

**Evaluation of The GK-12 Fellowships to Enhance Science Education in Oregon Schools**

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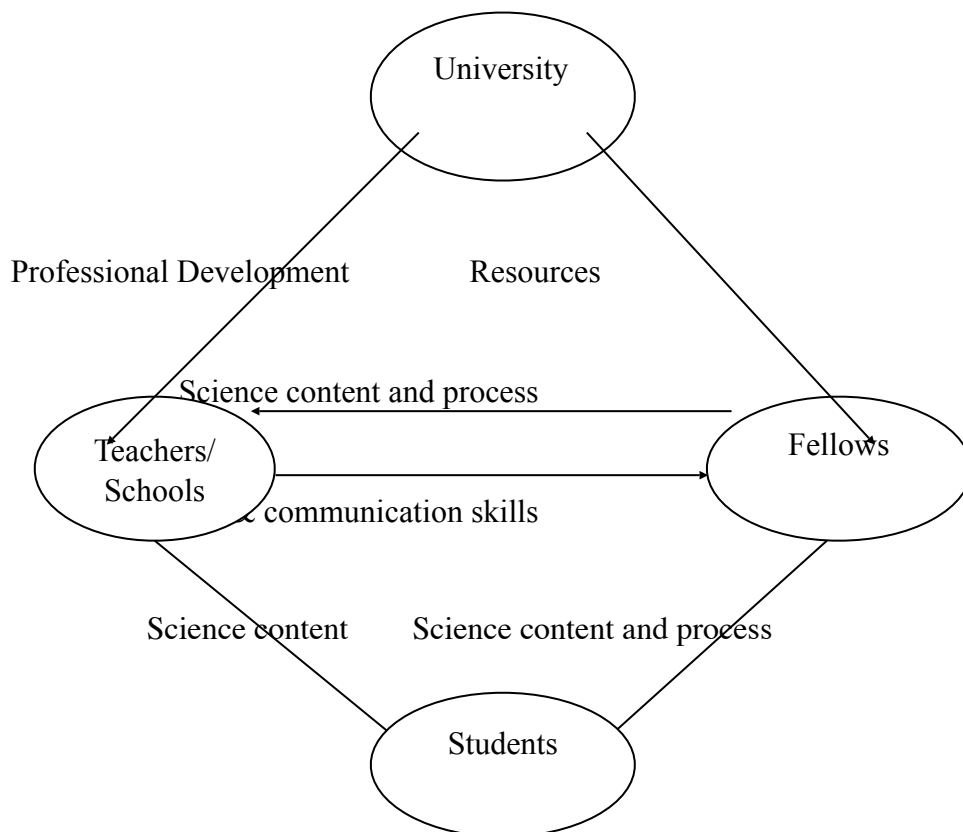
## **Introduction**

Enhancing science literacy in the general population has been the focus of much educational research in the past two decades. A key component of improving scientific literacy for all is a sound understanding of the nature of scientific inquiry. Science teachers' understanding of the nature of scientific inquiry is a critical part of efforts to increase scientific literacy (National Research Council, 1996, 2000; American Association for the Advancement of Science, 1989, 1993, 1998). However, teachers who lack training in methods for teaching inquiry and who do not have access to adequate teaching materials may be more reluctant to use inquiry-based methods that stress the processes of science (Caton, Brewer, & Manning, 1997). Research indicates that scientist-teacher partnerships have the potential to positively influence science instruction and learning in K-12 classrooms (Falk & Drayton, 1997; Caton, et al., 2000). As teachers carry out investigations with scientists, they often develop greater enthusiasm for science, deepen their understanding of scientific processes, and gain greater confidence in their ability to teach science using inquiry-based methods (Caton, et al., 1997).

In order to support scientific literacy through scientist-teacher partnerships, the National Science Foundation (NSF) initiated the Graduate Teaching Fellows in K-12 Education program (GK-12) (National Science Foundation, 1999), a three-year grant program whose intention is to construct partnerships between university graduate students and K-12 teacher. Graduate students in science, engineering, mathematics, and technology partner with classroom teachers, collaborating to create curriculum which demonstrates key concepts, helps students understand scientific processes and habits of mind, provides role-models of science professionals, help teachers increase their content knowledge, and assist with instruction. The graduate students also serve as a link to resources which the university can provide. The expected outcomes include improved teaching and communication skills for fellows, improved learning by K-12 students, increased professional development opportunities for teachers, and stronger partnerships between universities and nearby school districts. Figure 1 outlines the outcomes in the collaboration model anticipated from the NSF.

Studies on GK-12 programs suggest that university students who serve as collaborators in science curriculum planning not only enriched the school science content and activities (Bruce, et al., 1997), but also had a better opportunity in the course of the collaborative relationship to learn and reinforce their own understanding of inquiry-based learning and its value (Thompson, et al., 2002). As the school teacher and students are exposed to authentic, inquiry-based research which the scientist brings to the classroom, both teacher and students become active learners and enhance their content knowledge of science (Herwitz & Marion, 1996).

Figure 2. NSF's expect outcomes of the partnerships



Although most research studying the partnership programs had reported positive effects on students, fellows, and teachers, most programs did not operate without challenges. Sustainability probably was the issue that most collaboration programs were concerned about, such as looking for funding, and recruiting scientists. In the instance that university students served as resource role, whether science contents and science were to be delivered appropriately by the science students was another issue that the partnership programs were addressed.

### **The GK-12 Fellowships to Enhance Science Education in Oregon Schools**

The GK-12 Fellowships to Enhance Science Education in Oregon Schools, a project operating from the Oregon State University campus, is funded by the National Science Foundation GK-12 program. The project is currently in its third year of operation. The OSU GK-12 Fellowships project puts graduate science students into K-12 classrooms in western Oregon to assist schools in improving their science programs, with the overall goal of facilitating active science and mathematics learning in K-12 schools. The emphasis is on inquiry-based learning in order to assist students in meeting Oregon's state benchmarks. The graduate fellows work directly with teachers in the classrooms, teaching lessons, developing new activities, arranging field trip, and bringing their own resources and expertise to the classroom. The program coordinators defined five themes designed to meet the goals of active science learning:

1. *Inquiry-based learning* — Inquiry-based learning involves activities which encourage students to ask questions and search for meaning, with the goal of increasing student content learning and student engagement with science. Elementary schools in the program used science kits to facilitate inquiry learning, while middle and high schools used laboratory exercises.
2. *Communication of content* — Fellows were to play an important role in communicating science content, under the assumption that their content knowledge would be different from or greater than that of the teacher. The fellow was to act as a resource for scientific knowledge.
3. *Use of appropriate learning styles* — The activities taught needed to be appropriate for the age of the students and the school setting, with sensitivity to individual learning needs, school climate, and diverse cultural backgrounds.
4. *Use of technology* — The fellows were to enhance the use of appropriate technology in their classrooms, including the use of computers, development and use of new software, and other learning technologies.
5. *The research paradigm* — As the fellows were engaged in their own research, it was expected that they would communicate the research process as part of their teaching.

Program implementation took place in three phases. Phase I consisted of summer training for fellows and teachers, conducted by the Department of Science and Mathematics Education on the Oregon State University campus, in which fellows were introduced to teaching methods and to the Oregon State standards and benchmarks. Phase II was the in-school engagement phase, where fellows worked with one or more classes in the schools every week. Phase III was an extended outreach phase, where fellows participated in many different outreach programs, including working with science museums, weekend science programs, and science clubs.

The purpose of the evaluation was to examine the impacts of the program on schools during the 2002-2003 school year. The questions driving the evaluation were:

- Are the NSF's expected outcomes of the GK-12 program being achieved?
- Are the five goals of the OSU GK-12 project being met in the classroom?
- Are participating students learning science?
- How do teachers, fellows, and students perceive the impact of the program?

### **Selection of case studies**

In order to evaluate program impacts, the evaluators selected eight fellow-teacher partnerships to examine as case studies. Purposeful selection was used to identify cases which would reflect the widest range of schools served. Eight partnerships were selected. Four cases were at elementary schools (grades K-5), two at middle schools (grades 6-8), and two were at high schools (grades 9-12). One was an urban elementary school, one was a rural school serving a Native American community, and the remainders were in suburban settings in small cities. Table 1 summarizes the placement and backgrounds of the selected fellows.

Table 1: Placement of graduate fellows selected for the evaluation

<b>Fellow</b>	<b>Department</b>	<b>Program year</b>	<b>Teacher</b>	<b>School level</b>	<b>Setting</b>
WB	Math	PhD, year 6	TP	High	Suburban

JK	Chemical Engineering	MS, year 1	TL	High	Suburban
EG1	Crop and Soil Science	MS, year 1	JG	Middle	Suburban
EG2	Zoology	PhD, year 2	CO	Middle	Suburban
CB	Fish and Wildlife	MS, year 1	SK	Elementary	Suburban
MM	Zoology	PhD, year 4	JB	Elementary	Suburban
TS	Bioresource Engineering	PhD, year 6	LR	Elementary	Urban
KS	Environmental science	PhD, year 4	PW	Elementary	Rural

## Data Sources

Classroom observations were conducted to observe at least one lesson taught by each of the fellows. Field notes were taken during the observations. Semi-structured interviews were conducted with teachers and fellows selected for study. Interviews were scheduled to occur on the day of or shortly after the classroom observation. A list of open-ended questions was drawn up for each interview (see Appendix 1), though the interview format was kept open enough to allow fellows and teachers to talk about issues and events that they perceived as important. All interviews were audiotaped and transcribed for coding. Follow-up questionnaires, 3 questions for the fellow and 2 questions for the teacher, were sent via email to all participated fellows (Appendix 2) and teachers (Appendix 3). The teacher's follow-up survey was focused on the aspect of their professional development. The follow-up survey for fellows asked about the outreach, the partnership, and their advisor's attitude to their participation in the program.

At three schools where the evaluators could make arrangements, groups of students were interviewed using an open-ended interview format. Students were asked to recall the events they remembered best about science during the year, how science was different with the fellow in the classroom, and what they thought they, the fellow, and their teacher had learned from the experience. Several schools had science nights, in which families came to the school to participate in science-related activities. This provided an opportunity to conduct interviews to willing parents, asking them to describe what their children have reported about science class. The interviews were audiotaped and transcribed for later coding.

The classes from which the focus groups were drawn were also asked to fill out an open-ended survey (Appendix 4) asking them to describe and to draw a picture of themselves doing science in their class. At the family science nights, a 4-question survey (Appendix 5), which asked the parent's awareness of the GK-12 project and perception of their child's attitude toward learning science, was also provided at the site for willing parents to fill out.

Quantitative data will also form a part of the final report. Fellows were asked to conduct pre- and post-tests of science content with their classes and in classes where they did not teach. Three fellows followed through with the request, and two of them were able to give pre- and post-tests for content to the classes which they had interacted with on a weekly basis as well as to classes where they had never or had only been a guest once or twice during the year. The Beliefs About Science and School Science Questionnaire (BASSSQ) (Chen, 1997) survey (Appendix 6) of student attitudes toward science (Appendix 7) was to be administered twice during the school year to measure changes in student attitudes during program participation. However, due to some miscommunication, only pre-survey was carried out. No post survey was gathered. Details of the data collected were displayed in table 2.

## Analysis

Field notes were typed into a word processor and all audiotapes were transcribed for coding. Analysis proceeded from a deductive framework, beginning with a search for evidence concerning the five themes of the program. Data were entered into Atlas-ti qualitative analytical software for coding. During the coding process, issues that were not part of the deductive framework emerged, and were inductively coded. The inductive-deductive cycling brought to light evidence concerning the five themes of the program, as well as evidence of themes that were important to the participants. Both researchers cycled through the data multiple times, then compared coding schemes and negotiated points of disagreement to develop a single coding scheme.

Table 2. Data sources collected

Subjects	Qualitative method	Quantitative method
Fellows	<ol style="list-style-type: none"> <li>1. 8 case study in 8 diff. schools:               <ul style="list-style-type: none"> <li>- At least 1 period of classroom observation in each school (4 elementary, 2 middle, &amp; 2 high)</li> <li>- Semi-structured interviews with 8 fellows (30 min each)</li> </ul> </li> <li>2. Follow-up questionnaire (12 returned)</li> <li>3. Instructional logs</li> </ol>	<ol style="list-style-type: none"> <li>1. Pre-survey (BASSSQ) (none collected)</li> </ol>
Teachers	<ol style="list-style-type: none"> <li>1. Semi-structured interviews with 8 collaborating teachers (30 min each)</li> <li>2. Follow-up questionnaire (10 returned)</li> </ol>	<ol style="list-style-type: none"> <li>1. Pre-survey (BASSSQ) (45 returned)</li> </ol>
Students <ol style="list-style-type: none"> <li>1. Elementary &amp; Middle</li> <li>2. High</li> </ol>	<ol style="list-style-type: none"> <li>1. Open-ended interviews with 5 focus groups at 4 schools (5-10 minutes each)</li> <li>2. Follow-up questionnaire (100 surveys returned from 3 schools)</li> </ol> <ol style="list-style-type: none"> <li>1. Follow-up questionnaire (5 surveys returned from 1 schools)</li> </ol>	<ol style="list-style-type: none"> <li>1. Pre-survey (ESTES) (322 returned)</li> <li>2. Pre-content-test<sup>1</sup></li> <li>3. Post-content-test</li> </ol> <ol style="list-style-type: none"> <li>1. Pre-survey (BASSSQ) (42 returned)</li> </ol>
Parents	<ol style="list-style-type: none"> <li>1. Open-ended interviews with 7 focus groups at 2 schools (5-10 minutes each)</li> <li>2. Follow-up questionnaire (17 returned from 3 schools)</li> </ol>	

<sup>1</sup> Pre- & Post-content tests were based on 1 unit taught

Quantitative data were recorded into a spreadsheet software program for statistical analysis. Pre- and post-tests were compared using a simple paired t-test. Quantitative data were triangulated to qualitative data in support of the findings.

## Results

### Roles of Participants

#### *The Fellow's Role*

Fellows had identified their role in the GK-12 project as collaborative teaching; a supplement; bringing science in; bringing new ideas, resources to teaching science; supplementing in science curriculum; being sort of a role model of what scientist is; doing more participatory activities with the kids; helping to develop lessons/experiments; providing expertise for their expert area; and being an outside expert, more to advise the teacher on content than on teaching. During the interviews with the fellows, they reported:

I see myself kind of as a supplement. ... Also, I think my job is supposed to bring new ideas to teaching and new ways they could teach science to kids. (Fellow CB)

I guess I feel like I am in the classroom to supplement the science that is being taught.... And also to be sort of a role model of what a scientist is. (Fellow EG)

I see my role in the school as sort of an outside expert, more to advise them on content on than on teaching. (Fellow MM)

Teachers' view of the fellow's role was consistent to that of the fellow's. They realized that the fellow was not there to relieve them of their duty. Teachers expected the fellow to impart knowledge to them and students, model science teaching, enrich science curriculum, bring in other resources into the school, lift up levels of students' questioning skills and help students make connection with what they were learning. Teachers at the interviews stated:

We know how it is. We know that she's not in here to relieve us of duty and to do a prep but to model science teaching, or to model science really, to talk about science, to help kids, you know, to just kind of lift those levels of questioning up a bit and have them exposed to that type of thing. (An elementary school teacher SK)

I see it as the fellow having more knowledge than myself will impart the knowledge to me and the students. (A middle school teacher CN)

The fellow's role should be that being able to enrich our science curriculum, and to also help us extend what we're already doing with her expertise. I think the important role is also to bring in other resources into the school, and of course to suggest and help the teachers at [the school] make science curriculum more meaningful, to help students make connection with what they are learning. (An elementary school teacher JB)

#### *The Teacher's Role*

Teachers considered themselves playing the role of assisting and educating the fellow with teaching methods; strategies for communicating with children; dealing with student behavior; classroom management; adjusting the pace and level of instruction, evaluation; and closure. Teachers thought that their role basically stayed the same as without having the fellow in the classroom, and the fellow was there as additional resources for them. Teachers during the interviews stated:

I think my role is all about teaching strategies and delivery. A big part of that would be

classroom management and adjusting the level of instruction, content, pace of the instruction, things like um closure that teachers need to think about, evaluation, all those little kinds of teaching strategies. That's what I provide. (A middle school teacher JG)

The teacher's role, they are still teachers. The purpose is not for the science fellow to come in and be the science teacher. The idea is we don't want the fellow coming in and the teachers just take off and do something else. The teacher's role stays the same. The science fellow is just wonderful resource that we have and to help us implement the science curriculum. (An elementary school teacher JB)

And I think in turn I have been able to educate the fellow in educational teaching methods and models on this.... I was always there to help, but I see my role as helping them learn that. I mean, that's not their intent, they're not going to learn teaching methods because most of them are not ready to go teaching. However, they can't do a good job unless they have the ability to do the lessons well. (A middle school teacher CN)

Fellows also viewed the teacher's role as helping them communicate with children appropriately; discipline the class; prepare children with basic background information for hands-on activities; advise them on teaching strategies; and provide administrative information as needed. Fellows in the interviews responded to the teacher's role as:

I guess the teacher's role is more like they're there to help me see problems the kids may have in situations where it's not -- appropriate level-wise.  
And so I guess that's part of what the teachers do, is to do some of the prep work with the background activities so I can do more participatory activities with the kids. (Fellow EG)

I mean classroom management for one thing, they do a really good job with that, that's why I would hope that is their role. And also to help teach me the little things to ask, the little ways to break things up, instead of saying, "Okay, here's your little things to do right now," (Fellow CB)

Te teacher's role -- he is to me is someone I know is responsible for helping me in the school. And even as much as a not necessarily [?], because most of the time I think if I need to talk to any of the teachers I just talk to the teachers, I don't really go through him, it's just easier. But any questions I have about how the school is run, or any questions I have about staff meetings or anything, administrative or just structure in the classroom, what teachers normally do, if I need help even with coming up with a lesson, I can go to him for ideas. He's sort of my contact to the world of the elementary school teacher, and any aspect that I'm not familiar with, I can go to him as a resource. (Fellow MM)

## Science Content, Process, and Attitudes

### *Effects on Students*

The teachers interviewed all expressed the belief that students were benefiting from having the graduate fellows in the classroom. The teachers believed that student learning of content was improved by having someone in the classroom who knew the science.

Kids are using vocabulary that we haven't heard for a long time. And I really appreciate that. But watch the way these kids take ownership of what's going on now. It's really great. And it comes up to their writing as well. If you get to pick a chance for them to free write whatever a lot of things refer back to what have been doing in the treatment, it's going to be like that's cool. The kids do keep journals, so they have something to refer back to. (An elementary teacher LR)

Science fellows bring in very enriched vocabulary, different vocabulary, which is wonderful for the kids. Sometimes they get the same concept in a different way.... So the



science fellows bring in the vocabulary that we don't have because they are experts. An example might be that right now we are doing structures of life unit, and [the fellow's] expertise is zoology. That's just perfect. She brings in the information. (An elementary teacher JB)

And certainly the content, the kids have been exposed to content that they wouldn't have been otherwise. Just because of the expertise that the fellow brings to the classroom. (A middle school teacher JG)

Results from quantitative data also supported the teachers' statements. Students experienced learning gains in science during the time that the fellow was assigned to the school. Finding control groups for comparison was difficult; however, one fellow assigned to a larger elementary school was able to give pre- and post-tests for content to the classes which she had interacted with on a weekly basis as well as to classes where she had only been a guest once or twice during the year. A paired t-test showed that all four of the classes in which the fellow taught weekly and was able to test showed statistically significant learning gains on the post tests (p-values ranging from .04 to .0001). Of the three classes she had only visited but was able to test, only one class showed significant learning gains. One showed small gains that were not statistically significant, and the third showed a decrease in scores from pre- to post-test.

When the student was asked in the student survey about how the fellow had helped them learn science, most students mentioned that hands-on activities, experiments, and/or field trips the fellow provided to the class helped them learn science.

She (the fellow) does fun things like the erosion experiment (experiment) were fun and they taught (taught) about things being eroded. (A 5<sup>th</sup> grader)

[The fellow] showed us science in interesting ways. For example, fun with our "little critters" in "Wave Wars" how an animal might have adapted to being crashed by waves. In other words, we experienced AND learned about science we didn't just learn about it. (A middle school student)

She (the fellow) explained complex processes to us, with the HPLC machine. She let us use the lab at George Fox University, which gave us a hands-on experience with complex machinery. (A high school student)

Nevertheless, although students could name several outstanding events in the science year, some did not recall and understand the science behind the lesson. When interviewing a first-grade student what she had learned from her science class, the student immediately recalled having learned bugs and plants. When the interviewer further asked what she had learned about bugs and plants, she could only describe details of what she had done in the class, such as cutting, pasting, folding a butterfly out of paper. A group of middle school students in the interview also vividly recalled a demonstration that the fellow had done with liquid nitrogen. A group of elementary students remembered a unit on flight which involved flying model airplanes, building environments for lizards, and looking at preserved frogs in a jar.

Interview with 5th grade students:

(S): The first time when she came we did airplanes, and that was kind of fun.

(I): What did you do with airplanes?

(S): Like we twisted them up and put them on a string and flew them across the room or across our chairs or something.

(I): What did you find out from that?

(S): That um, uh, it was just really fun. I don't know what it was really supposed to be about.

### *(Science Process)*

#### *Attitude toward Science and Scientist*

Students seemed most interested in talking about how science was more fun with the fellow in the room. They appreciated the fellows' science knowledge and viewed the fellow as an expert. Some students, especially at elementary level, expressed on the survey that they did not like science till the fellow came to teach the science class:

He (the fellow) answered all the questions we asked. He also made all of the labs he did fun. (A middle school student)

[A fellow's name] was a great scientist. She made it easy for me to understand what she was talking about. I usually don't think science is fun but [the fellow] made it fun. (A 5<sup>th</sup> grader)

Before [a fellow's name] came I didn't like science but [the fellow] made me realise that it was fun. (A 5<sup>th</sup> grader)

To some other students, science became a new topic to talk about at home. One middle school student in the student surveys revealed:

When I get home from school, my parents ask me what I learned and I could tell them a lot of things. Sometimes, when they don't even ask, I just tell them all the cool things and most of those cool things are in science with [the fellow]. (A middle school student)

Teachers and parents also strongly perceived the positive attitude that students held toward science and learning science due to hands-on activities the fellow had brought into the class. One teacher at the interview stated:

But they really are enjoying science, it's a real positive thing, and I'm sure that's because of the inquiry base. And it's real hands-on stuff.  
... I mean, and their parents when they came in for conferences said, "I don't know what you're doing in science, but boy, they just love it!" And I say, "Ask them to talk to you about it." (An elementary school teacher SK)

One middle school teacher observed that students developed more positive attitude in learning science was because students looked up to the fellow who represented as a scientist, as opposed to herself, a teacher, to them.

But what I think is really important about having the fellows teach is the relationship that is developed with the students and it is very different from the relationship with me as a teacher. The fellow doesn't have to be the disciplinarian. The fellow usually has less discipline problems because the kids sense there's a difference. The fellow is able to -- there is respect for the scientists in them that they don't have for me. The kids really look up to the science fellows. To me that is one of the crucially important parts. They look up

to them, they learn. (A middle school teacher CN)

The collaborative fellow with the above quoted teacher attributed the explanation to more hands-on activities that she had had with the students in the science class than other classes remaining on the day.

An obvious change of the student attitudes toward scientist is students could put a human face on scientist. 'Scientist' to most students was no longer someone who was male and wore white coat and goggles. Two elementary school teachers at the interviews reported:

I think the most outstanding that has come up is when I first started the program 3 years ago, I had my kids talk about what a scientist looks to them. We had no one in the building at all. And a scientist is generally a male, with white coat doing something. And as soon [a fellow], the first fellow, was here, the kids were totally [?] because he was so down to earth. Kids looked at him and "wow". (An elementary teacher LR)

What a positive role model, too, you know, here you have a female and a scientist, you know, working in the schools and they know she's at the university and stuff, so the whole thing is a plus. (An elementary school teacher SK)

Although most lower-grade students, such as 1<sup>st</sup> and 2<sup>nd</sup> graders, might not be able to distinguish the fellow as a scientist versus as a teacher, for older students, seeing a real scientist in action helped them understand the reality of science being a career option. One middle school teacher at the interview stated:

I think the kids have seen a professional scientist, and I think they've been able to relate a lot of the things I've talked about, a lot of the concepts, to what the scientist actually does at the university. There's always that communication between the fellow and the kids. So I think that they have kind of looked at this scientist as, whoa, there really is someone out there who uses this you know, these process skills, and they need to understand this stuff, because they do it for a living. (A middle school teacher JG)

One other middle school teacher also reported that her students, after participating in a field trip, had realized that they could be a scientist by doing something they loved. The teacher recalled the event:

I remember last year, one of the activities we did was we visited Kristen's lab on campus. We also visited other labs. And so there was a woman who did some snake research, and so we got to go through her lab and see all the snakes. And I remember the question was asked of her, something about why did you choose to do this. And she would confide that ever since she was a kid she'd always loved snakes. And she always realized that it didn't have to be a hobby, but it could be her job. I remember watching a couple of the kids' eyes, that concept that they could do something that they loved. And I don't know if that will influence them. My hope is that it will, that they will realize that they can be a scientist. (A middle school teacher CN)

Nonetheless, in some cases, the way students perceive what science and scientist are may heavily depend upon how the teacher presents the scientist to them. One fellow mentioned how a teacher made students feel proud of being a scientist by wearing a lab coat: And actually, how they view a scientist, that's interesting that you brought that up, because in one of the second grade classes, the teacher did this scientist of the week

thing, and so every week she would choose one of her kids to be scientist of the week, and they got to wear a lab coat on Friday, and they got their picture taken, and it was really great because she really wanted them to see themselves as scientists. They can wear the white lab coat, and, you know -- and you can be a scientist when you do good observations and if you [?]. (Fellow MM)

### *Effects on Teachers*

Teachers were strongly aware that they themselves were influenced by the project. All teachers reported that they were learning science from their fellows, and all were appreciative of the time the fellows spent in finding or designing activities that the teachers could keep on file. Some teachers at the interviews addressed that watching someone expert in the area taught science helped them gain confidence in teaching science:

And I have to be real honest. I used to rely on them (fellows) a lot more because my knowledge was less in the beginning. My knowledge has increased a great deal having had exposure with the fellows over the years. So, I have more knowledge in science. So, I didn't understand some of the subject areas to the depth that I understand now. So, I have relied very heavily on the science fellows. To be honest, there was time when fellows were talking to the class, I was just like one of the students, and I am asking as many questions as they did. The fellows have so much knowledge that they can impart to me. I have gained a whole lot in the last two and half years. I have been to some workshops, but it is different to have someone else in the classroom on such long-consistent basis that I can always come back to ask questions and I can see, or demonstrate something. It's very different to have someone else in the classroom. (A middle school teacher CN)

And I think they'd (other teachers would) be more confident watching someone else do it, and they see it done it a couple of times, and then maybe next time it's more automatic and they go, "Oh, I remember how we set that up," or, "I remember how we did that." We talk about science more than we did, so that's always good. (An elementary school teacher SK)

Another middle school teacher emphasized that the fellow helped him try activities that he would otherwise never have tried, as he felt he lacked the scientific knowledge.

Oh, I think that the um lessons that I can do now that I wouldn't have done before. Both of my fellows have gone out and put time into looking for resources and lessons that other teachers have created by going to the net, the Internet, and finding things that others have been successful with and brought that into my classroom and demonstrated those to me. (A middle school teacher JG)

Two of the elementary teachers reported that they took part in the science activities along with their students, which the students themselves reported during one of the student interviews. The students stated that their teacher had participated in the activities alongside them and had said to them that she was learning science with them. One middle school teacher in the interview addressed that he was corrected by the fellow in class, which helped him to understand something that he didn't understand before.

The content, the transferring knowledge to the students directly, I have been corrected in class [laughs], you know, in a nice way, and it's really helped me understand some things that I didn't understand before. (Post-observation interview with middle-school teacher JG)

Students also strongly believed that the teachers had learned science content from the fellows. A group of middle school students interviewed recalled the fellow correcting errors the teacher made in class:

There was like, we were trying to find out the speed of something, and [the fellow] was being quiet in the back like, he's like "I'm going to let you try and find it out." And so [the teacher] was up on the board like, and he was like, "No, no," and came and helped him with something. (Interview with middle-school students)

Although teachers frequently expressed how they had learned a great deal about science, fellows did not bring this up in interviews nearly as often as the teachers did.

Awareness of GK-12 professional development activities outside of the classroom was mixed. Of the ten teachers who responded to a follow-up email, four were unaware that other opportunities existed. Two others said they were too busy and too stressed to participate. The remaining four reported an increase in curriculum development at their school as a result of their involvement in GK-12. Having an on-site scientist as a resource and a role-model appears to be the type of professional development which teachers appreciated most. Two teachers in the survey wrote:

One GK12 Fellow developed some extension activities for a science kit and presented those activities and the science behind them at a teacher workshop. Now Playground Physics is an integral part of the 1st grade curriculum in the Corvallis School District and in several neighboring districts (5 small rural districts and Springfield too). The Fellow's presentation really helped bring deeper understanding of physics to primary teachers and from there to their students -- a lasting impact! (An elementary school teacher GG)

At the start of the school year (8/02), [the fellow] did join my staff in a professional development workshop. During this week, four teachers and [the fellow] worked together sharing ideas, this was a great way to start the school year. For myself, I did gain a few lesson plans or project ideas from observing and working with [the fellow]. I believe one fellow teacher, [the teacher's name], may have gained even more as far as professional development with chemistry topics. Throughout the year, [the fellow] was often present at many pre-engineering group staff meeting. For example in the spring, [the fellow] gave good ideas while assisting with our school's first project/science fair. Here she some time shared ideas. (A high school TL)

Even though most teachers had positive attitude and feedback toward the project, a few teachers were perceived having negative response to the project. One fellow teaching at a rural school reported that she had a good interaction with the leading teacher at the school, but:

The other teachers were very hands-off. Some of them had very strong biases against science, which were very evident from day one [laughs]. The fourth-grade teacher did not participate in our program at all, all year long, even though he was encouraged to do so throughout the year.

### *Effects on Fellows*

During the interviews, both teachers and students stated that the fellows had developed improved teaching and communication skills during their time in the classroom. One middle school teacher reported:

I have watched every fellow grow in terms of how they interact with students, time lessons, and teach their lessons. It's always fun to watch them get to the point where they can teach an effective lesson.

Six 4<sup>th</sup>/5<sup>th</sup> students in a focus group interview observed that the fellow had learned patience from their teacher in communicating with them. Fellows themselves reported that they had reinforced their content knowledge, and had experienced how the teacher managed the class:

I just, um, and for, I think, first of all it forces me to reinforce all the content knowledge that I do have. (Fellow JK at a high school)

Um, a lot just in terms of classroom management, dealing with kids. He's a very experienced teacher and has a really, really good relationship with the kids. And he's very -- he doesn't like to come down heavy on them, I don't know if that's the right, um, a silly way to phrase it, but he keeps order in the classroom but he doesn't, you know, raise his voice and try and use kind of authority and power, but he does, he does keep control. And he also just, the very personal, human relationship he has with the students is really good to, to see. So just observations of him in the classroom is really good. (Fellow EG2 at a middle school)

Fellows also had increased awareness of how the school and the education system worked in general, and some reported that they had gained a lot of respect for teachers for their hard work:

I think seeing how the educational system works.... I've seen a lot of the behind-the-scenes in the whole schools and that kind of stuff, and one of the best parts I think is that I always eat lunch on Thursday afternoons with the science teachers because I'll come in in the morning and have lunch with them, and it's been, it's been really good to see where their needs are and what, how the school system works and how the school district works, and how you know, and all that kind of stuff that I would never have understood before, and so I think for me, just opened my eyes to how the education system works. (Fellow JK at a high school)

I've certainly learned, I've earned, I've gained a lot of respect for teachers [laughs] that I may not have had, of how hard their job is, and that they work harder than anybody else, I mean they work way harder than we do. And uh, you know, um at this time it's made me very aware of the education crisis that's going on, and how that is really affecting the schools and the students in a way that I wouldn't know because I don't have school-age children and I don't work in a school or for a school district. (Fellow KS at an elementary school)

In addition to developing their teaching skills, fellows reported an increased positive attitude toward outreach in general. In follow-up survey, some fellows reported that they intended to continue participating in K-12 outreach in the future:

I definitely see myself doing outreach in the future and I definitely feel like I have skills to do this that I didn't have before.

Yes, I see myself doing more K-12 outreach, probably in the form of participation in outdoor schools, science camps, science competitions, and outreach presentations such as lab tours.

However, there was some negative effect imposed on fellows as far as their participation in the program was concerned. The most common constraint was that fellows felt their research time became more limited than expected, even though some were warned prepared before involving in the program:

As far as my big degree program, it was a comment made to me by the other fellows that left last year was that to be prepared to be completely distracted from your research. That this takes way more time, and that, you know, it's true, it takes more time than anybody anticipates to prepare, um, it takes more time out of your day to go out there and out of your week.

Although all fellows responded in the follow-up survey that their major professor had been supportive to their participation in the program, half of the responded surveys (six out of 12) stated that their professor had expressed concerns of their research progress:

He is supportive, but is always concerned about my getting research done. He has expectations (though not necessarily specifically stated) that I will continue to make good progress on my projects. (Fellow KL)

We haven't really talked about it but we've both had to come to terms with the fact that I'm not getting as much done on my research as either of us would like. (Fellow EG2)

### *Research Paradigm*

The research paradigm was difficult to communicate, as teaching about research was constrained by prescribed curricula. Where fellows had more freedom to choose the topics they taught, they were better able to bring their own research and knowledge of the processes of science into the classroom. One fellow building predator prey models with students reported:

We just have been interested in nature of science, and that may be where we address the whole idea of how research works. What is it the scientists really do when the science is tentative? And I think it comes up certainly in the activities, especially with the modeling type of stuff. (Post-observation interview with fellow TS)

Some fellows found it difficult to bring their own research into the classroom because their research did not fit the current topic, or because their own research had not progressed very far at that point:

Um -- and I didn't really bring in my research very much. Partially it didn't overlap that well with the curriculum, but partly it's um I study manure and compost [laughs]. (Post-observation interview with fellow EG2)

I've been able to use my content that I have, but my research hasn't fit in. But then my research is pretty, it's not very far along either, I think if it was further along then I would be able to do more, but -- it hasn't been something that's fit in very well, and so... (Post-observation interview with fellow JK)

Other fellows interviewed expressed a certain level of confusion about what the project actually required them to do in communicating the research paradigm. Some fellows

referred research paradigm to scientific method, while some talked about inquiry-based activities.

## Teaching Strategies

### *Inquiry-Based Learning in the Classroom*

Inquiry-based learning was observed in most classrooms, and was identified as an important goal by all teachers and fellows. In all cases, fellows strove to develop lessons that allowed students to ask their own questions or to freely explore materials. For the fellows, an important aspect of inquiry-based learning was student enthusiasm. Most fellows identified inquiry-learning with activity, and contrasted this with having students listen to a lecture:

..... there was one period where I did an open inquiry lab experience and it was, they used it for one of their CIM or CAM -- anyway, I approached it in a different way. They had it fairly structured in the past, and I did a very, very, very open-ended and they came up with their own questions which was the big difference. Um, and end, during one of the times, he [the teacher] said this was the most fun I've had all year. So I think it kind of, I, not, I think if I was a teacher for fifteen years I'd want more structure, but I think having a new face come in that didn't want structure I think is a different perspective. (Fellow EG at a middle school)

I think the inquiry-based learning is really important. I can see the kids shut off when I am talking too long even if I am propping them so they can have some hands-on activity. If they don't get a chance to move around and do stuff, they are not going to remember anything. But they can have very intuitive of sense of what's going to happen because of their everyday experience. (Post observation interview with fellow TS)

Teachers also perceived that inquiry was important to student learning. One teacher reported that children enjoyed science because of the inquiry base:

I think it's really important that it's inquiry based and we're doing hands-on science, I mean, you can see how much the kids love it, and you know, it seems a little random at first while you're getting them going, but then when you go around and you listen to them... they really are enjoying science, it's a real positive thing, and I'm sure that's because of the inquiry base. And it's real hands-on stuff. (Interview with an elementary school teacher SK)

The same teacher also addressed that 'closure piece' which connected the activities to learning was equivalently important:

..... because you can do the activities but if you don't do that closure piece or why are we doing this or what does this mean, now that's really the powerful part of inquiry-based learning. And if you don't do that, you never know if you've made those connections, or we had a lot of fun in science today, but it's sort of like yeah, but, what were you learning and why do you think this was happening, and just get to some of those things. (Interview with an elementary school teacher SK)

Several constraints on the use of inquiry-based learning were identified both in interviews and observations. Time was an important factor, as fellows working within a particular curriculum had a limited amount of time in which to teach a particular topic, and approaching the topic using inquiry-based activities took a considerable amount of time. Teachers verified the constraint on the use of inquiry in class:



And the inquiry piece is a tough one to do in class and I try to get at it as much as I can. I do support the idea that it's very important and that it needs to be part of the classroom. .... And that's a scary thing to do when you have thirty-seven kids and you just turn them loose (to give students freedom to be creative). (A middle school teacher JG)

The fellow's knowledge of what constituted inquiry was another constraint. In two cases, fellows associated "inquiry" with the algorithmic "scientific method" which is frequently taught in science texts:

To me that's (the inquiry's) important because that gives them almost the strict methodology of how science happens and they also apply that ability to do things in a structured way to other parts of their learning. I've touched on that a little bit on first graders. Well, I tried. You're very limited in what you can do... And they -- just approaching science and realizing that there are certain things sometimes that are OK and certain things that are not OK to do. And it's understanding what the experiment is and what the control is. As a scientist that's really important. And that's what inquiry really is. (Post-observation interview with fellow MM)

Some fellow interpreted that the opposite of inquiry would be kind of a lecture format. Some wasn't quite sure what inquiry was and guessed it was something that required students to figure out for themselves. In most cases, fellows often equated inquiry to hands-on activities. One fellow at the interview explained why she conducted a lot of inquiry in class:

Okay, yeah, we did a lot of inquiry-based learning because of our lack of resources. We realized early on and I was warned by last year's fellow that we'd better make it hands-on because the attention span and the behavior issues make it impossible to just give a straight lecture or give them a paper to fill out. (Fellow KS at the interview)

### *Learning Styles*

Use of appropriate learning styles was also reported in the interviews and observed during classroom observations. Though fellows had been taught about learning styles in their summer training prior to entering the classroom, they showed some alternative conceptions about the nature of learning styles, often referring to "auditory" or "visual learners." Nevertheless, the fellows recognized the necessity of adjusting their teaching to fit the academic abilities of their students, and showed remarkable sensitivity to student learning needs and processes.

But actually having the video, and, like, the square dance, the total makes it all, um, the structure of the lesson was just so effective, and just realizing that you have to do really it three different ways in order to really get it in there, and that was really rewarding to me. (Fellow MM)

Teachers generally praised fellows' sensibility to student learning needs. One teacher was particularly impressed with the fellow's intuition of using different strategies to teach different individuals:

I just want to say that one thing that both [the prior year's fellow] and [the current fellow] have very instinctive way of knowing what levels the students are at. Because even in my classroom we have students who might struggle with writing or reading, and others that

are very high-level readers. And very instinctively she knows how to work with these kids. And she's able to switch. She will use one strategy with one student and very different strategy with another student. I think that comes over time, in having the fellow in school for a whole year, they really do get to know the students, and appreciate the students. (Post-observation interview with elementary teacher JB)

One fellow with strong background knowledge of Native American cultural issues elected to teach in a rural school serving a largely Native American population. During an interview, the teacher with whom this fellow worked described how valuable the fellow's knowledge of the students' culture had been. The fellow, whose expertise was in environmental science, taught a unit on salmon that incorporated both western science and the cultural knowledge of Oregon Native Americans. The students later recognized the fellow's lessons in a lecture were given by a Native American elder. Not only did the fellow realize the cultural environment, but also she knew how to deal with characteristics of student needs there. The fellow reported:

They just won't do it. So, one of the reasons I have them work in groups or have them do activities that they can talk to each other, and be creative, is it's the only way that I can get them to really engage in the material.

Based on student surveys, students also stated that their fellow had used adequate ways to help them understand science in the class.

She (the fellow) helped me learn because she goes step by step and she explains. (A 5<sup>th</sup> grader)

A first-grade child at an interview also mentioned that the fellow taught differently from her teacher in the science class. The student described the fellow always explained the science activity first before handing out the materials, whereas the teacher passed out the materials and explained the activity in the same time. She claimed the way the fellow taught helped her better understand what the activity was to be in the science class.

Nevertheless, most fellows reported that they had to make initial adjustments to their expectations of what students could accomplish in a given amount of time. Two fellows recalled the adjustments they had to make in dealing with various student needs:

For instance, one of the things I have problems is that she (the teacher) has a huge range of kids there, and they're functioning between third and fifth grade, even though it's a class of fifth graders, and it's a huge range, and so I try to target right at the middle so that the more advanced kids aren't bored, but you need to have the lower kids involved to some extent, but I also feel like I should give the lower level kids a chance to finish the activity but what happens is the higher level kids finish and are bored, so when that happens I try -- having something for them to do when 50% of the class is done. So that's one of the things I feel I need to work on. (Fellow EG)

One teacher really helps me think of questions to ask, and she'll ask them questions that make me aware of all the things that they're not quite ready to manage. But the other day, she's like, "Oh, don't worry about it if you can't talk to them and everything, if they don't listen to any of your class, because I think that exposure is 99% of the thing, just get them out there, get them into it, and then they'll get something out of it, they'll see it," and -- I think she was trying to make me feel better. (Fellow CB)

Cooperating teachers reiterated these same themes. Teachers reported that their fellows experienced a period of adjustment as they sorted out ways to communicate complex content in an age-appropriate fashion. Both middle school and elementary school students interviewed were keenly aware of how their own feedback helped the fellows adjust their teaching strategies. Observations confirmed the information from the interviews. When fellows encountered student questions and confusion, all fellows tried different means, including demonstrations, visuals, and analogies, to help students understand the contents and concepts. Many students responding to the student survey recognized the fellow's effort of helping them with their study:

[The fellow] does lots of demonstrations to help us get and feel for the topic. (A 6<sup>th</sup> grader)

He had a hard time putting into lamens (?) term but we got it after a while. He helped us with lots of visual aids. (A middle school student)

### *Technology in the Classroom*

Using technology in the classroom was challenging for most fellows. Use of computer technology was dependent on the availability of school computers, lab scheduling time, and fellows' attempt in using the technology. Fellows explained the difficulty of using the technology in class:

In terms of the technology, they only have one computer in the classroom, and it's the teacher's computer, and I guess they recently finished setting up a computer lab down the hall, but because of how it's available we haven't really used much technology in the class. (Post observation interview with Fellow EG)

Um, use of technology, that one was really difficult when I started out there, I expected to be able to use the computer technology, but their computer lab is reserved throughout the day for different classes, and so whenever I was out there, the class that I was teaching, there was another class in the computer lab. (Post observation interview with Fellow KS)

We haven't really in the classroom use the Internet very much because there are 5 computers for the class and there are 20 to 25 students in the classroom. So I haven't been creative enough to integrate that into the lessons because if there are 5 or even if paired up to 10 students on the computers, then I have to (have) twice as much lesson planning to keep the other students occupied with something relevant. So I haven't really come up with a good way to do that although I certainly use the Internet when I am developing lesson plans. (Post observation interview with Fellow TS)

One fellow at an elementary reported using computers to search the Internet for information, to record data into spreadsheets, and to have students write reports, skills with which the students were already fairly familiar. One other fellow at a high school reported having helped the teacher learn to use computer-based probes, which put new and unfamiliar technology into the students' hands. While the fellow did not seem to think this was a particularly impressive feat, the teacher remarked that this had been quite useful:

Thank you for bringing that up, yes, this summer, you know, so I had met her at the end of last school year and this summer she took one of ours [computers] up there and helped me

get it set up so that we could use um the um temperature probes and the pH probes that we have, so that when I came back in the fall, she had all the details worked out, and so that first nine weeks we were using um especially the temperature probes a great deal. And now they're up and running and we've been, so, that technical assistance was really tremendous. It's hard to find time to you know do some of that detail work. (Post-observation interview with high school teacher TL)

One high school math teacher was also impressed with the fellow's incorporating the use of the computer software to the math class:

Her (the fellow's) work at the computer lab getting my students in both levels last semester to do some geometry sketch pad work to understand relationship between angles, or circles and angles, or whatever the lesson was. She had that well prepared and really brave to take kids up there (the lab). ... she made some really nice lessons and God help from teachers in the building to do that more than I do.

Beyond computer technology, several of the fellows were able to introduce other science technologies on field trips to laboratories. One class used laboratory equipment to analyze various hot peppers for the amount of capsaicin. On these field trips, students were able to use analytical equipment that they would never otherwise encounter, giving them a taste of the kinds of technology associated with scientific research.

### Emergent Issues

#### *Negotiating Roles and Communication*

All teachers and fellows interviewed unanimously viewed their relationship as collaborative: sharing content knowledge, exchanging teaching strategies, and implementing science curriculum together. Most expressed that they had pleasant experiences working with each other. Teachers in the interview reported:

The relationship between me and our fellow is, several things, to help make her time spent at [the school] as effective as possible, to make sure that she is able to share her expertise with as many people as possible, to help her get to that information across, to share teaching strategies with the fellow to model teaching strategies, to help her help us implement our science curriculum. (An elementary school teacher JB)

She's [the fellow's] so cool, I mean, and she's very generous with her time, and, um, and she comes into the staff room and has lunch with us and just kind of hangs out and talks, and so, people kind of know her as a person and, you know, friends and stuff. And she's very positive about the kids and stuff. And she's not, I mean, you don't get the sense that she's saying like, "Oh, God, you guys are pathetic, you don't even know any of this stuff" – which we probably are, but at least she's nice to us. (An elementary school teacher SK)

Well, I don't want to glamorize it, but it's been terrific. I mean [the fellow] she, she's amazing to work with. She really knows here stuff, and she's an extremely pleasant person, and so it's just, it's been wonderful. (A high school teacher TH)

The level of reliance on the fellow in teaching the class varied from teacher to teacher. A few teachers or the school heavily relied on the fellow in delivering science knowledge.

She [the teacher] didn't know very much chemistry at all so I felt more like, you were the expert so just take over wherever you can in this area. (Fellow JK)

Um she [the teacher] had a tendency to rely on me for the teaching curriculum for the science as all the teachers did. I did not get a very strong impression at all that there was a whole lot of science curriculum at [the school], so in some ways I felt like I was it [laughs]. And then the teachers would follow up with it. (Fellow SK)

Not all the communication in the collaborative relationships went smoothly. One middle school teacher, who was in her third year in the project, addressed that time management was a serious issue in her cooperation with the current fellow. She said she and the fellow sometimes had different points of view in scheduling the lessons. She stated that the fellow often did not arrange enough time to teach a lesson. The fellow also had poor time-management ability in class, when compared to the previous two fellows she had worked with. Because of poor time-management problem, the teacher reported that it was difficult for them to pull off good lessons.

I think I made the assumption that all the fellows were the same. The first two years, the two individuals (fellows) were highly organized and were very, very professional. I guess I didn't appreciate [the fellows] (from previous years) as then because I just made the assumption that everybody was like that, because they were both so incredible. [The current fellow] has unbelievable knowledge. She's not as organized, she has very poor time management, and it's a lot more difficult for her to pull off good lessons, in that she would not make the time -- there has not been the time before lesson to occur to go over them so that we can help her with the teaching end of it, what makes a good lesson. I feel her lessons have been much rougher because the time has not been put in. And there's not an organization -- it's been a lot more haphazard on her part. That's her style. (A middle school teacher CN)

The observation conducted in this fellow's classroom somewhat verified the teacher's concern. The fellow did not seem to have much control over the class. However, it should be noted that the teacher was taking a sick leave on the observation day. A substitute was in the classroom assisting the fellow with the classroom discipline, which was found not much of help. Also, the classroom observation was undertaken on the day prior to Thanksgiving holiday.

When the fellow mentioned above was asked how her relationship with the teacher was, the fellow also responded some issue related to time management. But, the fellow was referring to the teacher not taking the meeting time seriously, and she was not sure how often to meet with teachers as well as when to meet to be optimal. She was obviously not aware of the time management problem the teacher had reported in designing and teaching lessons.

So, I guess that's one of the things that has changed over time, trying to figure out how often to meet with them, and how to make sure that when we meet that's an optimal use of both of our times. I guess that's what I felt like, like I was staying to meet with them, but then I felt like she would run off and do things while we were meeting, I felt like it was a waste of time, so, people were like coming and she'd like go and talk to them and I would stay here, like I have thirty-five minutes to meet with her and she, instead of asking them to come back, would -- so hopefully -- I told her I have less time now, so hopefully being shorter about the time she'll focus on having the to work on this. (Fellow EG)

### *The Curriculum Development and Teaching Process*

In designing and developing the curriculum, some fellows had more choices than the

others. Two elementary schools relied on commercially-produced classroom science kits to provide a structured curriculum and to provide large areas of content. Under the circumstances, the fellow was left no choice but to teach with the science kit lessons. One teacher at an elementary school reported that she organized all the science kits as well as the fellow's schedule for other teachers at the school to implement science class:

Well, we're required to go through a certain number of science units in a year. What I love about this, is I know that every teacher in our building is now teaching science on a routine basis now because of [the fellow]. Because I organized all their kits and I said, "These are your choices, what are you going to do?" I ordered them all, I told them which days we would be doing them, and when they would have [the fellow]. (An elementary school teacher SK)

One elementary school teacher claimed that science kits were inquiry based teaching. When being asked how the fellow could teach differently if the science kits used were inquiry-based curriculum, the teacher replied:

Because that's something they're more familiar with. They not only model that, they kind of use a different approach, and they make more connections between what we are doing and the actual world. I think the fellows really help us with the communication of the content, and theories and concepts. Sometimes, when the kids think some of the concepts might be a little bit vague, the science fellows help us take those ideas and concepts further, deeper. We have a lot of students who can take it to the next level, and often times the classroom teacher doesn't have the information or experience or the knowledge or even the content to do that. So that's where it's nice to have science fellows. We have students even at the elementary level who know a lot more than the teacher about certain areas in science. So without the science fellow, those students can't be stretched and can't take to the next level. (An elementary school teacher JB)

In one elementary, the science kits were old and poorly maintained, thus the fellow had to develop her own curriculum. And in one other elementary school, even though the science kit was available, the fellow was not asked to teach with the kit. Teachers saw teaching the science kit curriculum as their responsibility, so they would like the fellow to bring in her new materials. The fellow at the interview reported:

And when I came in and had the initial conversation with (the collaborating teacher). She told me that I am not responsible for teaching the science kit and that curriculum. They have that equipment and teachers should be able to work through activities with the kit without a problem. They would rather I bring in outside activities through my own research or other experience and at different content that is not necessarily coupled to exactly what they are teaching during science that week. (Post observation interview with fellow TS)

At the middle school and high school levels, most fellows and teachers had more room in discussing what would be taught. One middle school fellow reported that he and the teacher usually shared their ideas of developing the curriculum lessons. He reported he had been regarded as a partner in teaching:

The teacher I work with definitely views me as someone to collaborate with. He definitely views me as a partner in teaching, which is nice. Um so some of the times I'm just there in the classroom kind of helping out and I'm not bringing new materials, new ideas, I'm just working with the kids and on experiments it's

just nice to have someone else in the room who can work with them on it, too. Other times, I say here's something I'd really like to do, he says great, and I kind of develop it and go through it that way, other times he um he says here's something that I've never felt that I taught well, or in one case there was an experiment he had seen at a conference that he was really excited about but didn't have the time to develop, so, kind of pass it on to me and see what can I come up with. And before every unit, like a chemistry unit, there are times like you know when we'll talk about he's doing and what kind of holes there are and what [???]. And he's every excited to take the things that I come up with so he can use them in the future years. (Fellow EG2)

In some case, teaching content could be constrained by the curriculum. One fellow serving at a suburban high school participated in teaching an advanced placement (AP) chemistry class reported that the AP curriculum is strongly dictated by the content of the AP exam, leaving little room for teacher discretion in selecting lesson topics.

In the aspect of teaching process, most fellows and the teachers had developed a good collaborative pattern in teaching the class. The typical teaching pattern observed was that the teacher would get the class started, some would make a brief review of previous lesson, and then the fellow took over the class. Once in a while the teacher would assist the fellow with making some comments or explanations. Most of the time the teacher circulated the classroom to help students with activities. And the teacher would end the class by making the homework announcement. Some would make a brief review of the current lesson before the homework announcement.

One other type of teaching pattern reported by a fellow was that both the fellow and the teacher took turns in teaching the class. One fellow stated:

It tends to usually be one of us is running the show and the other is helping, so that will just switch on the days, so, that's pretty often that he'll start, get the class started, then I'll take over to do the lesson, or you know, he'll do the main everything in front of the class and my job will be just working out with the students, so it's a pretty clear relation, but we're both always doing [?].

One fellow serving at a rural school, however, had very different experiences from the other fellows. The fellow reported that most teachers at the school did not assist her with her teaching. She explained that she often became the main teacher in the science classes. And some teachers would just leave the children with her and be engaged to other tasks while she was teaching.

Um, I think that both my experience and [another fellow's] experience at [another rural school but in the same school district] is very different from the other fellows at the other schools because of how much we were put in a teacher role rather than an assistant role. We were the primary instructor for the science class. Um, a lot of times the teachers don't even participate, they just sit back and watch.

So, um, as far as problems in roles, I think there's a tendency to see the fellows as a break for the teachers. So they're like, Wooo, yeah, this is my chance to sit back and all of them did it, some of them took advantage of me more than others, there was, um, I had repeated issues of having to remind people that they could not leave their students alone with me. That I'm not a teacher. They kept, they'd bring their kids and they'd be like, I'll be right back! And I'd be like, No! [laughs] You have to stay! (Fellow KS)

During the evaluators' observations of this fellow's two classroom teachings, one

teacher was quite active in co-teaching the class with the fellow, which the fellow later clarified in an interview that the teacher was far more participating with the observers in the room than the teacher normally was. The other teacher being observed actually sat in the back of the classroom and remained silent throughout the whole period of the class. He occasionally asked some overactive, moving around students (3<sup>rd</sup> graders) to sit in their seat. The fellow mentioned “part of it is just the environment of the school”.

### *Sustainability*

#### 1. Can the program continue?

One most concerned issue of the program is whether it can continue after the funding ends. The university/school partnership programs obviously require serious commitment from both sides of the participants. Based on the findings, most schools and teachers had very positive attitudes toward the program and also welcomed the continuation of the program. However, without funding, it will be hard to recruit volunteered participants from the university. Some fellows in the follow-up survey specifically addressed that their advisors encouraged them to apply for the fellowship was because of the funding. In addition to funding, time constraint is another issue to the fellow. Most fellows reported that their research work had been reduced in some degree due to their participation in the project. Most of their major advisors also expressed concern about their research progress, even though the advisors all supported fellows’ involvement in the project.

Enhancing the awareness of the importance of younger student science education to the public, especially to the higher education, may play a critical role in recruiting human resources from the higher education. Dissemination of information is an essential task to increase the public awareness to the project. One fellow suggested one way of disseminating the information was require every fellow to give an on-campus presentation of their work as part of the fellowship. Additionally, fellows, teachers and professors must get out and present results of the project to the public. Selected fellows should be chosen to give regional and national presentations. Selected teachers and professors should give national presentations. This will not only disseminate results to the OSU community and serve as a form of recruitment, but will also promote the public’s awareness of the importance of the school science education. Funding will always be an issue, but that is an obstacle that can be overcome when more creative thinking and human resources are involved.

In the recruitment of graduate participants, one fellow recommended:

I would recommend that they (the program PIs) really target in the future either PhD students who have reached that point where they don't have to take classes, or Master's students who really are in the writing phase of their Master's and not taking classes, because I just think it's too much. You know, I really do. I don't know how I would have juggled all of this and classroom homework deal too.

(Fellow’s attitude toward the program)

#### 2. Can the effects continue?

Another sustainability issue involves whether the effects of the project can continue. Evidence shows that some teachers believed that they could continue teaching high-quality



science, having gained both science knowledge and lesson ideas. One middle school teacher reported:

I now can use those (the curriculum the fellow had helped him develop with) as long as I teach. And I may not have taken the time to develop those lessons if these fellows had not come into my classroom. So that's absolutely wonderful that I now have, I mean I have gained, thinking selfishly I have really gained a lot by having these fellows in my class. (A middle school teacher JG)

However, some teachers stated that it would be difficult to continue delivering a high-quality science program without the assistance of the fellow. One elementary teacher explained that he did not think he could do as good a job as the fellow had done in his class:

... and the reason why I can't is because I am not a zoologist. I couldn't find mistakes in our curriculum. I don't have the vocabulary. (An elementary teacher JB)

(Teacher's attitude and school support)

Other effects that students have benefited from the program will not be able to continue once the funding stops, such as good field trips the fellow had arranged for them, materials, and equipments that were acquired from the program budget. Students will also lose the opportunity to interact with a real-life scientist who has been role model to them. Without the resource person, the fellow, continuation of the connection between the school and the university will also be difficult to sustain.

#### *Fellow's Responsibility to the Project*

In the GK-12 project description, fellows' responsibility had been clearly stated, which included of (1) attend training and preparation in summer, which was composed of two 3 credit hours of courses with either focusing on science or math (2) spend 10 hours each week in classroom activities and an additional 5 hours each week in preparation (3) participate in extended outreach, such as SMILE (Science and Math Investigative Learning Experiences, and OMSI (Oregon Museum of Science and Industry). Though not written in the document, fellows were also required to be engaged to the following tasks: (a) attending biweekly GK-12 meetings (b) keeping journal of instructional logs (c) administering pre- and post surveys regarding attitudes toward science to students, teachers, and themselves, and (d) conducting pre- and post-content tests based on one unit of lessons for the purpose of evaluation to the program. These tasks were requested mostly through verbal announcements in the regular meetings, or via emails.

Some issues were observed during the fellows' implementation of their responsibility. One problem found is about fellows' understanding of their role in the project. One fellow at the interviewed claimed:

um, the GK-12 educational classes that we took over the summer I didn't find particularly useful because they were very much geared to teaching you how to be a teacher, and yet that's not really what we're there to do, so, I mean, it's nice to have those science content standards, but we're not responsible for the science content, as far as what the students

learn. The school is responsible for that, and it's good to be aware of it when we design our lesson plans, but I felt like so much of what we did in the summer session was for teaching majors. And that's not what, that was a common comment throughout our fellows, was that we were being trained to be teachers, but was really never what we were supposed to be doing out in the classroom, we're not education majors, and there's a big difference between being a science major and an education major, and the grant was designed to bring scientists in the classroom, not to turn us into education majors, and so that was really, I mean, very little of that was applicable or useful, and it isn't that it's not valuable, it's just that for what we were being sent in to do, it didn't relate. Because we aren't responsible for the science curriculum in the schools, and how much these kids get for the testing. And to confuse the two I think just encourages the teachers to just sit back and say, "Teach them the science, we're not going to teach it." You know? So it's, that I saw as being kind of problematic.

(Different point of view and experience from one other fellow)

I guess what I have always been interested in educational process and learning process. I was really interested in the science education classes. I thought they were fun and I learned some neat things about the process of learning and different level of knowledge and content the way they presented. I had really a good time this summers. It's really rewarding working with kids at the 4th and 5th age of level. (Fellow TS at an elementary school)

One middle school teacher pointed out that a scientist needs to know appropriate teaching strategies in order to deliver the science and science lessons to students effectively. The teacher at the interview stated:

It's always fun to watch them (the fellows) get to the point where they can teach an effective lesson. I was always there to help, but I see my role as helping them learn that. I mean that's not their intent, they're not going to learn teaching methods because most of them are not ready to go teaching. However, they can't do a good job unless they have the ability to do the lessons well.

One other issue involving the fellow's responsibility was the fellow's implementation of collecting and providing required quantitative data to serve the evaluation need. Fellows, at the very beginning of the year, had been repeatedly informed that they had to administer pre- and post attitude surveys to themselves, teachers, and students, as well as pre- and post content tests based on one unit of lessons. The time to conduct the surveys and tests was also advised at the meetings, and help was offered if needed. Till the end of May, which was far beyond the data collection deadline, a total of 409 pre-attitude surveys were collected. However, none of the fellows had administered the post surveys, resulting in no post surveys were available for the evaluation task. The effort of conducting and coding the pre-survey data became a waste. One fellow's excuse of not being able to perform the duty was because she handed the consent forms (for conducting the surveys to students) to the teacher and never got it back. With regard to the pre- and post content tests, only three fellows had followed through the request. Reasons for those who were not able to administer the tests include:

I only did one survey as I wasn't given the survey until after I had taught in the classrooms. None of the test questions matched the units I was teaching well enough to be evaluative (in my option). So I don't have either of those. (Fellow

AL)

I tried to find material from the timms website for the pre/post tests a few months ago, but was having some difficulty finding questions to address the curriculum I was supposed to teach. I talked with [the coordinator] about it, and she thought it'd be better not to give a test at all if I couldn't use the tested questions. So I don't have one.

In confirming with the second response, the educator who taught the summer training courses was asked to comment on it. According to the educator, the fellows were to start with TIMSS and NAEP questions and then asked the educator for assistance if they needed it. The educator also commented that this was evidence of the difficulty that the fellows had thinking about assessment.

In addition, a three-question follow-up survey was sent to the fellows via email twice, three fellows never responded to the survey.

### **Conclusions**

Figure 2 presents the modified, actual relationships/effects of the GK-12 project

### **Limitations**

### **Recommendations**

1. Clearly specify the fellow's role and responsibility at the application phase. Make sure applicants fully understand the nature of their role and duties they will be expected to accomplish.
2. The project has to provide more training to fellows about the concepts of inquiry-based learning, as well as skills of implementing inquiry at the classroom setting.
3. The project should further clarify what the fellows need to teach in order to meet the goal of addressing research paradigm to both students and participating teachers.
4. Fellows in the field also need further assistance from the program in order to bring a wide variety of science-related technology to their classes. Use of technology also seems constrained by the fellows' knowledge of and comfort level with various technologies. Therefore, fellows also need more training in order to integrate the technology into the classroom teaching.
5. Better strategies are needed in order to increase the public awareness of the project, especially encouraging parents' involvement in their child's science learning process.
6. Better communication and more rigid supervision are needed to assist fellows with fulfilling their responsibility.

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## **Appendix 1: Interview questions for Teachers and Fellows**

### **I. Teachers' roles and GTFs' roles in the collaborative relationship**

1. What is the relationship between the teacher and the Graduate Teaching Fellow that you understood? What is the intent of the grant of GK12 project?
2. How would you describe the Fellow's role?
3. How would you describe the teacher's role?
4. To what extent was your experience similar to or different from your vision of the relationship?

### **II. Understanding and Achieving the five themes emphasized through GK 12 fellowship project to facilitate science teaching and learning**

1. There are five themes that the GK12 fellowship project emphasizes for science learning and teaching in the classroom. Which themes seem to stand out most to you?
2. Give examples of your experiences that helped you successfully/unsuccessfully address the themes?
  
1. Did science/math courses you take helpful to implement five themes into your teaching or learning?
2. (For fellows) Do you have TA experience? Has this influenced your classroom experience? Has your classroom experience influenced your TA experience?
3. In your opinion, what is science?
4. Is there anything that you did not expect in your classroom or outreach program, but interests or puzzles you?
5. How have you benefited from the GK-12 program?

## **Appendix 2: Follow-up survey to fellows**

Hello, everyone

We have just a few quick follow-up questions as we gather the last of the data for evaluating the GK-12 program. If you could take a minute out of your busy day and answer these by May 16, we'd be very appreciative.

1. What has your major professor's reaction been to your involvement in GK-12? Has s/he been supportive? Has s/he expressed concerns? Any examples would be helpful.
2. The National Science Foundation is interested in using the program to strengthen partnerships between universities and K-12 schools. Have you seen this happening with the schools where you've been assigned? Please give us an example or two.
3. Do you see yourself doing more K-12 outreach later on in your careers as professionals? Give examples of what you foresee doing.

### **Appendix 3: Follow-up survey to teachers**

Hello, teachers

We have just two quick follow-up questions as we gather the last of the data for evaluating the GK-12 program. If you could take a minute out of your busy day and answer these in the next week, we'd be very appreciative.

1. The National Science Foundation is interested in using the program to strengthen partnerships between universities and K-12 schools. Have you seen this happening in your school? Please give us an example or two (from this year or prior years).
2. NSF is also interested in providing professional development opportunities for teachers through the GK-12 program. Have you seen this happening in your school? Please give us an example or two (from this year or prior years).

Thank you very much for all your help in this evaluation. We're working hard to let NSF know that GK-12 is worth funding again.



#### **Appendix 4: Survey for students**

1. How do you think **XXX** (the person who co-teaches the science with your teacher) represents being a scientist? Write about the things that **XXX** does and says that show s/he is a scientist.

2. How has **XXX** helped you learn science?

3. Draw a picture of yourself doing science on the back side of this sheet.

## Appendix 5: Survey for parents

May 2, 2003

**Dear Parents,**

**Please help us to help your child better learn science by answering the following questions.**

Please circle your child/children's grade levels: Kindergarten 1<sup>st</sup> 2<sup>nd</sup> 3<sup>rd</sup> 4<sup>th</sup> 5<sup>th</sup>

1. Are you aware of the GK-12 program that the school is participating in? If yes, do you know the purpose of the program?
2. Has your child talked about science at home? What things has your child been saying about science?
3. Have you perceived any difference in your child's working on science assignments or science activities at home? If yes, please give us some examples.
4. Do you have any suggestions regarding how the program can help your child better learn science?

Please return the survey to the basket by the door or mail to the following address:

Margie Haak

153 Gilbert Hall, Oregon State University Corvallis, OR 97331 tel: 737-6716

## Appendix 6

Teacher \_\_\_\_\_ Class name/Period \_\_\_\_\_ M   
 F

### **BASSSQ** Your Views about What Occurs in Science

Please indicate how often, in your opinion, each practice **occurs in science**

<u>Process of Scientific Inquiry</u>	Almost Never	Seldom	Some- times	Often	Almost Always
1. Scientific observations depend on what scientists set out to find.	1	2	3	4	5
2. Scientific inquiry involves challenging other scientists' ideas.	1	2	3	4	5
3. Scientific observations are affected by scientists' values and beliefs.	1	2	3	4	5
4. Scientific inquiry involves thinking critically about one's existing knowledge.	1	2	3	4	5
5. Intuition plays a role in scientific inquiry.	1	2	3	4	5
6. When making observations, scientists eliminate their beliefs and values.	1	2	3	4	5
7. Scientific observations are guided by theories.	1	2	3	4	5
8. Scientific inquiry starts with observations of nature.	1	2	3	4	5
9. Scientific investigation follows the scientific method.	1	2	3	4	5
10. Scientific ideas come from both scientific and non-scientific sources.	1	2	3	4	5
<u>Certainty of Scientific Knowledge</u>	Almost Never	Seldom	Some- times	Often	Almost Always
11. Scientific knowledge gives a true account of the natural world.	1	2	3	4	5
12. Scientific knowledge is tentative.	1	2	3	4	5
13. Scientific knowledge is relative to the social context in which it is generated.	1	2	3	4	5
14. Scientific knowledge can be proven.	1	2	3	4	5
15. The evaluation of scientific knowledge varies with changes in situations.	1	2	3	4	5
16. The accuracy of current scientific knowledge is beyond question.	1	2	3	4	5
17. Currently accepted scientific knowledge will be modified in the future.	1	2	3	4	5
18. Scientific knowledge is influenced by cultural and social attitudes.	1	2	3	4	5
19. Scientific knowledge is free of human perspectives.	1	2	3	4	5
20. Scientific knowledge is influenced by myths.	1	2	3	4	5

**Please fill out the back side of the questions.**

### **Your Views About What Should Occur in School Science**

Please indicate how often, in your opinion, each practice **should occur in school science**.

<u>Process of School Scientific Inquiry</u>		Almost Never	Seldom	Some- times	Often	Almost Always
21.	In science classes, investigations should enable students to explore their own ideas.	1	2	3	4	5
22.	In science classes, students should work collaboratively.	1	2	3	4	5
23.	In science classes, students should discuss ideas with others.	1	2	3	4	5
24.	In science classes, students should think creatively.	1	2	3	4	5
25.	In science classes, students should explore different methods of investigation.	1	2	3	4	5
26.	Students should view science as a problem-solving exercise.	1	2	3	4	5
27.	In science classes, inquiry learning should start with observation.	1	2	3	4	5
28.	In science classes, students should apply the scientific method.	1	2	3	4	5
29.	Students should enjoy themselves during science experiments.	1	2	3	4	5
30.	Students should be taught that there is a distinction between theory and observation.	1	2	3	4	5
31.	In science classes, students should consider ethical issues related to scientific investigation.	1	2	3	4	5
<u>Certainty of School Scientific Knowledge</u>		Almost Never	Seldom	Some- times	Often	Almost Always
32.	In school science, students should be critical of accepted theories.	1	2	3	4	5
33.	In school science, students should view scientific knowledge as tentative.	1	2	3	4	5
34.	In school Science, student understanding should be influenced by their existing knowledge.	1	2	3	4	5
35.	In school science, students should examine the history of accepted scientific knowledge.	1	2	3	4	5
36.	In school science, students should learn that more than one theory can account for a given set of data.	1	2	3	4	5
37.	In school science, students should learn about competing theories.	1	2	3	4	5
38.	In school science, students should be taught that accepted scientific knowledge will be modified in the future.	1	2	3	4	5
39.	In school science, students should examine how society influences what counts as scientific knowledge.	1	2	3	4	5
40.	In school science, students should consider social issues related to accepted scientific knowledge.	1	2	3	4	5
41.	In school science, students should be taught that scientific knowledge is objective and therefore free of human values.	1	2	3	4	5

## Appendix 7

# ESTES ATTITUDE SCALES

(Elementary Form)

Thomas H. Estes, Julie Johnstone Estes  
Herbert C. Richards, Doris Roettger



6. Being able to add, subtract, multiply, and divide is all the math most people" need.
7. It is easy to understand math.
8. People who use a lot of math in their jobs are the only people who need to study math.
9. Math words and signs are confusing.
10. There's no sence in trying to work a math problem that's too hard.
11. Math is interesting.
12. School would be a better place without math.
13. Most teachers really know how to teach math.
14. Math is doing the same thing over and over again.

## Reading Attitude Scale

15. Reading is fun for me.
16. Books are boring.
17. Reading is a good way to spend spare time.
18. Reading turns me on.
19. Books do not make good presents.
20. Reading is rewarding to me.
21. Reading becomes boring after about a half hour.
22. Free reading teaches me something.
23. There should be time for free reading during the school day.
24. There are many books I hope to read.
25. Reading is something I can do without.
26. A certain amount of time during summer should be set aside for reading.
27. Books usually are good enough to finish.
28. Reading is not exciting.

## Science Attitude Scale

29. Exploring outer space may be important to people.
30. Experiments and demonstrations make science easy to understand.
31. Studying science is a waste of time.
32. The more you know about science the more you like nature.
33. Science is boring.
34. Science classes are usually fun.
35. The more you study science the more you learn.
36. It is fun to figure out how things work.
37. It is not important to know about the discoveries of scientists like Einstein.
38. Elementary students should not have to study science.
39. Science helps people to think.
40. Most people do not have to understand science.
41. It is no fun to study animals and insects.
42. Many good hobbies come from the study of science.