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Role Perceptions and Role Dynamics between Graduate Scientists and K-12 Teachers in a School-University Outreach Project: Understudied Constructs

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Abstract

Partnerships between scientists and teachers are an important focus of the current reform in science education. This study examined the roles and the dynamics of interactions in an NSF-funded Graduate Teaching Fellows in K-12 Education (GK-12) project. Data sources included interviews with teachers, fellows, and students at eight K-12 schools. Data were analyzed for emergent categories recognized by teachers and fellows alike. Roles played by the fellows were those of science/math expert, scientist/mathematician role model, source of material resources, source of curricular enrichment, and teaching partner. Teacher roles were perceived as liaison between fellow and schools, teaching partner, teaching mentor, and science/math learner. Although the project underdefined the roles of the teachers, teachers showed noteworthy consistency in perception of their roles. The roles of the fellows differed from those of the project description and evolved idiosyncratically within each teacher-fellow partnership. Because a consistent understanding between project directors and participants regarding roles is critical to the success of a project, the authors suggest that further research into roles that emerge within partnerships is vital for the future development of K-12 projects.

Introduction

Scientists play an important role in the professional development of teachers; in fact, the National Research Council (NRC) considers the scientists' role in teacher professional development as an obligation *(NRC 1996)*. Scientist-student partnerships are important, but scientist-teacher partnerships have the potential for more lasting impact on K-12 students simply because a teacher may interact with a much higher number of K–12 students than a scientist over the course of a professional career. However, a communication gap exists between the professional scientist and the education professional. Scientists who can speak knowledgeably about their research may be unable to effectively communicate such knowledge to practicing teachers and their students. Teachers, in turn, understand how to communicate effectively with their students but may have insufficient knowledge of the science content *(NRC 1996)*.

Programs exist to help bridge this gap. Well-structured professional development programs can serve as bridges between scientists and classroom teachers, drawing together the knowledge of the natural world that scientists bring to the partnership with the knowledge of the classroom environment that teachers bring, integrating their diverse ideas into effective classroom instruction *(Barstow 1997; Linn et al. 1999)*.

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However, professional development programs that pair scientists and teachers have as great a potential for difficulties as for successes *(Pennypacker 1997; Falk and Drayton 1997)*. Programs may pair teachers with an "expert" to increase teacher knowledge, but too often the process by which knowledge is transferred is not well articulated. Program developers may be unclear about exactly how pairing a teacher with a scientist will bring about change in the teacher's pedagogical content knowledge and how this will translate into changes in daily classroom practice *(Falk and Drayton 1997)*.

In programs where university students rather than scientists served as the science resource, similar concerns arise. The development of a cadre of scientists who are willing and able to participate in K-12 outreach may be enhanced by the use of university students, as graduate students develop positive attitudes about outreach through guided participation and are more willing to participate in the future. However, the time and attention needed for outreach can draw both graduate students and professional scientists away from their research, a perceived drawback *(deKoven and Trumbull 2003)*. A study by Bruce and colleagues *(1997)* revealed that university science students enriched teachers' science content knowledge and broadened their ideas of learning and teaching science, but science students were not necessarily more expert in science than the teachers were.

Negotiating roles within a partnership can also be problematic if those roles are inadequately defined at the outset or if the participants bring to the partnership expectations of roles that differ from the vision defined by the project. Poorly defined roles can leave partnerships and role dynamics to develop idiosyncratically. Poor role description also invites confusion as partners attempt to negotiate their roles and their knowledge bases within the partnership. Conflict and on-the-spot role negotiation may create barriers to success and waste participants' time and energy *(Nelson 2002; Thompson et al. 2002b)*.

To place this study in a larger context, the authors asked: what happens within K–12 outreach that facilitates or creates barriers to the development of a cadre of scientists with knowledge of K–12 teaching and learning environments? Because inconsistency between project descriptions and participant perceptions of roles may affect the implementation of a project intended to bridge the communication gap between science and education, questions specific to this study were:

1. How did participants perceive their own roles and each other's roles?
2. How consistent were perceived roles compared with project-defined participant roles?
3. What role dynamics emerged during project implementation?

Description of the Study

Context of the study: The Graduate Teaching Fellows in K–12 Education program (GK–12), which is funded by the National Science Foundation, places graduate-level scientists into K–12 classrooms, where they work directly with children and teachers over an extended period of time. The classroom teachers helped the fellows communicate with the students effectively, thereby creating a cadre of scientists with effective outreach experience. The fellows assist the teachers in bringing new science activities to the classroom and help the teachers develop a stronger understanding of scientific concepts.

The GK–12 Fellowships to Enhance Science Education was a GK–12 project operating out of a state university in the Pacific Northwest. Graduate fellows were recruited by campus-wide announcements to science, mathematics, and engineering departments. The fellows received summer training from faculty in the Science and Mathematics Education Department before they were placed in elementary and secondary schools in three districts. Fellows were required to spend ten hours each week in classroom activities and an additional five hours each week in preparation. In elementary schools, the fellows worked with as many classes as was practical, though one teacher served as a partner and liaison with the school. In secondary schools, fellows partnered with one or at most two teachers to develop and deliver science and mathematics lessons. Fellows were also required to participate in other outreach programs, such as science museums or after-school science clubs.

Sources of data: The original project grant was analyzed to determine what roles the principal investigators had envisioned for participants. The language used in the grant was to be compared to the language used by participants as they talked about their roles in the project.

In the second year of the project, during the initial phase of this study and under the direction of the project coordinator, one of the authors interviewed thirteen selected fellows and observed four exemplary fellows teach a lesson. This author also carried out two focus-group interviews with students that revealed information about how students perceived the roles of the fellow and the teacher. During the third year of the project, the project coordinator requested that two of the authors select eight case studies out of fifteen project sites. Case studies were selected to reflect the widest range of schools served, including rural and urban schools from elementary to high school. The two authors also interviewed three focus groups of students from two of the selected schools. The fellow and partner teacher in each of the case studies were interviewed separately. All interviews were audio taped. The authors observed at least one lesson each fellow taught. During data analysis the authors e-mailed fellows and teachers to clarify points from the interviews. Data from the case studies were the primary data source for studying relationship dynamics, and interviews from prior years provided confirming and disconfirming evidence.

Data analysis: Data analysis employed analytic induction, an approach to data interpretation in which explanation is sought through cross-case analysis. Field notes were typed into a word processor and all audiotapes were transcribed for coding. Data were entered into Atlas.ti qualitative analytical software *(2000)* for coding. Analysis was initiated from a deductive framework, beginning as a search for evidence concerning roles within the project. 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 participant views of their roles. Both researchers cycled through the data multiple times, then compared coding schemes and negotiated points of disagreement to develop a single coding scheme.

Results

Project-defined roles: The project defined the fellow's role somewhat differently according to the grade level the fellow was assigned to. In grades K–5 the model was that of "adopted scientist," with the fellow assigned to one mentor teacher who acted as a liaison between the fellow and the school. Fellows worked in multiple classrooms with multiple teachers, teaching a large number of students. Within this model, the fellow was expected to:

- communicate content,
- promote inquiry activities,
- serve as content resource,
- test and evaluate resources, and
- enhance teacher knowledge of science.

Fellows assigned to secondary schools, grades 6–12, operated under the "teacher assistant" model. Fellows were assigned to one mentor teacher, and might work with that same teacher throughout the day or work with one or two other teachers. Within this model, the fellow was expected to:

- promote hands-on learning,
- assist with curriculum development,
- enhance the teacher's knowledge, and
- develop new curriculum materials.

Roles for teachers were less well defined. The only teacher role distinctly defined in the project description was that of liaison between the school staff and the fellow. However, project goals implied one other role: teachers were to assist fellows in preparing in-class activities, suggesting a teacher mentor role. The project description also stated that teachers were "expected to be the primary beneficiary of the assistance afforded by the fellow," which implies not an active role of a teacher-learner, but that of a passive recipient of information. Consequently, this was not categorized as a role.

Figure 1: Roles and role dynamics as defined by the GK–12 project grant

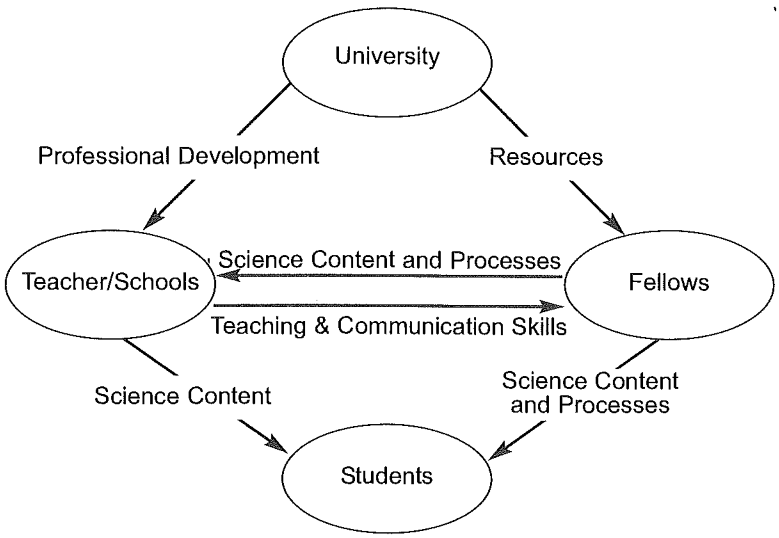


Figure 1 illustrates the dynamics between the various participants within the project as defined by the project grant. The dynamic between teacher and fellow is relatively simple, with science content information moving from fellow to teacher, and pedagogical information moving from teacher to fellow.

Participant-defined roles: Fellows: Despite the distinctions between elementary and secondary grades in the grant, descriptions of the fellows' role given by fellows and teachers in both elementary and secondary were quite similar. Role descriptions given by fellows and teachers fell into five categories:

- science/math expert
- scientist/mathematician role model
- source of resources
- curricular enrichment
- teaching partner

SCIENCE/MATH EXPERT: Fellows and teachers alike discussed the role of the fellow as a science expert from outside the school, who brought in scientific content knowledge and a working knowledge of scientific research. Their expressed purpose within this role was to increase both student and teacher knowledge of science and scientific processes:

> I see my role in the school as sort of an outside expert, more to advise them on content on than on teaching, obviously . . . and I'm being paid to help them out with science content, with bringing in new ideas from the most recent research, etc. . . . yeah, just as an in-house expert. *(Interview with fellow MM, elementary)*

The "in-house" aspect of the fellow as an expert was expressed more strongly by teachers, who recognized their own shortcomings in scientific knowledge. High school teachers were fairly confident within their own fields but recognized that their knowledge of their disciplines was not as deep as that of the fellows and that they may hold misconceptions. The elementary and middle school teachers, though interested in science, knew that their knowledge was very limited.

> 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. She has found mistakes in our curriculum. She has found vocabulary that's wrong and has corrected them for us in our curriculum. *(Interview with teacher JB, elementary)*

SCIENTIST/MATHEMATICIAN ROLE MODEL: Teachers valued fellows as role models, particularly in the elementary grades where students may have little idea of who scientists are and who can be a scientist. Fellows, too, recognized their value as models of scientists and mathematicians as real people. Teachers working with female and minority fellows were particularly vocal about the fellow as a role model, who demonstrated that science and math are real and possible careers for all students:

> And another thing, what I think is a very important role that I forgot to mention is that our students can see that science is a career, we have someone who is a scientist, and that's really important. . . . Not only a scientist, but female, and part of what they embody, is that this is something you can do. *(Interview with teacher JB, elementary)*

SOURCE OF RESOURCES: Teachers viewed the fellows as a source of science and mathematics resources, including activities, labs, field trip ideas, and university connections. Fellows, in turn, recognized their role in providing new ideas for teaching science and developing new activities. Students on all levels noticed the difference and realized that the fellows made otherwise inaccessible activities available to them:

> A nice thing that occurred is that we went on a field trip and were able to use some high-tech equipment that we'd never be able to lay eyes on even in . . . a high school classroom, so the students got to go to the university, use their lab, use their equipment, and then they did some analysis . . . so that was, you know, really awesome and [the fellow] was completely responsible for setting that up. *(Interview with teacher TK, high school)*

CURRICULAR ENRICHMENT: Teachers and fellows alike viewed the fellow as an enrichment to the science and mathematics programs, not a substitute for a good curriculum. One school was an exception: at one elementary school, the fellow was placed in a special science classroom, and classes came to that room. In that instance the fellow was entirely in charge of developing a science curriculum. In all other schools, the teachers described how the fellows brought in knowledge and resources to enrich existing curricula:

> But first of all you need to understand that we don't see those coming from [the university] as being the core of our science program. . . . Our fellows come up from [the university], and I always look at it as they are bringing in even more science on top of what [we] have already taught, which has been really special because it is often times things don't fit into our three whatever the plan is

> we have to follow. So it is frosting the cake. *(Interview with teacher LR, elementary)*

Participant-defined roles: Teachers: The project description outlined the teacher's role as that of liaison between the fellow and the school as a whole, with an implied role of teacher as mentor. While recognizing the teacher in these roles, teachers and fellows gave a much richer description of the role the partner teachers actually played in the classroom. Descriptions of the teacher role derived from interviews with participants fell into four categories:

- Teacher as liaison
- Teacher as teaching partner
- Teacher as a teaching mentor
- Teacher as learner

TEACHER AS LIAISON: In this capacity, teachers served as a go-between to help fellows communicate with other teachers and with other building staff. Teachers also assisted fellows in learning about the environment of their classrooms and their particular schools, and in understanding the school system in general.

> 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. *(Interview with fellow MM, elementary)*

TEACHER AS TEACHING PARTNER: Fellows and teachers almost universally viewed one another as teaching partners. Fellows understood that their role in this partnership was to provide content knowledge and a working knowledge of professional science and mathematics, while the teacher's role was to help translate the fellow's knowledge into terms the students could understand. The collaborative style was idiosyncratic for each site: fellows and their mentor teachers negotiated their roles and their workload within the partnership at the site.

> 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 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. *(Interview with fellow ErG, middle school)*

TEACHER AS TEACHING MENTOR: While fellows were recognized as the science and math experts, fellows and teachers recognized the teacher as the teaching expert.

> 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. *(Interview with teacher JB, elementary)*

TEACHER AS LEARNER: Teachers recognized themselves as learners in the collaboration, learning science from the fellow just as their students did. Teachers viewed this as an active role; they were not passive recipients of knowledge. Fellows were less apt to recognize this aspect of their mentor teacher's role, though in one case study, the fellow, teacher, and students interviewed all remembered incidents in which the fellow had corrected the teacher's misconceptions. The teacher was comfortable with this, and all participants in this case study recognized that the teacher was learning from the fellow. In several case studies, teachers sat among their students, modeling the role of a learner:

> 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. *(Interview with teacher CO, middle school)*

Discussion

Comparison of participant-perceived and project-defined roles shows that some emergent roles were comparable to those described in the grant, though described in different terms. For example, "Communicate content" and "Content resource" were folded into a single role, "Science/math expert." Both the project directors and the participants viewed the fellows as (1) communicators of content to students and (2) sources of curricular resources and enhancement. Teachers were seen by the project directors and the participants in the capacity of (1) liaison and (2) mentors to help fellows communicate science to students.

Some roles defined by the project were missing from the participants' perceptions. First, while the project intended fellows to be promoters of inquiry learning, the fellows themselves did not bring this up in interviews. Field observations revealed that fellows engaged students in hands-on learning, but at the elementary level, much of the activity was guided by kit-based science curricula.

Second, the fellows rarely described themselves as enhancing teacher knowledge. Though teachers saw themselves as learners, the fellows seemed keenly aware of the teachers' classroom expertise and their equality as partners. In the few instances where the fellows noted that the teachers learned from them, it was almost with embarrassment.

Roles unanticipated by the project emerged in participant interviews, suggesting that the participants viewed these as important roles. First, the fellows were perceived as role models of science/math community members. Teachers were particularly enthusiastic about this benefit to their students. Yet the role should not have been entirely unexpected, as other studies have shown fellows to be positive role models *(Trautman et al. 2002)*.

"In several case studies, teachers sat among their students, modeling the role of a learner . . ."

Second, both teachers and fellows saw themselves as teaching partners, working together on an equal footing to improve science education in their classrooms. Development of the partnerships was guided more by participant expectations than by the project guidelines.

Finally, teachers also saw themselves as active learners in their own classrooms. Though the grant anticipated that teachers would gain new scientific knowledge, it did not state the role of teacher as learner as actively and explicitly as the teachers themselves did. Other studies have shown teachers taking on the role of active learner, though they were not always described as such in the programs studied *(Thompson et al. 2002a)*.

Table 1: Comparison of project-defined and participant-perceived roles within the GK–12 project

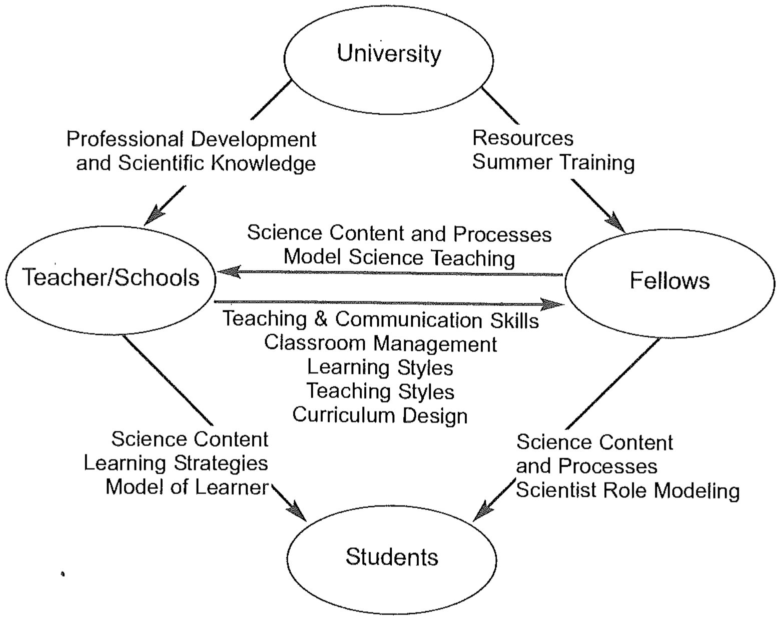
	Defined Roles	Perceived Roles
Fellow's Role	Communicate content	Science/math expert
	Serve as content resource	Science/math expert
	Promote inquiry/hands-on activities	
	Test and evaluate resources	Source of resources
	Enhance teacher's knowledge	
	Assist with curriculum development	Curricular enhancement
	Develop new curriculum materials	Curricular enhancement
		Fellow as teaching partner
Teacher's Role	Liaison between the fellow and the school	Teacher as liaison
	Teaching mentor	Teacher as teaching mentor
		Teacher as teaching partner
		Teacher as learner

Table 1 summarizes these findings.

Figure 2 represents the richer picture of role dynamics that emerged from data analysis. The figure depicts results of the entire project; role dynamics between teacher and fellow, the focus of this study, are shown by the arrows in the middle of the diagram. The dynamics that actually emerged as the project was carried out were more complex than the grant indicated (Figure 1). As a result of this data analysis, descriptions of information flowing between teachers and fellows were expanded to include the types of teaching and communication skills that the participants valued. Students not only gained additional science content and knowledge of science processes; they also were exposed to novel models of scientist and learner.

Parts of the model were implied in the grant and in conversations with participants; these need further exploration. In this model, information flows from the university, as represented by the project directors, to teachers and fellows. The fellows met with the project directors in a monthly group meeting, but the

Figure 2: Roles and role dynamics emergent in the project



dynamics of that interchange and any effects were not part of this study. The essentially one-way flow of information from university to the teachers also needs to be explored. If projects are to be partnerships and not interventions, two-way conversations must occur between all participants.

The flow of information from fellows and teachers to students is also depicted as unidirectional, but this also needs further study. One purpose of the project is to enhance student learning, but a study encompassing not only learning outcomes but the role of the student in the project could be illuminating.

Implications

Although this study purposefully selected cases that represent the widest range of schools served, the sample size was relatively small. The dynamics of roles between the teacher and the fellow may reflect only the situation in the settings studied. Nevertheless, emergence of unexpected roles within this study points to a need for deeper understanding of roles and role dynamics within teacher-scientist partnerships.

Complexities within partnership models have the potential to increase the richness of the interchange between participants and in so doing enrich the experience of the students at whom the project is ultimately aimed. However, increased complexity can also result in increased difficulties, particularly if the roles are not well defined at the outset. Unexpected roles that emerge within a project may benefit participants; unexpected roles and role dynamics may also present barriers to success.

This has obvious implications for the research community. At the time of this study, the authors found very few papers that specifically address participant roles and role dynamics in university K–12 outreach. A need exists for more research in this area, along with dissemination of the results to universities and the K–12 teaching community

The results have implications for project planners as well. Because time and energy can be wasted early in a partnership as partners negotiate roles on their own, further study of the types of roles that emerge from outreach programs can be of great use in planning outreach programs in order to (1) reduce wasted effort on the part of the participants and (2) maximize the likelihood of beneficial roles developing within scientist-teacher partnerships.

Informed project planners are better able to clarify expected roles within new partnership projects. Clear expectations can facilitate recruitment and selection of participants whose own goals and expectations are aligned with those of the project. Supervision of participants and two-way communication between participants and planners throughout project implementation are vital to ensuring success.

This study is a contribution toward understanding partnership dynamics. Further research is needed to provide a better understanding of the types of roles that develop within outreach projects, in order to increase the prospects for the development of productive and effective K–12 outreach partnerships.

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