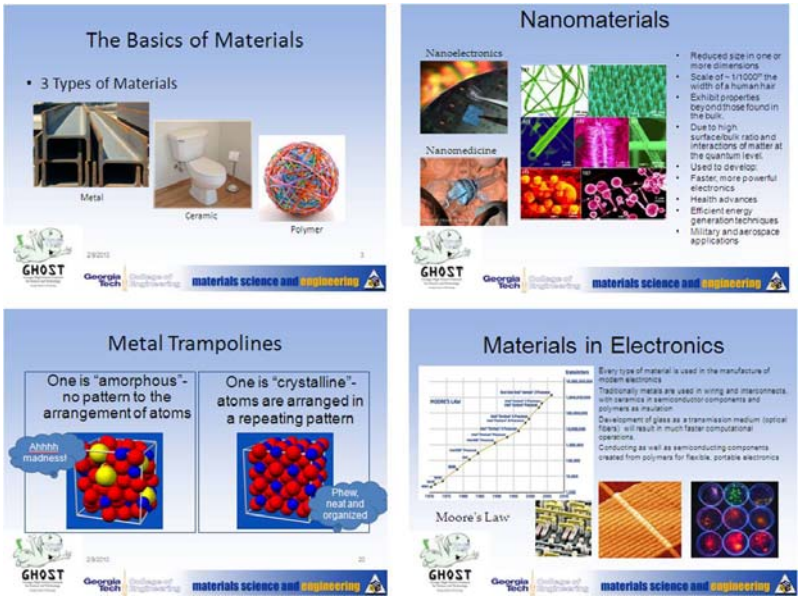

Figure 2: Representative PowerPoint slides from the GHOST Program.

Figure 3: Photo from a GHOST visit to Chamblee High School: Explaining the importance of materials in the advancement of electronics.

Adaptation of GHOST to Younger Students

Although the curriculum was initially developed for high school students, its flexibility permitted it to be adapted for younger students. Since the founding of the GHOST Program two years ago, MSE has participated in Georgia Tech's Kids@College Day. Students from the immediate Atlanta area, ranging in age from 5-18, visit Georgia Tech's campus to see some of the opportunities that an education in science and engineering has to offer. The MSE portion of the Kids@College Day has been a huge success with both younger and older students taking interest (Figure 4).

Figure 4: Photo from Kids@College Day: Liquid N_2 experiments.

Student Group Visits to Georgia Tech MSE

In addition to promoting MSE within high school classrooms, MSE students offered guided tours of their labs on the Georgia Tech campus to several student groups from the local Atlanta area. Student groups ranging in size from 40 to 125 have visited Georgia Tech MSE facilities. To maximize the learning experience for each student, the groups are divided into smaller groups of approximately ten students. Each group has the opportunity to tour a variety of MSE labs with each tour consisting of relevant demonstrations pertaining to that lab's research and discussions of its applications. Although coordinating the logistics of student transportation and scheduling tours has proved to be a logistical challenge, there has been no shortage of enthusiasm among MSE student, staff, and faculty volunteers.

Volunteers

Volunteers for the GHOST program are recruited from the MSE undergraduate and graduate student body. Achieving the number of volunteers necessary for each GHOST visit has been easy since MSE students often volunteer to be an active part of the program. Faculty support through the supplying of some of the demonstration materials and staff support with arranging the logistics of high school class visits to Georgia Tech MSE have been exceptional. The NSF funded Georgia Tech MSE Georgia Intern Fellowships for Teachers (GIFT) program aided in establishing the current MSE-high school teacher network. This group continues to play an integral part in promoting Materials Science and the GHOST program throughout the K-12 education system.

GHOST Part II (2010-2011): Upcoming Outreach Activities

Part II of the GHOST Program will focus on maintaining and extending the student-teacher network through GHOST visits as described in *GHOST Part I*. A number of teachers have expressed significant interest in continuing their involvement with the GHOST Program in the coming years. These teachers are also actively spreading interest to other schools and teachers.

High School Science Fair Outreach Clinics

Although a large number of students have been reached since the inception of the GHOST program, high school teachers have expressed interest in informing their students about the fundamentals of research through participation in science fairs with guidance provided by Georgia Tech MSE students. Both Georgia Tech undergraduate and graduate students have met the science fair idea with strong enthusiasm and willingness to take part and guide the high school students. In addition to continuing GHOST Part I, the science fair expansion will be implemented in the form of monthly science fair clinics.

Undergraduate and Graduate student volunteers from Georgia Tech MSE will travel to local Atlanta metropolitan area high schools and work with groups of high school students on science fair projects in a "clinic" type environment. During the monthly clinics, student volunteers will discuss materials-related science fair project ideas with the high school students and coach them on creating winning science fair displays, based on the judging criteria for Intel Science Talent Search competitions. Some supplies will be provided, with preference given to students that would be unable or unwilling to complete a science fair project without funding assistance.

Clinics will take place once a month from the start of the school year in mid-August, and will occur until the month of the science fair, usually January or February. Clinic schedules will be coordinated with the teacher contacts and will be done during class time. At the first clinic, the GT student volunteers will give a presentation outlining suggestions for the students to approach a successful science fair project. Examples of these criteria are:

- Developing a relatively simple, creative scientific experiment supported with sufficient and well-collected data
- Creating an eye-catching, organized display that clearly explains the scientific significance of the project
- Keeping a comprehensive lab notebook that includes all procedures, observations, and results in detail

Volunteers will then break the students into small groups and discuss specific suggestions for successful projects. At subsequent clinics, volunteers will again break students into small groups and assist them with making supply lists, planning their experiments, and understanding the scientific concepts necessary for comprehension of the experiment. Timelines will be handed out for the students to follow during the weeks between clinics. The detailed schedule and planned activities for clinics 2-6 is shown in Table 3.

Table 3: Proposed schedule and objectives for clinics 2-6.

Assignment	Complete by:
Have project topic ready, bring in composition notebook, get participation sheet signed by parents.	Clinic 2 (9/2010)
Gather supplies for experiment. If participating in Intel STS, complete all necessary entry forms.	Clinic 3 (10/2010)
Set up experiment and complete at least two trials (If participating in Intel STS, bring in completed research report)	Clinic 4 (11/2010)
Complete experimental trials, bring lab notebook with recorded data to class, be ready to sketch out a plan for display	Clinic 5 (12/2010)
Bring in foam board, text, and photos/charts/graphs/tables and be ready to complete the display (glue sticks, construction paper, and markers will be provided)	Clinic 6 (1/2011)

Table 4: Contact information for organizers of the GHOST Program.

Name	Position	Email	Phone
Alex Sharenko	Undergrad. Student and GT MA Vice Pres.	alexsharenko@gmail.com	404-312-4481
Kara Evanoff	Grad. Student and GT MA Pres.	evanoffk@gmail.com	412-877-9413
Lindsey Goodman	Grad. Student and former GT MA Pres.	lindsey.goodman@gatech.edu	646-369-9665
Adam Jakus	Grad. Student and former GT MA Vice Pres.	adamjakus@gatech.edu	770-530-3617
Naresh Thadhani	Professor and GT MA Advisor	naresh.thadhani@mse.gatech.edu	404-894-2651

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