A Study of the Role of Research Scientists in K-12 Science Education

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THERE has traditionally been a gap between those who teach science at the K-12 level and those who do science. Few K-12 science teachers ever have science research experiences in their training; yet they attempt to teach students how science works. The true experts in science are research scientists; yet they are at universities, colleges and research institutions, and may have little to do with K-12 science education.

In recent years, there seems to be more attention being given to bridging this gap between scientists and K-12 science education. Many institutes and programs directed toward K-12 science education have utilized the expertise of scientists. (Alper 1994; Heinze et. al. 1995; Hermens 1995; National Science Foundation 1994/1995). The Center for Science, Mathematics and Engineering Education at the National Research Council (the operating agency of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine) has established Resources for Involving Scientists in Education (RISE). The mission of RISE is to "effectively engage the scientific community in the systemic reform of K-12 education" (National Research Council 1995). Interest in involving scientists in K-12 science education was also demonstrated by the Sigma Xi Scientific Research Society's National Forum on Scientists, Educators and National Standards (Sigma Xi 1994).

This study was intended to find out some details about the involvement of scientists in K-12 science education and their perception of K-12 science education. Such information should prove useful in determining how scientists might best contribute to K-12 science education in the future.

The Survey

A survey form was sent to a random sample of 500 recipients of grants from the National Institutes of Health. The survey consisted of six items:

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Table 1. Scientists' ratings of K-12 science education in the U.S.

	Responses (n = 169)	*% Response*
Poor	33	19.5
Fair	77	45.6
Good	41	24.3
Very Good	5	2.9
Excellent	1	0.5
Varies by school district	2	1.2
No response/not sure	10	5.9

1. How would you rate K-12 science education in the U.S.?
2. Have you done anything to assist K-12 science education in the past 12 months?
3. If yes, briefly list your specific activities in K-12 science education in the past 12 months.
4. If yes, approximately how many total hours did you spend in K-12 activities in the past 12 months?
5. Briefly describe the best ways scientists can be of assistance to K-12 science education. Place a checkmark next to those items that you personally would be able to participate in.
6. What do you think is the biggest problem facing K-12 science education today?

A total of 189 survey forms (38%) were completed and returned. Of these, 20 returned forms could not be used because they contained no responses or claimed no knowledge of K-12 science education. One scientist wrote, "I'm embarrassed, but I don't even know what K-12 science education is." Thus, 169 (34%) had useful responses that could be included in the results.

It is of interest that some scientists would take the time to claim no knowledge about K-12 science education and return the form, rather than make a quick phone call to find out what was meant by K-12 science education.

Scientists' Perceptions of K-12 Science Education

Table 1 shows the response to the question: "How would you rank K-12 science education in the U.S.?" Only one respondent (0.5%) rated K-12 science education as excellent; 46 respondents (about 27%) provided

Table 2. Scientists' activities supporting K-12 science education.

Activity	Individual Responses (n = 167)	% Response
Presentations to students	52	31.1
Provide student research opportunities	37	22.2
Science teacher enhancement	27	16.2
Participation in science contests	20	11.9
Work with own children	11	6.6
Miscellaneous support	10	6.0
Donate/loan equipment	6	3.6
Held position influencing K-12	4	2.4

a rating of good or very good; 77 respondents (about 46%) gave a rating of fair; 33 respondents (about 20%) rated K-12 science education as poor.

In a previous survey, college science teachers were asked: "What is your perception of high school preparation of students for college courses?" In this survey, only 1% considered the preparation to be excellent; 9% rated the preparation as good; 90% of the respondents considered high school preparation to be from fair to very poor (Druger 1985/86).

Obviously, many of the scientists surveyed do not have a favorable perception of precollege science education. This issue was not investigated further, but there seems to be room for considerable improvement in either precollege science education, in the perception of scientists, or both.

Scientists' Activities in K-12 Science Education

When asked: "Have you done anything to assist K-12 science education in the last 12 months?" Ninety-one respondents (54%) said yes, while 76 respondents (45%) said no. (Lack of an answer was scored as a "no" response.) The specific activities of the respondents are listed in Table 2. The four most frequent types of activities were: presenting lectures/demonstrations to elementary and secondary school classes (31%); sponsoring secondary students in lab/research apprenticeships (22%); teacher enhancement, including research apprenticeships for teachers (16%); and participation in science contests (12%). A few of the respondents held positions that influenced K-12 science education (e.g. member of an education committee, director of an outreach program).

Of the 91 individuals who said they assisted K-12 science education in the past 12 months, 46 (51%) indicated that they engaged in only one K-12 science education activity; 45 respondents engaged in 2–5 activities (Table 3).

Table 4 shows an estimate of the total number of hours that the 91 scientists spent in K-12 activities during the past 12 months. The average number of hours spent was approximately 26 hours, ranging from 1–5 hours to more than 1300 hours.

Table 3. Number of activities per scientist.

Number of Activities	Number of Scientists (n = 91)	% of Scientists
1 activity	46	50.5
2 activities	23	25.3
3 activities	16	17.6
4 activities	5	5.5
5 activities	1	1.1

The Best Ways Scientists Can Be of Assistance to K-12 Science Education

Scientists were asked to describe the best ways scientists can be of assistance to K-12 science education. Ninety-one scientists (53%) responded to this and 350 responses were given. The activities are listed in Table 5. Also, the willingness of respondents to participate in the specific activities they recommended is indicated. Three general categories of high interest seemed to be: presenting lectures/demonstrations in local schools; hosting students in lab internships; and working with teachers. The majority of respondents (58%) who suggested these activities indicated willingness to participate in them.

Some interesting points were raised with regard to scientists assisting K-12 science education:

- *With the present state of biomedical research in the USA, I would be unable to encourage young people to*

Table 4. Number of hours spent on K-12 science education.

Amount of Time	Number of Scientists (n = 91)	% of Scientists
1–5 hours	18	19.8
6–10 hours	13	14.3
11–15 hours	5	5.5
16–20 hours	9	9.9
21–25 hours	6	6.6
26–30 hours	4	4.4
31–35 hours	1	1.1
36–40 hours	3	3.3
20–40 hours	2	2.2
41–45 hours	1	1.1
46–50 hours	5	5.5
50–100 hours	6	6.6
200 hours	1	1.1
240 hours	1	1.1
1300+ hours	2	2.2
Didn't know number of hours	3	3.3
No response	11	12.1

Table 5. The best ways scientists can assist K-12 science education.

Activity	% Response (n = 350)	% of Response Willing to Participate
Presentations to students (Lectures, demos, career days, etc.)	24.5	65.1
Student lab internships	18.9	68.2
Teacher enhancement (Workshops, lab internships, advisors, etc.)	18.8	64.6
Develop curricula/materials (texts, labs, software, etc.)	9.7	47.1
Lobby for improvements (Administrative/legislative changes, etc.)	6.0	28.6
Science contests (Science Fairs, Olympiads, Days, etc.)	5.1	66.7
Serve as science ambassadors (Explain science to media, be role models, etc.)	4.3	53.3
Individual interactions (Tutoring, mentoring, counseling, etc.)	3.7	53.8
Extra-curricular involvements (After school clubs, summer camps, etc.)	2.8	30.0
Increase college participation (Make increased interactions easier)	2.8	10.0
Organizational involvement (School boards, textbook committees, etc.)	1.4	60.0
Miscellaneous support (Science museums, PBS, etc.)	1.1	50.0
Teach own children	0.9	66.7

consider this career. In spite of being actively involved in the lobbying efforts for several national organizations, I still am uneasy that we are poised to lose an entire generation of scientists.

- *I have no idea, but until such public service activity by academic scientists is rewarded by academic institutions (e.g. figures strongly and positively in tenure and promotion decisions) they will not, and should not be expected to contribute.*
- *Scientists in my position are fighting for their jobs because to be funded by the NIH (in my case) you must be in the top 10% of the applicants. To be this good, one must work 60-hour weeks, and still this may not be enough. I would love to help K-12, but it is not realistic for me.*
- *If there was a formal program at a local school asking scientists to talk to students, I would volunteer.*
- *Scientists can best be of assistance by simply being available to teachers and students in such capacities as seminars, tours, shadowing programs, show-and-tell programs, and other programs similar to the ones we already have in place. Programs include research programs in the lab for high school students and teachers, summer institutes for teachers, Saturday morning biology lecture series, and the Biology Bowl.*
- *Allow Ph.D. trained scientists coming out of University Science Departments to teach K-12. In most communities standard Ph.D. trained scientists cannot fill K-12 positions. We have a glut of Ph.D.s now; why not use them in primary and secondary education! These are people who are really scientists who know not only the facts but who also know the discipline and excitement of discovering these facts. These latter two pieces are often left out of K-12 science education.*

These comments should stimulate worthwhile discussion.

The Biggest Problem Facing K-12 Science Education

One hundred sixty-three scientists (96%) responded to this item and provided 272 responses. The responses are summarized in Table 6. By far, the biggest problem identified was inadequate science teacher preparation. One hundred eleven respondents (41%) identified aspects of teacher preparation as the biggest problem; 52 respondents (19%) identified issues related to funding and resources as being the biggest problem; 42 respondents (15%) identified perceptions of science as the biggest problem. Only 14 respondents (5%) targeted factors related to the schools and the educational system as the biggest problem.

Sample comments of interest concerning identification of the biggest problem facing K-12 science education included:

- *It is taught much too fact-oriented with little attention to how the facts are found and verified. The excitement of its disciplined flexibility and continual growth is rarely displayed. It is taught as a collection of fact-filled subjects rather than as an underlying thought process that has made our world vastly different from that of our grandparents and will surely make the world of our grandchildren unrecognizable by us.*
- *Science is best learned and appreciated by doing it. Many schools seriously lack proper laboratory facilities and resources.*
- *Not rigorous enough. Not enough independent thought processes are taking place. Students want to be spoon-fed material.*
- *Most science teachers I have encountered are improperly trained in science and often have little interest in their specialty. I strongly believe that high school science teachers should have their major in a scientific subject and that the education part be limited to a one-year diploma. The bogus Masters Degree in Education should be abolished. Science teachers should be instructed in the scientific method as well as in classroom techniques.*

Table 6. Perceptions of the biggest problem facing K-12 science education.

Problem	*Responses (n = 272)*	*% Response*
Preparation of teachers (Poor science backgrounds, insufficient opportunities for continuing education, isolation of teachers from practicing scientists, etc.)	59	21.7
Science teaching methods (Too much emphasis on facts, lack of interesting/dynamic teaching, poor use of technologies, poor depiction of what science really is like, etc.)	52	19.1
Inadequate resources available/Insufficient funds available	52	19.1
Lack of appreciation for science/Misunderstandings about science (On part of the general public, students, politicians, etc.)	42	15.4
Lack of interested, motivated students	16	5.9
School & educational system problems (Overcrowded classes, priorities, inequity among systems)	14	5.1
Miscellaneous (Lack of focused national goals, "general brain rot," etc.)	13	4.8
Low expectations/Dilution of standards	11	4.0
Student specific problems (Discipline, lack of parental involvement, etc.)	9	3.3
Don't know/Not sure	4	1.5

- *Dilution of standards. Schools should quit trying to be all things to all people, and get back to basics.*
- *The average student is not receiving sufficient education in science that impacts on their daily lives. Thus, they are more susceptible to quackery and religious or cult zealotry.*
- *Teaching science as if its "done," not that science is something we do.*
- *Society does not want to invest in scientists. Were science education more rewarding, we'd have better teachers. Also, I think we can invest in K-12 science teachers and support some of their research endeavors. This would produce more excitement and dedication on their part.*
- *Controversies about science are taught using the methods of the 17th century Catholic Church ["This is the correct position and all conflicting viewpoints are unscientific" (heretical)] rather than scientific methods as in bringing relevant data to bear on the issue. It is taught as dogma rather than as an intriguing, ongoing puzzle.*
- *Public education's goal is to teach to the average. It promotes mediocrity. The best people are not entering the teaching profession.*
- *The ranks of educators in K-12 are drawn from college education majors with only minor interests in science, instead of from science majors with minor interests in education. Archaic teacher's union systems ensure that scientists don't have part-time jobs teaching in K-12, although their expertise is exactly what is needed.*
- *Teaching is not a very good career option. We need to increase teaching salaries substantially and, at the same time, increase qualifications/training of teachers. How can teachers portray the excitement and process of science unless they have experienced it? Perhaps high school teachers should have sabbatical leave to work in research labs for one year.*
- *Teachers are not educated in hands-on science work or in science theory. Schools should hire specialists (e.g. university faculty on leave) to help fill in the gaps.*
- *Public schools are hostage to the NEA and spend too much time on nonessential items. They should stress science, math, and English rather than sex education and values classification.*
- *High school teachers must have a difficult time staying up with ever-changing + advancing technology + knowledge. They need continuing education opportunities & innovative ways of keeping their students interested in science.*
- *I don't know for sure, however, motivation of non-scientist students to learn some math and some science for understanding of current and future contributions of science and technology to their lives and jobs.*
- *Poor education of parents and a lack of appreciation of the benefits of science to society. We send a sad message to students by valuing entertainers/sports figures above teachers and doctors.*
- *Teachers in K-6 especially do not know much science, since they usually are regular classroom teachers. They tell kids things that are wrong, cannot answer questions beyond the superficial, and do not have time to set up experiments. Thus, unless there is a science teacher (which our school was fortunate enough to have for awhile) no serious science can be done until high school. High school teachers seem pretty good to me, from a small sample, but science at that level suffers from an image problem. Society mistrusts research; science is difficult; science is not fun.*

These comments should generate useful debate and discussion.

Concluding Comments

This survey was intended to identify specific perceptions and involvements of scientists in K-12 science education, not to make qualitative judgments about the merit of such activities. Clearly, scientists responding to the survey do not have a high regard for the quality of current K-12 science education or science teacher preparation.

About 54% of the respondents contributed to K-12 science education during the 12 months prior to the survey. This finding may be misleading, since 62% of the scientists who received a survey form did not return the form. This could be interpreted to mean that 62% of the scientists sampled either do not know what is going on in K-12 science education, or did not participate in any activities, or simply didn't bother to return the form. Apparently, some scientists who returned the form and claimed ignorance about K-12 science education lacked sufficient interest to even find out what K-12 means, although this information was easily obtainable.

This survey provides a variety of practical suggestions about how scientists can use their expertise to assist K-12 science education. We hope that scientists who read this article will find activities they would like to do. Yet scientists are busy doing research, obtaining and managing grants, contributing to science societies, and teaching at the college level. Can they realistically be expected to assist K-12 science education without detracting from their research and other professional activities? Should the role of scientists include responsibility for contributing to K-12 science education? These are questions that could be resolved on an individual level, but the answers could also be incorporated into institutional and societal expectations.

Our belief is that research scientists can individually contribute a reasonable amount of time to K-12 science education. If each scientist does so, the collective impact can be substantial. At the very least, scientists should make an effort to become aware of current reforms in K-12 science education. Knowing what's going on is a critical step in the right direction.

Personal experience indicates that, if asked to present an occasional lecture, or asked to do something on a short-term basis, scientists are willing to help. Long-term commitments are usually in conflict with their primary interests. Although it may be desirable to involve scientists in improving K-12 science education, there are many ways teachers can help each other make improvements. For example, in conducting workshops for science teachers, we have relied heavily upon a team of experienced teachers teaching other teachers, along with presentations by different scientists.

We have also initiated a program whereby talented

high school science teachers with expertise in a particular science topic (e.g. DNA technology) teach one-credit courses to other teachers. These one-credit courses (12.5 contact hours) are offered on a flexible time schedule and they emphasize content as well as pedagogy. Thus, teachers can learn about important topics from other teachers who teach these topics effectively in the high school classroom.

Another major, related issue concerns integration between K-12 science education and science education at the college level. The National Science Teachers Association has recognized this problem and takes the position that: "K-16 coordination is essential for effective, meaningful and developmentally appropriate science education." (NSTA Position Statement 1995/1996). The development of major reform efforts in K-12 science education (e.g. *National Science Education Standards* 1996; AAAS Project 2061 *Benchmarks for Science Literacy* 1993, 1995; and the NSTA Scope, Sequence and Coordination project 1995) further emphasizes the need for such coordination in the future.

We should be thinking of science education as lifelong learning and scientists have an important role to play in achieving this goal. If we are to improve science education, scientists and educators at all levels must at least be knowledgeable about what's going on at every level and work as collaboratively as possible.

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