

# Georgia High School Teachers in Academic Laboratories: Engineering's Important and Increasing Role

*Donna Barrett<sup>1</sup> and Marion Usselman<sup>2</sup>*

**Abstract** - Georgia Intern-Fellowships for Teachers (GIFT) is a collaborative effort designed to enhance the mathematics and science experiences of Georgia teachers and their students. Since 1991, GIFT has placed an average of 75 teachers per summer in 6-8 week summer research experiences in businesses, industries, public science institutes and academic research laboratories. From 1991 – 2001, approximately equal numbers of teachers were placed in “corporate” and “academic” GIFT positions. However, the new emphasis by granting agencies such as the National Science Foundation on the broader effects of research, and the concurrent weakening of the economy, has caused a dramatic shift in this balance. Over the last three years only 47 teachers have been placed in corporate settings, and 170 have participated in academic research. Academic GIFT positions in engineering laboratories have increased from 5% in 1997, to over 30% in 2004.

**Keywords:** K-12 outreach, teachers, research internships,

## Georgia Intern-Fellowships for Teachers Program Overview

### Introduction

Research suggests that the quality of the teaching workforce is the single most important factor in predicting student achievement [1]. “Quality” has many dimensions, however. Good teachers must have a solid knowledge of academic content, a high mastery of different pedagogical techniques, and a strong sense of professionalism. Science teachers also must have a fundamental understanding of the scientific process and satisfactory answers to the inevitable question by students—“When am I ever going to use this”? University and corporate research laboratories are in the unique position of being able to help teachers develop their strengths in most of these categories through summer research internships. When teamed with education experts, scientists and engineers can provide motivated teachers with summer experiences that increase their content knowledge, challenge them to explore new teaching strategies, and show them the practical uses of science and mathematics skills. These experiences also provide teachers with first-hand knowledge about how scientists and engineers actually approach problems, how they design experiments, and how they interpret data. And, in perhaps the most powerful effect of all, teachers in university research settings gain a sense of professionalism and renewal that can last a lifetime.

GIFT was initiated in 1990, as the Georgia Industrial Fellowships for Teachers program, by the Georgia Institute of Technology with the assistance of the Triangle Coalition for Science and Technology Education in Washington, D.C., and the California-based Industry Initiatives for Science, Mathematics, and Engineering (IISME). From the beginning, a unique feature of the GIFT program has been the inclusion of internships from both the corporate and academic arenas. Sponsors have included academic research institutions such as Georgia Tech, Georgia State, Clark Atlanta and Emory Universities, the Medical College of Georgia, the UGA Agricultural Experiment Station, and the

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Centers for Disease Control and Prevention, and corporations such as Bellsouth, Columbus Water Works, Georgia-Pacific, Georgia Power, Gwinnett Medical Center, EMS Technologies, IBM, the Medical Center of Central Georgia, SunTrust, and UPS.

### **GIFT Program Details**

GIFT is designed to:

- Provide scientists and engineers with an easy method of locating teachers interested in participating in research internship,
- Quickly provide teachers with the basic skills necessary to go into the research lab,
- Ease the transition and provide support throughout the summer by placing the teachers into small groups with a master-teacher facilitator,
- Assist teachers with creating an Action Plan for implementation in their classes in the fall,
- Foster the development of an extended community of learners by sharing summer experiences and linking teachers through a teacher listserv,
- Provide support for classroom implementation through classroom visits by GIFT staff, and
- Encourage extended partnerships between teachers and university mentors.

Sponsors hire teachers as employees at the rate of \$714 per week, with the typical GIFT experience lasting 7 weeks and teachers receiving \$5,000. GIFT also receives a \$2,000 program fee from corporate sponsors, and a \$1,250 program fee from academic sponsors. Funding from University sponsors comes from a variety of sources, most notably Howard Hughes Medical Institute and National Science Foundation grants. Many university faculty members with National Science Foundation grants have applied for and received \$10,000 Research Experiences for Teachers (RET) supplements [2] to allow them to host a GIFT teacher. Sponsors with HHMI grants may seek funds for the sponsorship of a teacher if a student works in the lab with the teacher [3]. Corporate and industry sponsors usually pay for the teacher stipend out of their regular personnel budget.

Teachers from 60 school districts and 13 private schools have participated in the GIFT program in the past 14 years, with the majority being from the metro-Atlanta area. In recent years GIFT has expanded to regions outside the metro-Atlanta area, including Augusta, Macon and the University of Georgia's Agricultural Experiment Station in south Georgia's Tifton area. Georgia Power also played a key role in corporate expansion by placing teachers in power generating plants throughout the state.

### **Logistics and Action Plans**

To participate in GIFT, sponsors complete an on-line survey, which includes a position description describing the nature of the summer work and a list of the skills required of the teacher, and they submit a letter of intent for participation. Teachers complete an on-line application that includes information about their background, courses they have taught, their technology skills and their geographical preference for work locations. GIFT uses the information from the sponsor and teacher databases to coordinate the matching of skills with preference. Sponsors are given access to applications of teachers who meet their job requirements; sponsors interview prospective applicants and select a teacher to hire for the summer. Approximately 140 teachers apply to the program each year.

The Action Plan is a formal document each teacher creates and turns in at the end of the summer. It represents the GIFT teacher's blueprint for transferring the summer GIFT experience into his/her classroom during the following year. The Action Plan must include:

- **The Needs Assessment** that contains a self-assessment of the teacher's teaching/learning environment in which they describe their personal or team vision for their classroom. Teachers describe their vision, goals, objectives, constraints, student needs, and opportunities for changing their classroom practice in mathematics and science. They link this concretely to the reality of their own classroom and students, their system's curriculum, and the standards. In establishing their personal goals and objectives for the entire GIFT experience, both the summer and implementation phases, teachers address the following topics:
  - Major student needs related to specific curricula;
  - Items they would like to change about their teaching methods;
  - Concepts they want to learn during the summer and teach "better" or differently.
- **A Summary of the GIFT Fellow's summer work experience** including discipline content, experimental techniques, instrumentation and technologies used, and the underlying rationale and theory.

- A **Portfolio** that represents key points in the learning process. It includes materials, processes, and products the teacher acquires throughout the summer. For example, it may include national standards, videos of teacher work experience projects, workshops, presentations of previous classroom implementation plans, grant information, equity materials, and career/workplace information, research papers, and corporate annual reports.
- The **Classroom Implementation Plan** contains the teaching and learning goals, classroom implementation, and evaluation plan. Teaching and learning goals include impact on student knowledge, awareness, skills, motivation, and attitudes. Classroom Implementation describes the details of the teacher's plan for achieving their changed classroom practice and defines the anticipated results. This plan includes long term inquiry-based strategies linked to national standards and learning needs in the curriculum, and it utilizes experiences, knowledge, skills, and materials acquired throughout the summer experience. The evaluation plan is designed to answer the question "How do I know if what I am doing is achieving the results I set out to achieve?" Teachers select measurable indicators and assessment tools to determine their success in approaching their goals.
- The **Communication Plan** includes a description of long-range interaction with the mentor. Teachers present their summer experience, Action Plan and its outcomes to colleagues at school and at local, state, and national meetings.

### GIFT Evaluation

GIFT is evaluated on an annual basis using:

- An extensive survey of teachers at the end of the summer that covers program content, usefulness of components, quality of lab experience, etc.
- A survey of mentors pertaining to program logistics, quality of experience, etc.
- A survey of teachers late during the following year to track success of action plan implementation.
- An evaluation of teacher Action Plans by CEISMC staff.

Results are used to constantly modify and improve the quality of the GIFT experience.

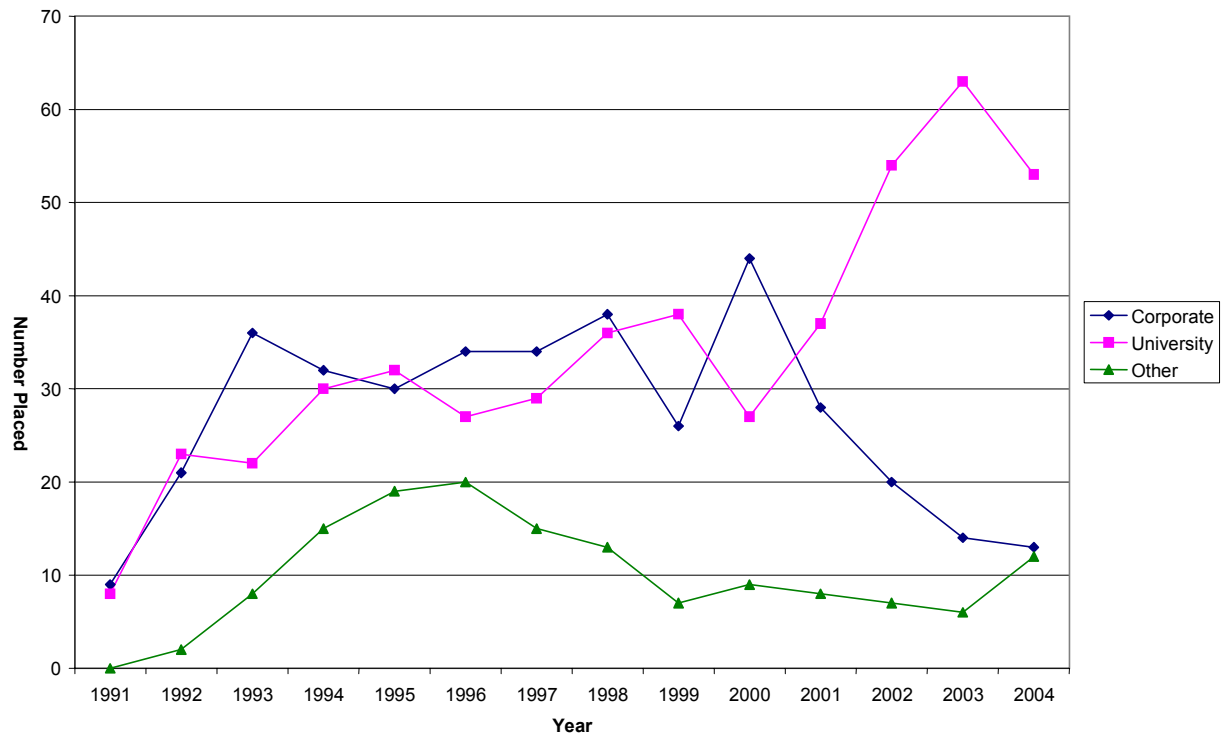
## Engineering's Role in GIFT

### GIFT Participant Overview

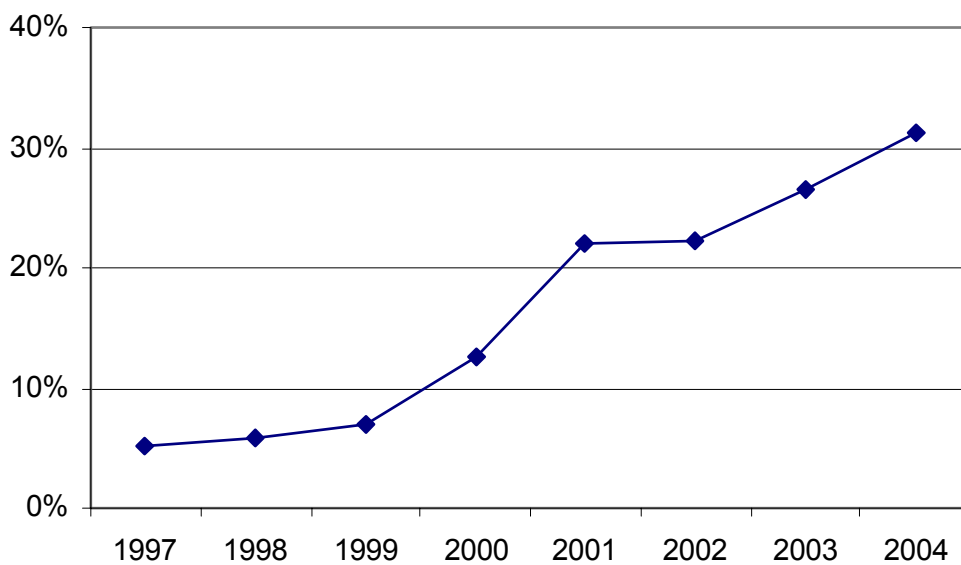
Figure 1 illustrates the general participation in GIFT over time, analyzed by type of position—i.e. "university" positions, "corporate" positions, and "other" positions (which includes positions at informal science entities, such as Zoo Atlanta, and at public health education units at CDC.) From 1991 – 2001, the number of GIFT positions in universities and corporations were approximately equal—332 worked in industry, 309 worked in academic labs. However beginning in 2002, there has been a dramatic shift in the balance between corporate and university sponsors. The national and local economic downturn caused many long-term corporate GIFT sponsors to terminate their involvement in the program. Concurrently, the National Science Foundation implemented, and more importantly began enforcing, the "Criterion 2" category in grant proposals, namely that NSF grantees are required to explicitly address the broader educational impacts of their research. NSF also made readily available Research Experiences for Teachers (RET) grant supplements, enabling faculty and academic units to financially support GIFT teachers without depleting basic research funds.

For GIFT, this increase in academic positions was assisted by a marked increase in the participation of engineering units at Georgia Tech, as illustrated in Figure 2. The Georgia Tech Center for Education Integrating Science, Mathematics and Computing (CEISMC), which coordinates the GIFT program, is located within the College of Sciences and most of the research positions had historically been in biology and chemistry, topics that clearly aligned with teachers' instructional obligations. However the last five years have witnessed an increased appreciation for the role that engineering can play in K-12 education, leading to the creation of an Engineering K-12 Center at the American Society for Engineering Education (ASEE), and a new ASEE K-12 Division. This emphasis, combined with the NSF focus on broader impacts and workforce development, has led to many more engineering faculty members participating in GIFT.

**Figure 1--GIFT Participants 1991-2004**



**Figure 2--Percent of GIFT positions in academic engineering labs, 1997-2004**



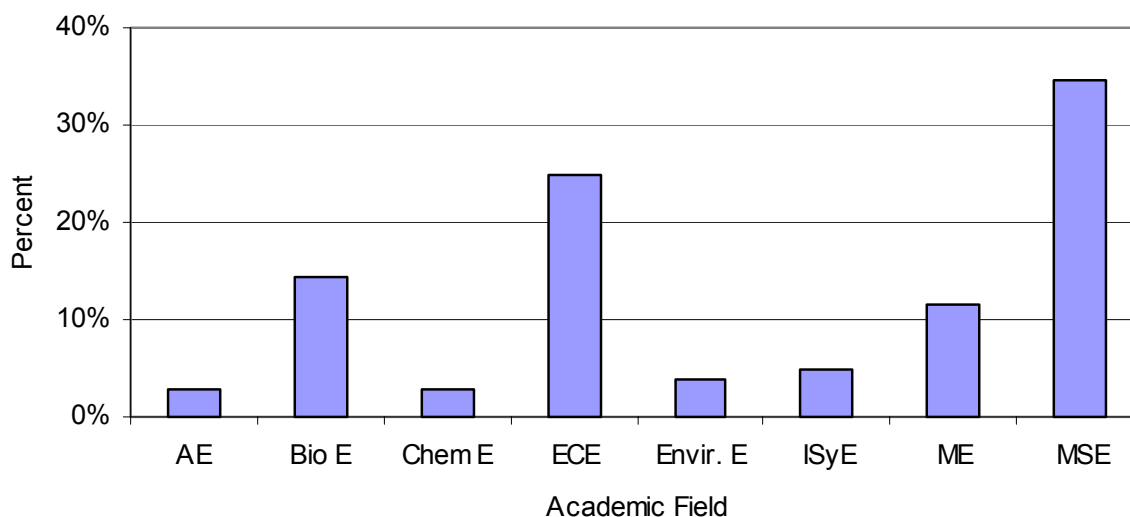
### Engineering Placements

Figure 3 shows an analysis of teacher placement by engineering discipline, which reveals three different models of engineering GIFT participation—1) Initiative by individual faculty members, 2) Coordination of placements by Georgia Tech Research Institutes and NSF-supported Engineering Research Centers, and 3) Coordination through an individual department Research Experiences for Teachers Site program. The first model is illustrated by the Schools of Aerospace, Chemical Engineering, Environmental Engineering, Industrial and Systems Engineering, and Mechanical Engineering. In these cases individual faculty have generally shown interest in hosting a teacher, and CEISMC has worked with them to find monetary support through NSF supplements to existing grants.

The second model, coordination by research institutes and Engineering Research Centers, is illustrated by the larger numbers of teachers placed in biologically-based engineering fields (Bioengineering, Biomedical engineering), and Electrical and Computer Engineering. Georgia Tech has a number of research institutes and Engineering Research Centers, including the Parker H. Petit Institute for Bioengineering and Bioscience, which contains the NSF Engineering Research Center for the Engineering of Living Tissues, the Microelectronics Research Center, and the Microsystems Packaging Research Center. These centers, all of which have educational, as well as research, missions, have been very active in recruiting their faculty to host GIFT teachers.

The largest number of teachers placed in a single engineering discipline is in Material Science and Engineering (MSE). This is a direct result of the efforts of a single faculty member who is dedicated to education and outreach, and who coordinates the placement of 6-7 teachers per year within labs in MSE. These “Material World” placements are funded by an NSF RET Site grant.

**Figure 3--Engineering GIFT teacher placement 1996-2004, by Discipline**



### Future of Engineering Placements

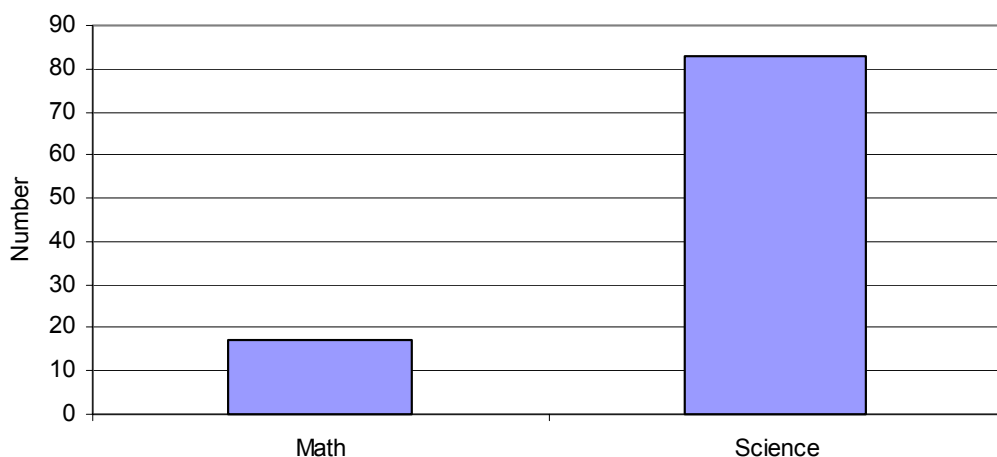
Academic GIFT placements, in science as well as engineering, are currently threatened by the budgetary cutbacks at the National Science Foundation. Since grant supplements, including RET supplements, are funded through discretionary funds available within individual NSF directorates, these are some of the first programs to be eliminated in tight budget times. In 2004 few GIFT teachers were funded through individual RET supplements. Instead, the costs were primarily absorbed by the large research centers and institutes and by a Georgia Tech NSF

GK-12 program, the Student and Teacher Enhancement Partnership (STEP). The number of academic placements will decrease dramatically in the near future if NSF eliminates its support of the RET program.

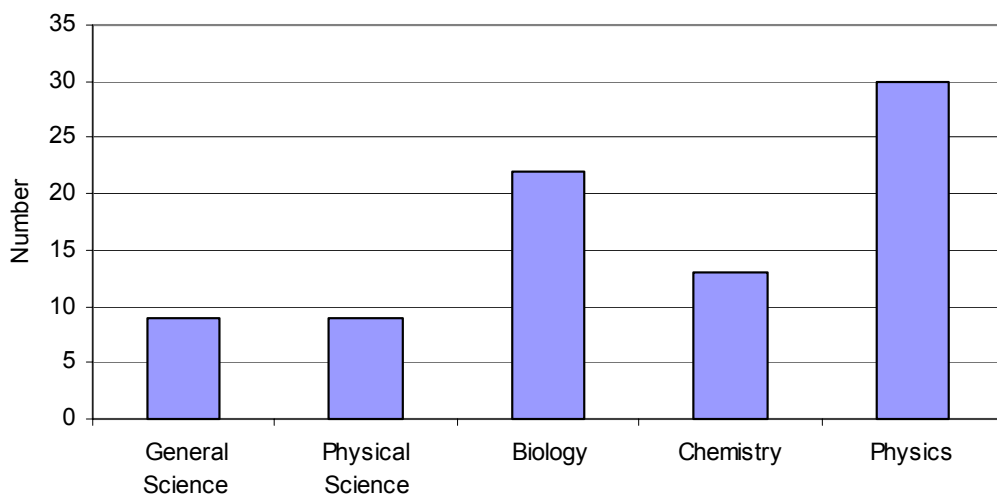
### Teachers in Engineering Laboratories—who are they?

GIFT teachers in general are primarily from high schools (72% for 2001-2004), are primarily female (64%), and are equally likely to be white (47%) or black (48%). In general, teachers placed in biology or chemistry laboratories are biology or chemistry high school teachers so that the summer assignment clearly supports the academic content that the teachers are required to teach during the school year. However Georgia does not have engineering standards in the educational curriculum and very few teachers teach “pre-engineering” courses. So which teachers choose to work in engineering laboratories? In the GIFT program, these teachers are overwhelmingly science teachers (Figure 4), primarily teaching physics or physical science (Figure 5). Because of the participation of Bioengineering and Environmental Engineering, a substantial number of biology teachers have also been placed, and Material Science and Engineering supports participation by chemistry teachers.

**Figure 4. School Teaching Assignment for Engineering GIFT Teachers, 1996-2004**

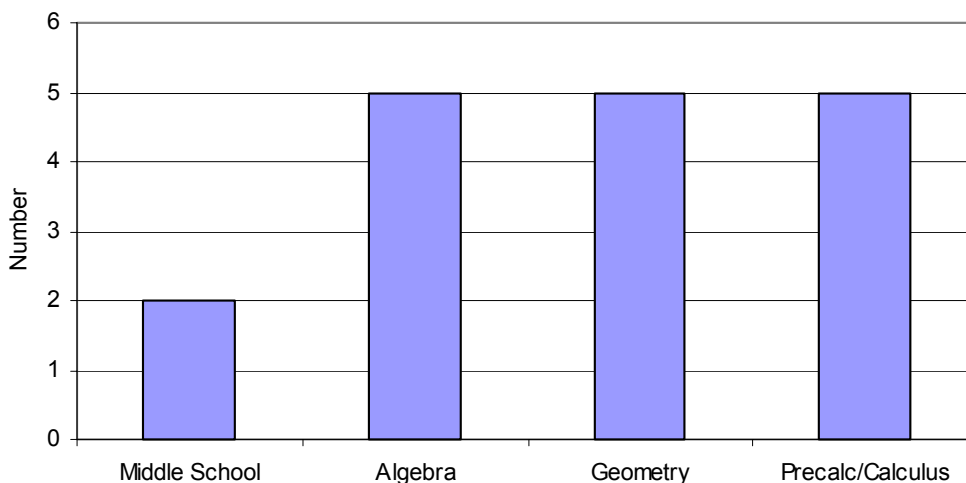


**Figure 5--Science GIFT Teacher Subject Areas, 1996-2004**



The mathematics teachers in engineering GIFT positions are equally split between Algebra I/Algebra II, Geometry, and Precalculus/Calculus (Figure 6).

**Figure 6--Math GIFT Teacher Subject Areas, 1996-2004**



#### Analysis of Action Plans

Since high school teachers don't teach engineering, what relevant new skills, activities, or ideas do engineering GIFT teachers take back to the classroom, and do these plans include engineering concepts? To investigate this, we chose and analyzed 14 random Action Plans of teachers placed in a range of engineering positions from 2001-2004 to determine the degree to which engineering was included in activities to be implemented with students. As seen in Figure 7a, 79 percent of the implementation plans reviewed included at least some topics in a field of engineering to

<b>Figure 7--Action Plan Analysis</b>	No Evidence	Some Evidence	Substantial Evidence
a. Action Plan includes engineering activities for classroom implementation	21.4%	28.6%	50%
b. Action Plan includes examples of engineering in description of work experience	7.1%	28.6%	64.3%
c. Action Plan includes evidence that the teacher gained a greater understanding of engineering	7.1%	35.7%	57.1%
d. Action plan indicates that the teacher received physical resources/materials related to engineering field	21.4%	28.6%	50.0%
e. Action Plan included websites/current engineering resources	14.3%	50.0%	35.7%
f. Plan includes opportunity for mentor to interact with students	14.3%	35.7%	50.0%
g. Plan includes opportunity for mentor to share information related to engineering field	14.3%	35.7%	50.0%

be implemented in the classroom. Teachers proposed involving students in hand-on engineering activities such as bridge support projects, analyzing the materials used to make roller coasters, crystal growth, using problem-based learning strategies in engineering situations, studying the importance of friction in Olympic sports and projectile motion and forces. For example,

- ☐ A third year mathematics GIFT fellow, pondering the importance of increasing the amount of student-centered instruction in his classroom, proposed to address cross-curricular objectives by incorporating a traditional science lesson on aerodynamics into his geometry class. Students review Bernoulli's principle and concepts of lift and drag, build their own airplanes, mathematically estimate the flight distance, and compile their data in MS Access databases.
- ☐ A second year GIFT fellow whose experience in a Mechanical Engineering laboratory led to the development of an Action Plan for Physical Science classes included students building bridges out of spaghetti. Students were to be instructed on compression, tensile and shear forces, build bridges and analyze the forces involved in breaking the bridges.
- ☐ A first year GIFT fellow in Mechanical Engineering spent six weeks at Tsinghua University in Beijing, China. His Action Plan proposed to expose students to ADAMS/View Software used during his GIFT experience to simulate the importance of friction in sports.

The majority of the Action Plans reviewed also included a summary of summer experiences that were rich in engineering and evidence the teachers gained a great understanding of fields of engineering (Figure 7b,c). Many teachers also received materials and supplies that could be used in their classrooms, ranging in value from \$300 to \$1500 (Figure 7d). Materials included Petri dishes and chemicals to perform crystal growth and analysis, pocket PC's, Vernier probes, dataloggers and various lab supplies. Over 85 percent of the Communication Plans included opportunities for mentors to interact with students and share information regarding their field of engineering (Figure 7f,g).

## Conclusion

The GIFT program seeks to improve student achievement and better prepare students for the future workforce by providing teachers with rich, in-depth experiences in "real world" science, engineering, and technology-rich environments. By stressing changed teaching practice and the inclusion of inquiry-based strategies, GIFT assists Georgia teachers in better aligning their classroom instruction with the National Standards, thereby providing richer, inquiry-based experiences for students. The increasing involvement of engineering laboratories has provided teachers, and by extension their students, with increased exposures to a variety of fields of engineering. This exposure provides students with realistic applications of their science and mathematics content, and also increases their awareness of engineering as a possible future career. The current fluctuations in NSF funding and the weak economy unfortunately provide a substantial challenge to the program.

## REFERENCES

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- <sup>2</sup> Information about NSF RET supplements can be found at <http://www.nsf.gov/pubs/2003/nsf03554/nsf03554.htm>.
- <sup>3</sup> Information about HHMI supplements can be found at <http://www.ed.gov/pubs/AchGoal4/hhs.html>

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### Marion Usselman

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