Lessons Learned from the Implementation of a GK-12 Grant Outreach Program

Laura J. Bottomley, Elizabeth A. Parry, Scott Brigade, La Toya Coley, Laura Deam, Elizabeth Goodson, Jan Kidwell, Jessica Linck, and Brent Robinson

North Carolina State University/Washington Elementary School

Abstract

This paper describes the lessons learned from the implementation of a National Science Foundation GK-12 grant in North Carolina Public Schools. Nine engineering students, both undergraduate and graduate, have worked with two elementary schools and one middle school as science, math, and technology resources and co-teachers. They have worked with over 1500 elementary and middle school students and over 100 teachers to date.

Introduction

The outreach program at the College of Engineering at NC State includes a GK-12 grant from the National Science Foundation aimed at using engineering students from the university level to enhance math, science and technology instruction. The grant was written and put in place as a response to two perceived problems. First, national reports indicate that U. S. students in K-12 schools currently lag behind their peers in other countries in math and science achievement[1]. And second, recruitment efforts directed toward women have stagnated for many Colleges of Engineering at a mere twenty percent of incoming classes for the past several years. The problem seems to lie at the time when students are making decisions about their careers. Most students decide as early as middle-school but primarily during high-school. Outreach efforts are usually directed at these ages, but the expected increase in interested students does not occur. These phenomena point to a need to change traditional methods at both the university and K-12 levels. We have chosen to implement this grant at the elementary and early middle school level.

The original grant proposal included four goals[2]:

- Integration of science, technology and engineering topics with math, reading and writing
- Encouragement of underrepresented groups in science, math, engineering and technology (SMET) through role models and particular teaching techniques
- Teaching SMET content to diverse populations, including hearing-impaired students, students for whom English is a second language, and others

- Adaptation of SMET content to different learning styles

Participants in the program have realized that the success of these goals is dependent on the achievement of some additional, less obvious goals:

- Encouraging teachers to teach science at some depth, even though students are assessed on math and reading, but not science

  The State of North Carolina administers end of grade tests to students in every grade from third through twelfth. These tests measure competency in math, reading comprehension and writing. If a student fails to pass any portion of the tests, he or she is in danger of being retained at the present grade level. If a certain percentage of students passes the tests, teachers can receive a monetary bonus, while if a greater than certain percentage fails, the principal may be subject to losing her/his job. The stakes are high for both teachers and students. Science has no place on this playing field. If a teacher includes science lessons, the temptation is to skirt the surface of a subject, as teaching it at depth takes research, time and a certain level of comfort.

- Finding a way to convince teachers and university personnel to behave as collaborative colleagues who each bring different, valuable skills to the problem at hand

  Teachers in a university town are accustomed to guests from the university community coming in to schools to give brief lessons/lectures on certain subjects. Almost without exception, these visitors are asked in as experts on a certain subject, but are assumed to have little or no knowledge of matters of education. This is a phenomenon particularly seen at the elementary and middle school levels. The traditional relationship between teachers and university personnel is usually not one of equals. If a program aims to have long-term impact on the way that science is taught, the collaborating parties must establish a *collaborative* relationship. In order for this to take place, both sides must recognize themselves as equal partners. Otherwise, change is resisted and, usually, is not possible.

- Translating weekly classroom visits to the type of interaction that will have a measurable long term impact on the students, teachers *and* the school, including how science is looked upon and how it is taught

  The temptation of this type of program is to simply send university students into the classroom to teach science lessons, albeit including hands-on activities, that enhance current teaching. This may have impact on student learning, but it is unlikely to have long-term impact on science teaching and attitudes unless careful attention is given to planning and integration with the teacher. In addition, the activities are unlikely to yield long-term empowerment of the students unless they contain an inquiry-based component. Simply duplicating an activity that has been outlined, and maybe demonstrated to them, may not impact how students view science as a subject.

Several hypotheses are evident in the selection of these goals for an "outreach" program, which might better be termed a "long-term recruitment" program. The central one is that, although kids may decide on future careers at the high school level, they will not choose a career in science or engineering if they have failed to develop a love and/or appreciation for science, math and technology at the age when they decide what they are good at and what they like to do. THIS age is elementary school, probably grades three through five. Part of the assessment of this program establishes data to support this idea. A program in Canada has already assessed 15,000 students and suggested the same result[3].

These then became the enhanced set of goals for the NSF Engineering Fellows program. To measure the success of these goals, we had to enhance our set of rubrics originally outlined in the grant proposal as well.

Data were collected in the form of surveys given to students, parents and teachers at the beginning of the year. The student and parent surveys were repeated at the end of the school year, as well. The percentages of students scoring at or above grade level on end of grade tests were recorded, as math and general problem-solving skills were part of the GK-12 curriculum. In addition, numbers of students participating in voluntary events like the science fair and the science answer box were recorded. The results of these assessment tools from year one of the grant will be discussed in the rest of the paper. The NC State program operated at one elementary school in year one, but a similar, collaborating program at Duke University operated at another elementary school. They used a similar survey, providing some data for comparison[4].

Results from student surveys

The student surveys were designed to be given to any student in grades K-5, so that all students could be given the same survey. (The middle school survey was slightly more complicated, but contained the elementary survey as a subset for comparison purposes. Middle school data is not yet available.) Since kindergarteners cannot read, the survey used short, simple questions that could be read out by the teacher and graphic smiling and frowning faces for the students to indicate their answers. Teachers and assistants were asked to help the students make sure they knew what questions were asking, without suggesting an answer.

The first part of the survey consisted of four questions:

1. Is science fun?
2. Is science something you use all the time?
3. How often do you use science (every day, every month, every week, one or two times a year)?
4. Are you good at science?

The second part consisted of ten pictures, of which the students were asked to mark the ones they thought were scientists (see Figure 1). In actuality, the pictures are all of scientists.

Figure 1: Ten pictures of scientists for children's survey (Marie Curie, Elena Ochoa, Charles Darwin, Chien-Shiung Wu, Wilfred Denetclaw, George Washington Carver, Sally Ride, Albert Einstein, Carlos Gutierrez, Mae Jemison)

In the 1999/2000 school year at Combs Elementary, enrollment equaled approximately 480 students. The first survey was issued to teachers with a request to administer in October 1999. A total of 268 surveys was returned. The second, identical survey was given to children in June 2000. Of the second survey 236 were returned.

The data were collected by grade level and by ethnicity, as well as gender. Ethnicity was listed in one of six categories: African American, Asian/Pacific Islander, Caucasian, Hispanic, other identifiable, not known. Since the children were not asked to identify their own ethnicity, the last category was inserted for cases where teachers and researchers were unable to identify the ethnicity of the child in question. A breakdown of the respondents is shown in Table 1.

	African American	**Asian/Pacific Islander**	**Caucasian**	**Hispanic**	**Other, identifiable**	**Unknown**
Fall 1999	45	36	127	22	17	21
Spring 2000	34	39	137	8	18	0

Table 1: Children's survey respondents by ethnicity

For the fall 1999 survey, twenty-two children out of 268 answered that they were not good at science. This number was surprising. However, the school in the study, although very socio-economically diverse, hosts a number of children from the university community and has always placed an emphasis on science through a science specialist. (A survey is planned for January

2001 at a totally unrelated school in the same county for comparison purposes.) Of the twenty-two answering that science is not fun, eleven were female and eleven were male, spread relatively evenly across ethnicity. For the spring 2000 survey, fifteen children answered that science is not fun. Of those, nine were male and six were female. Figures 2 and 3 show the graphs of students answering "no" to this question.

Figure 2 indicates a decrease in the percentage (and also, incidentally the number) of children who indicated that they thought that science was not fun after one year of interaction with the NSF Engineering Fellows from NC State. This decrease does not seem to depend on ethnicity.

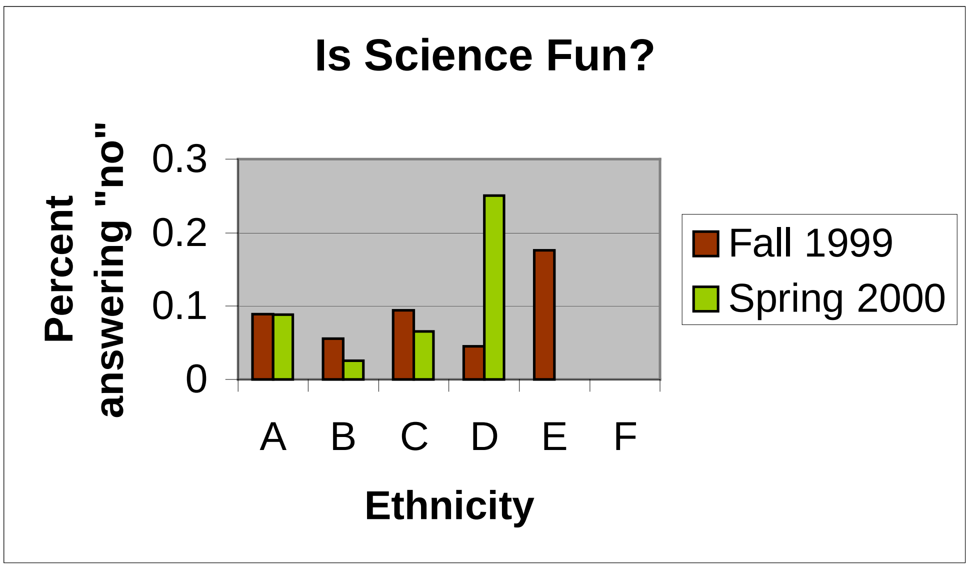

Figure 2: Students answering "no" to "Is science fun?" A=African American, B=Asian/Pacific Islander, C=Caucasian, D*=Hispanic, E=other identified, F=unknown

Survey data from Washington Elementary did not contain ethnicity, so comparison is not possible. Gender dependence in the Washington data is similar.

Figure 3 shows the students answering “no” to the first question as a function of grade level. Decreases are again evident from fall to spring, with the exception of fourth and fifth grade. In these two grades is also an indication of gender difference. In the spring, of the fifteen “no” answers, five came from girls in the fourth or fifth grade. Only one “no” answer came from a younger girl. More “no” answers came from the lower grades in the fall (20 out of 22 in grades K-3) than in the spring (6 out of 15), and the shift seems to have been caused by girls in the fourth and fifth grades. Since the numbers answering “no” are relatively small, it is hard to say whether this is significant or not, but we note it for future reference. It does seem to support the hypothesis that girls in grades four and five are deciding that they do not like science.

* The number of Hispanic students responding varied from twenty-two in the fall to eight in the spring. Of these students, one answered "no" in the fall and two in the spring.

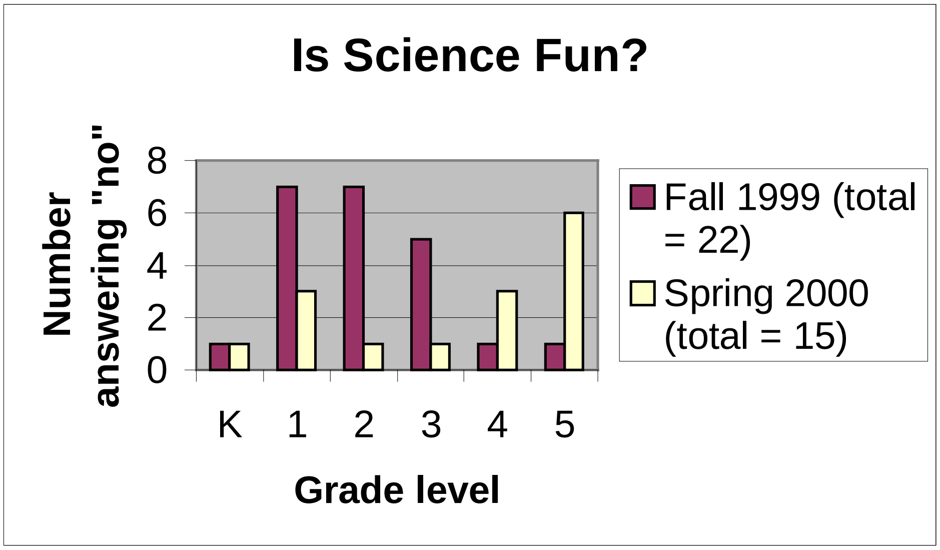

Figure 3: Students answering "no" to "Is science fun?" separated by grade level

The second survey question was "Are you good at science?" In the fall, 43 children answered "no" to this question versus 25 in the spring. The "no" responses were spread relatively proportionally across ethnicity, but reflected a greater number of second and third graders, as indicated in Figures 4 and 5.

In general, twice as many children responded that they were not good at science than that science is not fun. In the fall 20 girls and 23 boys answered "no," and in the spring 13 boys and 12 girls answered "no."

One point of note in the data was based on gender differences as a function of ethnicity. Table 2 shows the number of boys and girls answering "no" as a function of ethnicity. From table 2 the only clear gender difference is that more girl Asian/Pacific Islanders answered "no" in the fall. This difference disappears in the spring. This may have been due to the GK-12 program or may have been a statistical coincidence. This is an area to note in future surveys.

Fall/Spring	**A**	**B**	**C**	**D**	**E**
Girls	3/3	6/2	11/6	2/2	0/0
Boys	5/3	2/3	8/5	3/1	3/0

Table 2: Children answering "no" to "Are you good at science?" by gender and ethnicity

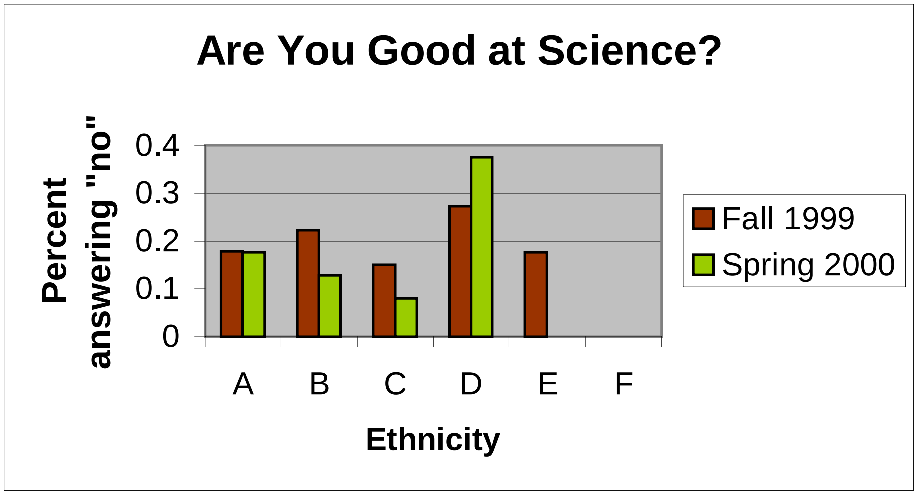

Figure 4: Students answering "no" to "Are you good at science?" A=African American, B=Asian/Pacific Islander, C=Caucasian, D[*]=Hispanic, E=other identified, F=unknown

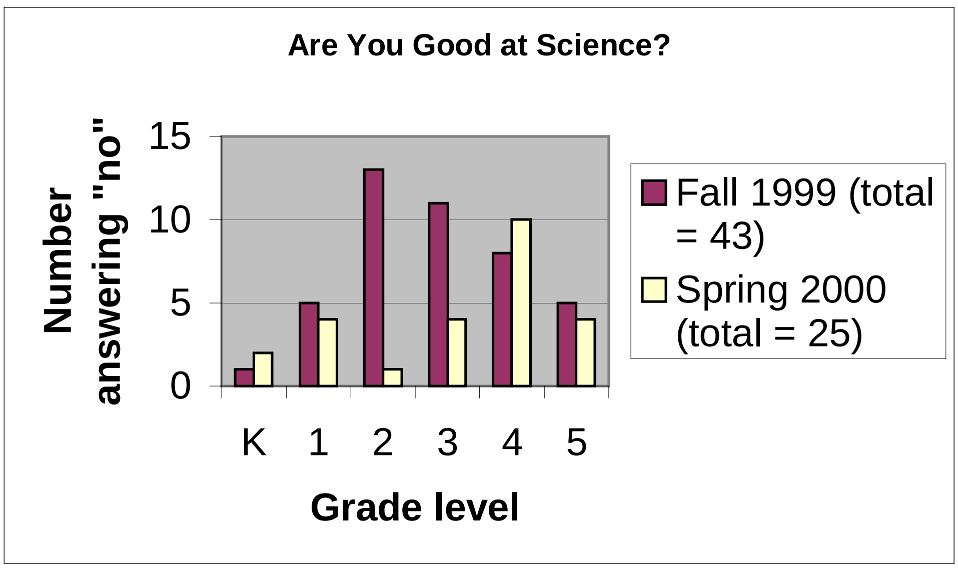

Figure 5: Students answering “no” to “Are you good at science?” separated by grade level

In general the shift of "no" answers upward in grade level tends to support the hypothesis that children in grades four and five are deciding that they are not good at science. In the fall, 30 of the 43 "no" responses came from grades K through three, and 13 came from grades four and five. In the spring, 11 of the 25 "no" answers came from kindergarten through third graders, and 14 came from fourth and fifth graders. The program seems to have had an effect in grades K through three. The effect in grades four and five might be seen when a survey is completed at an unrelated school. Although we did not ask about math in this particular survey, data in that area would also be interesting.

[*] The number of Hispanic students responding varied from twenty-two in the fall to eight in the spring. Of these students, eight answered "no" in the fall and three in the spring.

The same data at Washington Elementary versus grade level is depicted in Figures 6 and 7.

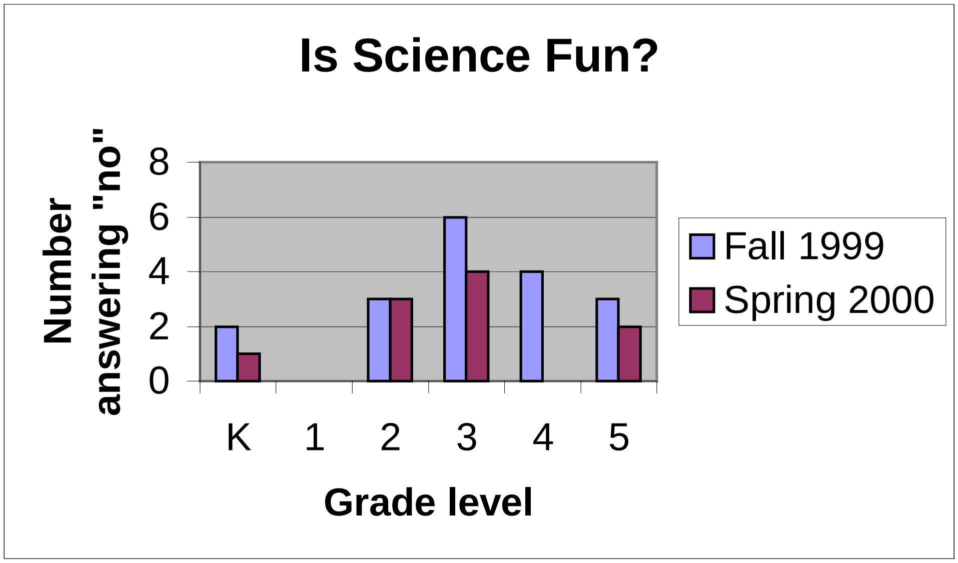

Figure 6: Students answering “no” to “Is science fun?” separated by grade level

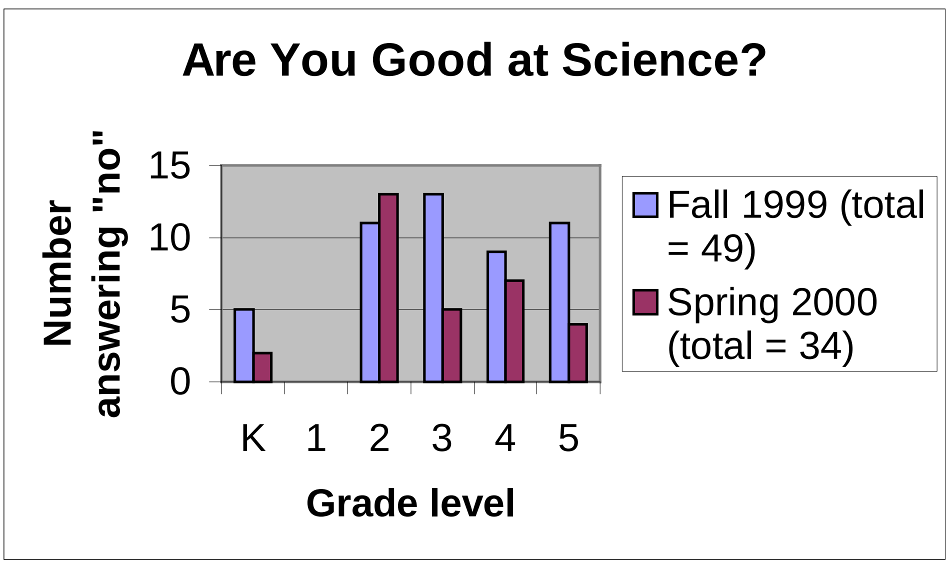

Figure 7: Students answering "no" to "Are you good at science?" separated by grade level

No data are shown for first grade due to the low number of responses in that grade. The same shift by grade level is not seen in this data, although the number of surveys returned is much lower for this school in the spring (293 in the fall versus 180 in the spring).

The final area of interest in the children's surveys is their identification of pictures as being of scientists. The results in this area defied hypotheses (namely that older children would reflect gender or ethnic bias over younger children). Figure 8 shows which pictures (from Figure 1) were identified as being of scientists. Only the chart from spring 2000 is shown, as there were not significant differences in the fall. The patterned bars correspond to male scientists.

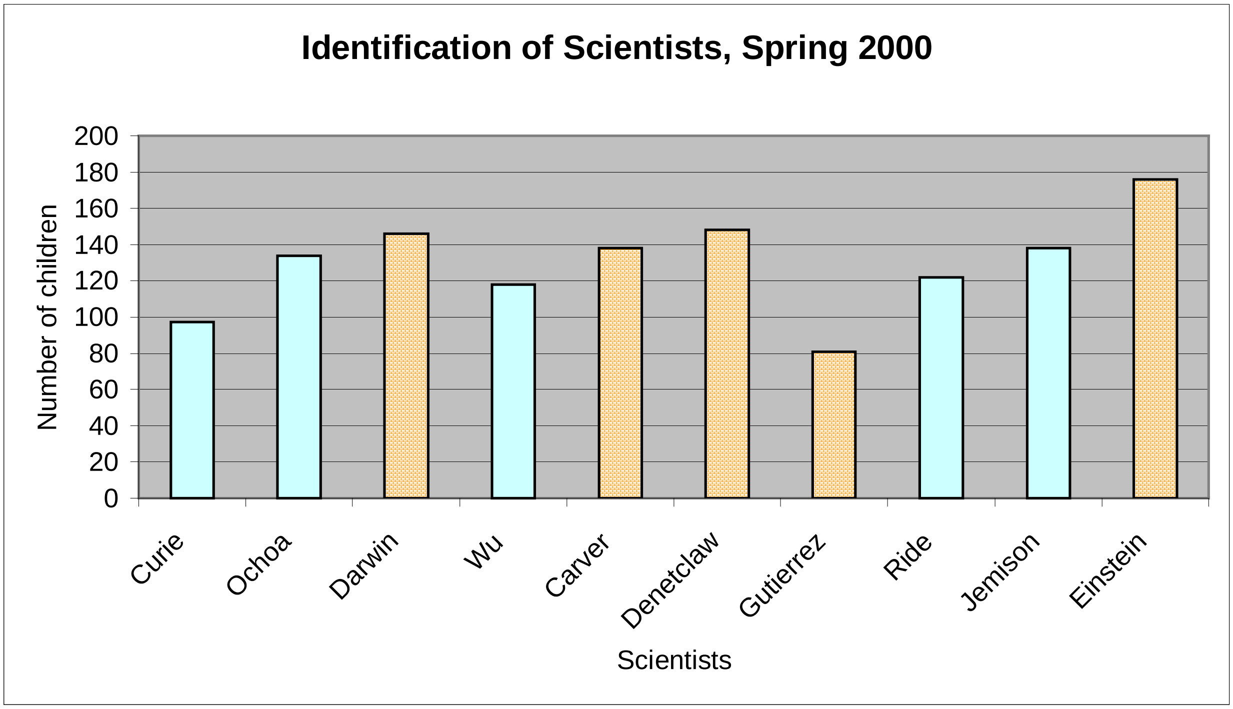

Figure 9: Number of children selecting pictures of scientists

The most striking dependence in this data is not that of gender or ethnicity, but that children showed a decided tendency to identify the smiling pictures as *not* being scientists when groupings of pictures are considered. One might be tempted to say that this also indicated a correlation with the age of the person depicted in the photograph, except that the unsmiling picture of Chien-Shiung Wu tended to be included in the grouping as being a scientist.

Teacher Surveys

Teacher surveys were given in the fall of 1999. A total of 13 responses was received out of a possible 26. The survey consisted of 24 questions asking questions designed to ascertain the teachers' attitudes toward the importance of science as a subject for children to learn and toward their own competence, preparation and enjoyment of science as a subject. In addition teachers were asked to indicate who they felt was their biggest influence in science. The survey was not repeated in the spring, as there was a general feeling that asking the teachers to do *one more thing* would cause more harm than good to the program in general.

Table 3 summarizes the results of the survey.

	Agreeing	Neutral	Disagreeing
As a subject, science is easy for me.	5	2	6
I like learning about science.	12	1	0
I enjoy doing science.	11	2	0
Science does not interest me.	1	1	11
I don't really understand much about science.	0	4	9
I feel very competent doing science.	8	1	4
As a student, I felt uneasy in science class.	3	2	8
I am well qualified to teach science.	7	2	4
My college training prepared me well for teaching science.	5	1	7
Science is a subject that is not very useful outside of school.	0	0	13
Students need a strong foundation in science.	0	0	13
Science is important for my students' future success.	13	0	0
I enjoy preparing for science class.	8	3	2
I have difficulty preparing good science lessons.	2	2	9
I feel very comfortable teaching science.	7	6	0
I feel unprepared when students ask questions about science.	2	3	8
I dislike teaching science.	0	2	11
I feel very competent teaching science to my students.	7	4	2
Preparing science lessons and tests makes me feel anxious.	1	6	6
I look forward to science class.	8	4	1
I am a good science teacher.	8	5	0
I am comfortable sharing science teaching techniques with other teachers.	8	3	2
I do not enjoy discussing science teaching strategies with other teachers.	1	1	11
I would like to observe other teachers' science classrooms.	11	1	1

Table 3: Teacher survey results, Fall 1999

The statements in the survey are displayed grouped into four areas, although they were interspersed in the original survey. The groups are attitudes toward science, opinions about the importance of science to their students, attitudes toward teaching science and willingness to collaborate in science teaching.

In general, the teachers stated that they like science and feel that it is very important for the future of their students. Teachers felt that their education did not prepare them well for teaching science, but a greater number now feel prepared. The confidence displayed by teachers in their science teaching was not overwhelming. Only about half the teachers said they felt very comfortable teaching science. The survey responses, however, indicated a willingness to collaborate in science teaching techniques.

Parent Survey Results

A parent was sent home with each child for their parents to fill out in fall 1999, followed by a slightly different survey in spring 2000. Parents were asked to note their feelings about science, their primary influences and the frequency with which they conversed with their children about science. In the spring survey parents were asked whether their children had talked more about science and/or math at home during the preceding year. The results for three of these questions are depicted in Figures 10 through 12.

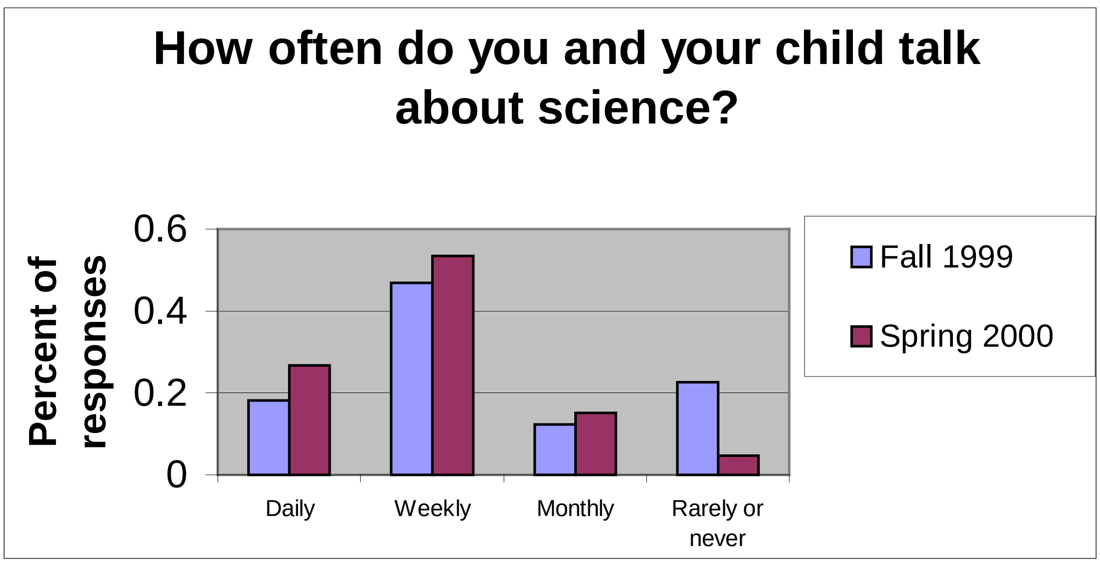

Figure 10: Parent responses to "How often do you and your child talk about science?"

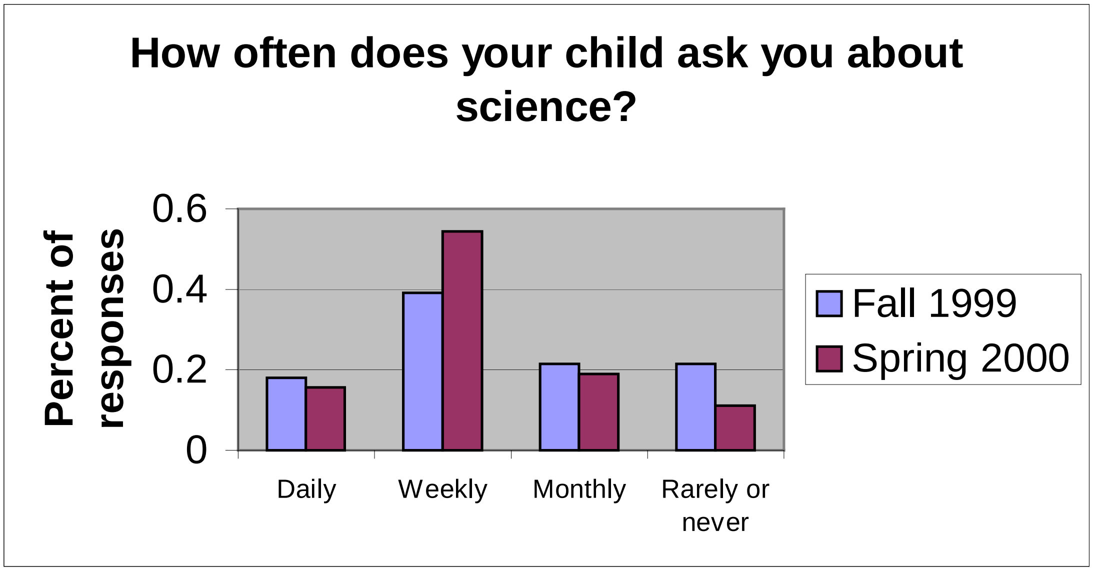

Figure 11: Parent responses to "How often does your child ask about science?"

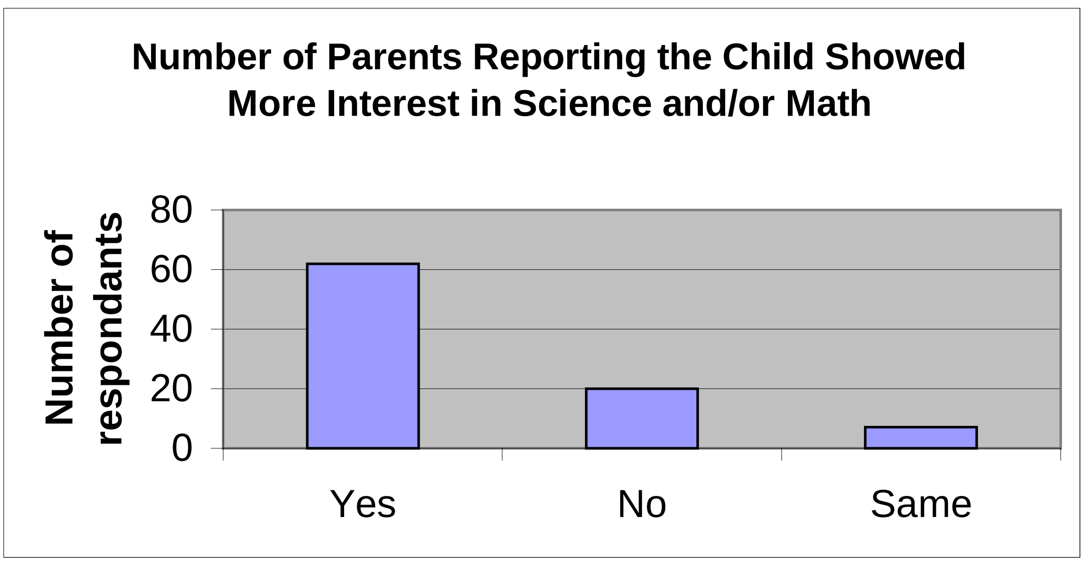

Figure 12: Parent responses to "Has your child shown more interest in science and/or math during this school year?"

According to the parents, the frequency with which they talked about science with their children and the frequency with which children asked about science increased significantly over the course of the GK-12 program's first year in the school. In addition, a large number of parents indicated that their children became more interested in science and/or math (about 2/3 said science and 1/3 said math) over the course of the year. Several parents mentioned the NC State university students who had worked with their children by name. Many wrote notes expressing thanks for the program. One parent stated that her feelings about science were now anticipation after interacting with her child about the GK-12 program at home, while she used to consider science boring and uninteresting. These surveys show a strong impact of the program with children beyond that reflected in the children's surveys. They also point to the idea that parent education may be as important as the education of children in changing the prevailing views of science, math and engineering.

Additional Assessment Measures

Some additional quantities are being tracked at each school the program works with. These include end-of-grade test scores (in the form of the number of students scoring at or above grade level), the number of children participating in the science fair offered by the school each year and any other changes put in place *by the school*, outside of the auspices of the program. Test scores are tracked as a measure of increased interest in learning that it is hypothesized the program could inspire, and number of science fair participants is tracked as a measure of interest in science. Science fair projects are required of fourth and fifth graders at Combs but are optional for all other students. Test scores for the 1999/2000 school year are compared with those of the year before the program began in Table 4.

	Third Grade		**Fourth Grade**		**Fifth Grade**	
	Math	Reading	Math	Reading	Math	Reading
1998/1999	86.2	88.5	93.3	76	100	87.9
1999/2000	86.3	83.3	100	98.6	91.8	90.4

Table 4: Percentage of students scoring at or above grade level of end-of grade tests, Combs Elementary

The number of students participating in the science fair in 1998/1999 was approximately 275, while the number participating in 1999/2000 was approximately 325. The interest level of the children seems to have increased.

Some changes put in place for the 2000/2001 school year included scheduling two family science nights and one family math night and focusing on science leaders for the month of February. In addition several teachers have used science in creative ways, independent of the program, including studying the book Bartholomew and the Oobleck using the scientific method and using science themes in bulletin boards.

Conclusions

Several conclusions are possible as a result of the data analysis. The GK-12 program clearly has the potential to make an impact on the way science is viewed and taught at the elementary school level. The beginnings of career pathways appear to be in elementary school as children decide which subjects they like and are good at, so future recruiting efforts may depend on the ability of science and engineering professionals to have a impact on school children starting with the very youngest.

References

[1] National Center for Educational Statistics of the U. S. Department of Education, *Third International Mathematics and Science Study*.
[2] Bottomley, Laura, Elizabeth A. Parry, et. al., "Engineering Students in K-12 Schools," *Proceedings of the 2000 American Society for Engineering Education Annual Conference*, June 2000, St. Louis, MS.
[3] McDill, Moyra and Marilyn A. Johnston, "Tracking the Gender Barrier Through Declining Interest in Technology," *Proceedings of the Ninth International Conference of Women Engineers and Scientists*.
[4] Ybarra, Gary, et. al., to be published.

LAURA J. BOTTOMLEY is the Director of the Women in Engineering and Outreach Programs at North Carolina State University and co-owner of Science Surround, a science education business for children. Dr. Bottomley received her Ph.D. in electrical engineering from North Carolina State University in 1992, and her MSEE and BSEE from Virginia Tech in 1984 and 1985, respectively. She has worked at AT&T Bell Labs and Duke University.

ELIZABETH A. PARRY is a former manager at IBM. She obtained her BS degree in engineering management with a minor in mechanical engineering from the University of Missouri-Rolla in 1983. She worked for a number of years at IBM before resigning to be a mom. She is now a co-owner of Science Surround and consults for the College of Engineering at North Carolina State University.

JAN KIDWELL is the Instructional Resource Teacher at Washington Elementary School in Raleigh, North Carolina.

SCOTT BRIGADE, LA TOYA COLEY, LAURA DEAM, ELIZABETH GOODSON, JESSICA LINCK, AND BRENT ROBINSON are students in the College of Engineering at North Carolina State University.