DOCUMENT RESUME

ED 465 608		SE 066 330

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TITLE	Examining the Influence of a Graduate Teaching Fellows Program on Teachers in Grades 7-12.
PUB DATE	2002-01-00
NOTE	33p.; In: Proceedings of the Annual International Conference of the Association for the Education of Teachers in Science (Charlotte, NC, January 10-13, 2002); see SE 066 324.
AVAILABLE FROM	For full text: http://aets.chem.pitt.edu.
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150) -- Tests/Questionnaires (160)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Graduate Study; Higher Education; Mentors; *Role Models; School Business Relationship; Science Instruction; *Science Programs; *Scientists; Secondary Education; *Teaching Assistants
IDENTIFIERS	National Science Foundation

ABSTRACT

A huge investment in public funding, approximately 10 million dollars for the 2002 fiscal year, has been dedicated to the implementation of the National Science Foundation's (NSF's) Graduate Teaching Fellows in K-12 (GK-12) program. In these GK-12 programs, graduate level scientists known as Graduate Teaching Fellows are placed in K-12 science classrooms to act as resources for science teachers. The NSF's investment is aligned with reform documents which call for scientists and the science education community to work together to realize the goal of scientific literacy for all. Although much research has been done on factors that influence science teachers' views of science and ultimately the way science teachers interpret and deliver science content, little research has been done on the impact that this type of program will have on science teachers' teaching practice. The purpose of this research is to examine the impact on the science teachers involved in a NSF GK-12 program. This program was implemented at a large Southeastern university and the local school district. Data were collected on one cohort for one academic year using qualitative methods of observation and interviews. The findings of this research highlight the need to examine in more depth three groups influenced by these collaborations: the science teachers, their students, and the scientists. (Contains 20 references.) (Author/MVL)

Examining the Influence of a Graduate Teaching Fellows Program on Teachers in Grades 7-12

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EXAMINING THE INFLUENCE OF A GRADUATE TEACHING FELLOWS PROGRAM ON TEACHERS IN GRADES 7-12

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A huge investment in public funding, approximately 10 million dollars for the 2002 fiscal year, has been dedicated to the implementation of the National Science Foundation's (NSF) Graduate Teaching Fellows in K-12 (GK-12) program (NSF, 2001). In these GK-12 programs, graduate level scientists known as Graduate Teaching Fellows (GTF) are placed in K-12 science classrooms to act as resources for science teachers. The NSF's investment is aligned with reform documents which call for scientists and the science education community to work together to realize the goal of scientific literacy for all (American Association for the Advancement of Science (AAAS), 1993; AAAS, 1998; NRC, 2000; NRC, 1996a; NRC, 1996b). Although much research has been done on factors that influence science teachers' views of science, and ultimately the way science teachers interpret and deliver science content, little research has been done on the impact that this type of program will have on science teachers' teaching practice.

The purpose of the research presented in this paper is to examine the impact on the science teachers involved in a NSF GK-12 program. This program was implemented at a large southeastern university and the local school district. Data were collected on one cohort for one academic year using qualitative methods of observation and interview.

Literature

The current reform in science education in the United States includes a call for scientific literacy for all Americans (American Association for the Advancement of Science (AAAS), 1989; AAAS, 1993; AAAS, 1998; National Research Council (NRC), 2000; NRC, 1996a; NRC, 1996b). Reasons given for the necessity of scientific literacy include a fairer distribution of economic opportunities and the important role of scientific and technological understanding to inform public and private decision-making. A key component of scientific literacy is a sound understanding of the nature of science (NOS) (NRC, 1996a, NRC 1996b). In this study Lederman and Zeidler's definition of the NOS, "the values and assumptions inherent to the development of scientific knowledge" (1987, p.721) will be used. A science teacher's understanding of the NOS plays an essential role in efforts to improve scientific literacy (NRC, 1996a, NRC 1996b). The view of the NOS held by the science teacher influences the curriculum offered, which in turn influences the view of the NOS held by students.

The relationship between teachers' understanding of the NOS and teacher practice has been studied for over ten years. The result of this research is not consistent. Lederman and Zeidler (1987) conducted research with 18 teachers from a variety of contexts and schools examining the impact that science teachers' concepts of the NOS have on teaching behavior. This study found no direct relationship between teacher's perspectives of the NOS and teacher behavior. Duschl and Wright (1989) investigated the manner and degree to which science teachers consider the nature of the subject matter when making decisions about the planning and delivery of instructional tasks. Although these researchers found that science teachers did not consider the NOS in their decision making, they hypothesized that other factors may be inhibiting science teachers' ability to teach in a manner consistent with beliefs.

Benson (1989) theorized that a science teacher's conceptions of disciplinary knowledge are reflected in the curriculum he/she teaches, but also are heavily influenced by institutional factors. Brickhouse (1990) examined the effect of science teachers' beliefs about the NOS on classroom practice. She found that science teachers differed in their views of the nature of scientific theories, scientific processes, and the progression and change of scientific knowledge. However, she found that science teachers' views of the NOS might be expressed in their classroom instruction. Hashew (1996) focused on science teacher's epistemological beliefs and the impact they have on teaching. He found that science teacher epistemological beliefs did influence teaching practice. That is, science teachers who held constructivist beliefs had common methods of instruction, assessment, and treated student knowledge differently than those science teachers holding positivist beliefs. Additionally, further work done by Lederman (1999) examining factors that facilitate or impede the relationship between teacher practice and understanding of the NOS, found that there are factors that may impede a teacher's ability to teach in a manner consistent with beliefs. Among these factors are teachers' level of experience, intentions, and perceptions of students.

The works cited above demonstrate that the view of science held by the science teacher, even when constrained by other forces, impacts how the material is chosen, presented and interpreted for the students in any given class. This selection, presentation and interpretation, in turn, influences the way that students accept and acquire information used to form their own views of subject matter knowledge. These assertions are further supported by research done on pupils' understanding of the NOS (Soloman, Scott, & Duveen, 1996) as well as by policy documents (NRC, 1996a; NRC, 1996b; The National Commission on Mathematics and Science (NCMS), 2000).

The same reform documents that call for scientific literacy urge the scientific and science education communities to work together to attain this goal of scientific literacy (AAAS, 1993; AAAS, 1998; National Academy of Sciences (NAS), 1998; NRC, 2000; NRC, 1996a; NRC, 1996b). The GK-12 programs implemented by the NSF represent one of the first major attempts to form collaborative partnerships between university scientists and K-12 science teachers working together in the school setting. Through these university-school collaborations, the NSF hopes to narrow the gulf between the world of school science and the world of the scientist by increasing the level of scientific literacy among the general population while increasing scientists understanding of K-12 science education (NSF, 2000).

The classroom teacher is the vehicle through which reform efforts in education are realized. Shulman (1987) was the first to conceptualize that classroom teachers had specialized knowledge, which he termed Pedagogical Content Knowledge (PCK), a knowledge base of teaching within specific subject areas . The National Board for Professional Teaching Standards (NBPTS) followed up this conception by articulating five core propositions that effective teachers possess (Standards, 2001) within the subject area they teach. The knowledge, skills and dispositions held by the classroom teacher within these categories influence the delivery of the enacted curriculum. Additionally, the categories of effective teaching provided by Shulman and the NBPTS are representative of the current standard by which effective teaching is measured. For these reasons, it is through the lens provided by the NBPTS and Shulman that this work is reported.

Context of the Study

The GTFs were placed in both high school and middle school science classrooms. In some of the settings, the GTFs worked alone with a single teacher called a Partner Teacher (PT). In others the GTFs were paired to work with a pair of PTs. All of the schools the GTFs worked in had a majority of students that would be considered disadvantaged.

The GTFs were told that their role was to collaboratively plan and deliver hands-on inquiry-based laboratory activities with their PTs. Toward this end a workshop was held prior to the beginning of the school year in which two experienced teachers worked with the GTFs and PTs to demonstrate the types of activities that might occur. Additionally, the GTFs were given access to a large number of hands-on science kits produced by one of the cooperating university's science outreach organizations.

During the school year the GTFs spent ten hours in the science classrooms teaching and five hours outside of class planning and preparing lessons. A seminar was held every other week for the GTFs in which business matters were handled and issues related to their teaching experiences were discussed. The GTFs were expected to turn in lesson plans of the hands-on laboratory activities they had completed that week during seminar, whether or not they had developed the activities themselves. The GTFs also were asked to develop lesson plans within their professional subject area for the entire academic year that might be used by the other GTFs in the program. Additionally, the GTFs took two education courses (one per semester).

Methods

Data were collected from August through May from a cohort of twelve GTFs and 10 PTs. Forms of data collection included both informal and formal interviews, observations of classroom teaching, and observations of PT and GTF interactions. For this paper, informal means that the data were collected without the aid of recording equipment or through the use of a collection instrument. Field notes were taken as soon as feasible after the conversation. Formal, on the other hand, means that the data were collected with the aid of recording equipment or through the use of a data collection instrument. Initial data collection took the form of informal interviews with GTFs and PTs. Additionally, informal observations of classroom interactions between GTFs and their PTs were conducted. From these informal interviews and observations, formal interview questions were formulated based on the goals of this particular grant. According to the grant proposal, these goals for PTs included: 1) an increase in science content knowledge, 2) an increase in the use of computer technology, 3) an increase in the use of specific learning tools such as inquiry-based technology, 4) an increase in communication links with learning communities, and 5) an enhancement of positive attitudes about science.

Interviews

Interviews conducted for this research were semi-structured in nature. Initial formal interview questions (See Appendix A and Appendix B) revolved around individual perceptions of meeting program goals, the impact program participation had on participants, and on ways the program could be improved. The initial interviews were then transcribed and used to generate questions for follow up interviews. In addition, questions for the second round of interviews stemmed from both formal and informal observations done of the interaction between the PTs and GTFs.

Additional questions for the second round of interviews came from the respondents themselves. One of the questions used in the second round of interviews asked the respondents to identify any questions that they would like to ask fellow participants. Respondents were then asked to answer their own question. Each participant's question was then asked of following respondents during their second interviews. All formal interviewing took place during the second semester of the GTF/PT collaboration.

Observations

Informal observations of GTF and PT interactions and teaching were conducted throughout the school year. In addition, a total of 30 formal narrative observations were done in varying classrooms on a rotating basis, completed in a manner to ensure an equal representation of all the contexts in which the collaborations were occurring. All formal observations were done using a narrative observation form (See appendix C). The form construction was guided by a series of questions that were developed based on the goals of this particular program.

Supporting Data Collection

Other data were collected to inform, direct, support or refute findings from formal data sources. Among these forms of data collection were GTF written reflections completed as part of one of the education courses taken by the GTFs. These reflections were read and used to inform directions taken in formal data collection. Additionally, the GTFs participated in a biweekly seminar conducted by the program director that focused on their experiences in the classroom. Discussions during the seminar that focused on topics relevant to this paper were also used to inform the direction and development of data collection.

Data Analysis

Interviews

Formal interviews were analyzed using the constant comparative method (Erlandson, 1993). The first round of interviews were transcribed and coded using the program goals for PTs mentioned in the observation section above as a supporting framework for possible initial categories. The initial coding displayed a large amount of data in two categories, subject matter knowledge and learning communities. Additionally, each of the two categories included a wide variety of information that required further analysis.

At this point the other sources of data were included in the examination of data to determine if they could provide direction for further analysis. A decision was made to include all sources of information in one coding session in the hope that the categories of analysis might become more clearly defined. A second round of coding then occurred. Categories relating to the following themes were identified: Subject matter benefits and detriments, Roles, Knowledge of Teaching in K-12 Arena, Students, Learning Communities, Time/Planning/Impact on GTF, Computer Literacy, and Odds-n-Ends.

The categories were then examined to determine which of these categories applied to the PTs and which applied to the other participants in this program. At this point a decision was made that only three categories clearly contained enough information regarding the PTs to make any interpretations, Subject Matter Benefits and Detriments, Roles, and Learning Communities. However, the data within these categories still was not clearly defined enough to make any interpretations. Questions were then created for the second round of interviews. The questions were based on information gathered from the initial data analysis as well as from the original goals of the program for PTs. That is, the second round of interviews followed a path similar to the initial interviews of focusing on the program goals while at the same time focusing on unique characteristics identified in the initial round of data collection.

The second round of interviews was then transcribed. Following transcription, the data were coded using the existing categories as a background while attempting to pull out distinct differences in the data within each category. As these categories began to develop, the initial data were re-examined to determine how closely aligned the total data collection was to the newly created categories. A decision was then made to only address findings related to the PTs in this paper and to address other findings related to the students, GTFs, and the program in other presentations. The following categories emerged at this point: Subject Matter Content Knowledge, Pedagogical Content Knowledge, and Learning Communities.

The final phase of analysis included taking these created categories and comparing them to the NBPTS five core propositions (Standards, 2001) for teachers and

Shulman's categories of teacher knowledge that make up a teacher's PCK (1987). These documents contain similar and accepted categories of teachers' knowledge. By using these categories as an outline, the categories, which this paper is based on, emerged from the data and are reported below. These categories are, Subject Matter Content Knowledge, Curriculum Knowledge, Knowledge of Learners and Their Characteristics, and Learning Communities.

Observations

The observations were used to gain an accurate picture of the types of teaching activities in which the GTFs and PTs were engaged. Areas focused on during observations included: content covered, types of activities implemented, use of computer technology, roles of the PT and GTF, and the interaction that occurred between all parties in the classrooms. These observations were instrumental in painting a picture of what was occurring in the classroom. Additionally, they served the purpose of generating ideas to be explored during subsequent interviews.

Supporting Data

Field notes, journal entries, GTF written reflections, and informal seminar discussions were used to inform, direct, refute, and/or support findings from more formal data sources. Additionally, a draft of the Findings Section of this paper was provided to all the PTs in this cohort as a final member check. Their feedback was then incorporated into the final version of this paper.

Findings

Analysis of the data collected demonstrates that PTs working with the GTFs increased their understanding of teaching science in a number of ways. Analysis of findings is discussed in terms of Content Knowledge, Curriculum Knowledge, Knowledge of Learners and Their Characteristics, and Learning Communities. Each of these categories is mentioned as being important to teaching effectiveness either by Shulman or in the NBPTS propositions, or both.

Subject Matter Content Knowledge

The collaboration between GTFs and PTs provided opportunities for PTs' to increase their subject matter content knowledge. This growth occurred in a number of forms. One form of this can be seen as a high school PT talks about working with his GTF. As stated by Guy, a PTteaching high school engineering,

> There certainly have been times when I directed toward my GTF to say, I don't know. Most of the time I'm not embarrassed to say I don't know in front of the class. And it is nice having someone that I can refer to and say you might want to ask the GTF about that.

In this form, the subject matter content knowledge sharing was publicly displayed in front of the students in the classroom. Carrie, a GTF working on her physics degree, also frequently encountered this in her collaboration with her PT. During one observation the PT directed the entire class to listen to an explanation she had given to a small group of students. When queried about this incident during one of her interviews she stated,

> He [PT] openly admitted to me in our very first meeting that he didn't have a very strong physics background at all. He is always asking me, "so could you explain this a little more? I don't know this concept. I've never understood it very much.".... He is not afraid at all to ask me, to freely admit, "Well I don't know this. Ms. Adkins [Carrie], can you help us, can you contribute to this?"

During observations of classroom teaching, numerous examples of this public display of subject matter content knowledge interaction between the GTF and the PTs were encountered.

These interactions were unique in a number of ways. In these interactions the PTs were able to interact with subject matter experts on an as-needed basis. Additionally, these interactions occurred in a setting in which the PT were comfortable, their individual classrooms, not a science laboratory or a university workshop. Each of the factors increased the likelihood that the PTs asked questions and gained information of relevance and importance regarding the curriculums they teach. Additionally, both GTFs and PTs agreed during interviews that this was one of the major benefits for the PTs in these collaborations.

These public displays not only provided opportunities for PTs' to increase subject matter content knowledge, they also provided an excellent example for the students in these classes of a type of collaboration between scientists and science educators encouraged by recent science reform initiatives. Collaboration is one element of a learning community, another category of teacher knowledge. Through these public displays, students in these classes were provided with models of scientific interaction that were more realistic than those typically encountered in a school science classroom.

Some examples of opportunities for growth in PTs subject matter content knowledge were not so public. When questioned about subject matter content knowledge, Don, a GTF working on his chemistry degree, states that he and his PTs' subject matter content knowledge conversations occurred in less public forums.

> He claims his chemical background is pretty rudimentary so he looks to me to ask about the periodic table and trends and why those things are, but mostly it's behind, in the absence of students. Just for his own sake of being able to explain to them what these concepts are.

The same phenomena is reported by Carrie,

> So when a particular topic is coming up, sometimes I kind of explain it a little more or whatever and try to enrich his content. So that when he interacts with the kids as well he can kind of have a better understanding.

These statements from the GTFs are supported by interview data collected from the PTs.

PTs reported growth in subject matter content knowledge, especially those areas in which they felt they were weakest. As stated by Kim, a middle school PT,

> I do have weaknesses, like geology is not one of my strong suits. Did they help to increase my knowledge? Yes they did.

In this form, the GTFs acted as a sort of tutor, assisting the PTs in building a broader base of understanding relating to the subject matter content they teach. Additionally, this type of collaboration between scientists and science educators also highlights a form of collaboration encouraged in recent science reform initiatives.

The analysis of the data discussed above demonstrates that PTs working with the GTFs in this context experienced increased opportunities to enrich their understanding of subject matter content knowledge. This occurred in at least two forms, public and private. The public displays highlight for all the stakeholders involved a form of collaboration that is supported by documents dedicated to the reform of science education in America. The second form, private, served to increase opportunities for the PTs in these collaborations to enhance their understanding of the subject matter content. This increased understanding of subject matter content knowledge on the part of science teachers is also highlighted in reform documents as a necessary element in improving the scientific literacy of all Americans.

Curriculum Knowledge

PTs in these collaborations also report they benefited from increased opportunities to enhance their knowledge of the enacted curriculum found in materials and methods for instruction. Anita, an experienced middle school teacher talks about curriculum knowledge during her final interview.

> That is the other thing I think I've learned from them. There are some really simple ways to adapt things. When you're first looking at an experiment to try and you're

> thinking, "there's no way I can do this." They've [GTF] shown me that there are real simple ways to do things that are not that hard.

These comments exemplify the types of comments made by PTs regarding the manner in which these collaborations assisted them in thinking about improvement of specific lessons or materials.

Sandy, a high school Biology teacher, echoes this type of curriculum knowledge enhancement when she says,

> I've gotten some good ideas on some new exercises or well, just things that I've had ideas but just didn't have time to develop.... He's added to my exercises for my students tremendously.

Alex, a high school GTF who worked with Sandy supports this interpretation. During one of his interviews he says,

> Because she just doesn't really have as much of the knowledge in that area [DNA technology] that I have. And I think I brought some things...to the classroom that wouldn't have been done in the classroom otherwise. I think maybe I helped reinforced the importance of that.

In addition to the enhancement of specific lessons or materials, PTs also indicated that these collaborations influenced larger issues related to curriculum knowledge. For example, Anita talks specifically about her view of the subject matter she teaches when asked how this collaboration has influenced her subject matter knowledge. She states,

> I don't know that I've learned more based on subject matter, but I sure learned how to approach the subject matter in

different ways.

Evidence to support this type of curriculum knowledge growth is found in interviews with GTFs as well as from observations of GTF and PT interactions.

Analysis of these data indicates that this type of collaboration enhanced opportunities for PTs to discuss and reflect on their curriculum knowledge. Some of these interactions dealt with the enhancement of specific lessons or materials. Other interactions focused on teaching methods and techniques for improving student understanding.

Knowledge of Learners and Their Characteristics

Analysis of the data indicates the PTs in this study experienced opportunities to grow in areas related to knowledge of learners and their characteristics. This lead PTs to reconsider their own methods and styles of teaching. For example, these opportunities influenced the way that the PTs considered students as they thought about the sequencing of material and the structuring of content delivery.

When asked about the impact of the GTF collaboration on her students, Anita discusses her own growth and how it has impacted her thinking about science.

> It's changed the way I look at science. I used to look at content first and lab second and now I look at lab first and then what content I need. So I think that is another impact for me and the students.

These comments reflect a change in teaching practice that indicates a change in belief about how students learn, that experience precedes knowledge. The intention of the change was meant to improve her students' understanding of science. This change in thinking related to her students demonstrates a better understanding of her students and how they learn science. These comments are representative of those made by other PTs focusing on students and how they best learn science. These comments were also supported by GTF interview data as well as by observations of changes in PT practice.

Additional evidence to support increased thinking about students' and how they learn on the part of PTs is found during interviews with GTFs working in other schools. For example, Lamar, a Biology GTF, discusses this when asked about opportunities to discuss teaching issues with his PT. He says,

> I think so...he's [PT] been talking about being more structured and methodical in his approach.... So I guess, just based, especially with the way Jamil [GTF] comes to class...he [PT] sort of saw what he [Jamil] was doing and the way the kids responded.

In this instance, the PT became aware of instructional techniques that were of interest to students and how the techniques improved student understanding.

In this form, working with the GTFs has directly influenced the growth that occurs in the PTs' thinking related to learners and their characteristics. These collaborations have provided the impetus for the PTs to share their dissatisfaction with their current conceptions of their students and what constitutes effective teaching of those students. This dissatisfaction with current conceptions of effective teaching is an important indicator of the possibility for change on the part of the PTs. Work on conceptual change indicates that the first step in undergoing a conceptual change is dissatisfaction with existing conceptions (Posner, Strike, Hewson, & Gerzog, 1982). This form of growth is an indicator of the potential these collaboration have for influencing future teacher development and practice.

Analysis of this data indicates evidence of PTs' growth in areas related to knowledge of learners and their characteristics. Anita decided to restructure the delivery of content, providing the experiences before the presentation of content. The PT working with Lamar and Jamil decided to reorganize his own classroom structure after witnessing the success enjoyed by his GTFs teaching in his class. Perhaps most important of all though, is the evidence that these collaborations may influence aspects of the PTs' knowledge base of teaching.

Learning Communities

Involvement in this GTF program influenced the opportunities these PTs had to participate in learning communities dedicated to improving the quality of science instruction. This involvement will be discussed in terms of three levels of participation. The first level is the level of the classroom. For the purposes of this paper this category shall be called Within Class Learning Community. In this level the PTs had opportunities to interact with knowledgeable others regarding teaching science within their own context, the individual classroom. The second level is the level beyond the individual classroom called Between Class Learning Community. In this level the PTs had opportunities to interact with knowledgeable others regarding the teaching of science beyond the individual classroom. The third level, University Level Learning Community, is the level in which PTs established contact with scientists and educators at the university level. This level includes interaction that occurred as a direct result of involvement in this GTF program as well as interaction that occurred as an indirect result of involvement in this program.

Analysis of data indicates that one of the main features of this program was the opportunity for PTs to interact with knowledgeable others regarding their own teaching practice. As mentioned above, a number of PTs indicated they had learned about their own teaching from interaction with the GTFs. Alice questioned her own personal philosophy of teaching, deciding that laboratory activities should precede the delivery of content. Matt, a PT working with Lamar and Jamil, reconsidered his own style of instructional delivery, deciding that a more structured approach might best benefit his students. Both of these changes came as a direct result of in-school collaboration between a scientist and a science educator focusing on the planning and delivery of hands-on inquiry based laboratory activities.

The GTF interviews also support the importance of these interactions with PTs as being a key element in these collaborations. When asked to give recommendations for future GTFs, Don talks about the importance of developing an interactive relationship with his PT. He says,

> I'd tell them [GTFs] to make sure they have a really solid foundation with your teacher.... There are differences in reactions and that point needs to be distilled. If you're coming from two different approaches to things, high school teacher versus researcher, one person's constantly thinking about simplifying things. The other person is trying to understand deep fundamentals of some random scientific thing.

These comments are representative of the types of comments made by several GTFs regarding the discussion of science and science teaching related issues. These discussion issues ranged in focus from the teaching of science (i.e. classroom management) to information relating to highly debated issues among the scientific community (i.e. the use and application of DNA technology). These are examples of the type of involvement in Within Class Learning Communities the PTs experienced due to participation in this GTF program.

PTs also indicated that participation in the program led to increased opportunities to interact with others regarding their own teaching practice beyond the classroom level. When asked about increased professional development opportunities, Kim states,

> I think with the whole program, I thought this summer [orientation workshop] was very beneficial....To me that was an opportunity for me to meet other teachers.... I thought that was very beneficial to me, just meeting those other science teachers.

This GTF program afforded PTs the opportunity to interact with others about their own teaching and issues related to science and the teaching of science. There are multiple types of opportunities these PTs had to become involved in learning communities focused on the teaching of science beyond the classroom level. The opportunity to meet and work with the other science teachers in the program, and the opportunities to reflect on their teaching in interviews and discussions regarding this GTF program are examples of this. In these interactions, the development of a community of learners occurred between people who worked at the classroom level, yet within differing contexts. These interactions are also representative of examples of involvement in Between Class Learning Communities that occurred as a direct result of participation in the GTF program.

Data analysis also indicated that the PTs in these collaborations established connections to University Level Learning Communities. As stated by Anita when asked about opportunities to participate in scientific learning communities,

> The other thing that has helped a lot was just working with the university. I have someone at the university I can call, even if it wasn't a GTF.... There are a lot of people out there willing to help that we just are so used to not having that we just don't even think to call.

Sandy echoes this idea. When asked about increased opportunities to participate in scientific learning communities because of her involvement with the program she states the following,

> I think so. Just because my name is out there more. The

university has called me, and the SEPUP program, I don't think I would have gotten involved in that.

These comments exemplify typical comments made regarding increased involvement in learning communities at the university level.

PTs in these collaborations developed connections outside of the classroom due to their involvement with the GTF program. Several shared professional development opportunities that came about as a direct result of involvement in the program. Among these were opportunities to become involved in classroom video conferencing technology, science workshops, and curriculum development. Additionally, the PTs reported involvement between their classroom students and the local universities increased as a result of participation in this grant. Included in these were opportunities for students to participate in science competitions, field trips and video conferencing.

Involvement in this GTF program influenced the opportunities these PTs had to participate in scientific learning communities. This involvement occurred on three levels of participation. The first was the level within classrooms called Within Class Learning Community. In this level the PTs had opportunities to interact with knowledgeable others regarding teaching science within their own context, the individual classroom. The second level was the level beyond the individual classroom, called Between Class Learning Community. In this level the PTs had opportunities to interact with science educators working in various contexts regarding the teaching of science. The third level was the level of involvement in University Level Learning Communities. This level increased opportunities for the PTs and their students to interact with those interested in science education at the university level. This level includes interaction that occurred as a direct result of involvement in this GTF program as well as interaction that occurred as an indirect result of involvement in this program.

Conclusions

Summary

A huge investment in public funding has been dedicated to the implementation of the NSF's GK-12 programs. The NSF's investment illustrates their position that these types of collaborations are important to the improvement of science education. However, little research has been done on the impact that this type of collaboration will have on science teachers' teaching practice. Science teachers are the main vehicles by which systemic reform will be implemented. The knowledge, skills and dispositions held by the classroom teacher influences the delivery of the enacted curriculum.

This study details the impact on the science teachers in a GK-12 program; a NSF funded initiative designed to improve the quality of K-12 science teaching. PTs experienced opportunities to increase their subject matter content knowledge. This occurred both publicly and privately.

PTs in these collaborations benefited from enhanced opportunities to increase their curriculum knowledge. In one form this lead PTs to gain knowledge related to new or better methods to highlight a concept or idea.

PTs also became involved in learning communities on three levels: within classrooms, between classrooms and with the university scientific community. These categories are consistent with types of teacher knowledge identified both by Shulman and by the NBPTS.

Implications

The findings of this research highlight the need to examine in more depth three groups influenced by these collaborations, the science teachers, their students, and the scientists. This research suggests that the PTs involved in these collaborations experienced change in a number of areas related to their knowledge of teaching. Further research needs to be done which examines how sustainable these changes are. Additionally, research needs to be done which explores how these collaborations influence teacher theory and practice after the departure of the GTFs from their classrooms.

Additional studies on the GTFs and the students in these classrooms need to be implemented. This research suggests a change in PTs due to this collaboration. A logical question then becomes, how does this impact the students in these classes? Do these collaborations influence students understanding of the nature of science? Do these collaborations raise student scientific literacy so often mentioned as a goal of science education and reform minded programs?

Finally, work examining the influence of these experiences on the GTFs needs to be conducted. Recent calls for scientists to enter the classroom have come from a number of stakeholders involved in the most recent science education reform movement. Additionally, the NSF has implemented a number of programs including the GK-12 programs that place scientists in the classroom. Part of this emphasis is focused on improving scientists' relationships with, and ability to work in, K-12 schools. Work examining how successful these programs are in increasing scientists involvement in, and understanding of, K-12 science education also need to be done.

This paper was partially supported by National Science Foundation grant number DUE-9979578.

Findings are those of the author and not the National Science Foundation.

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Appendix A

Initial Formal Partner Teacher Interview Questions

1) Have you learned anything new about your subject area as a result of working with the GTF? If so, what?

2) One of the goals of the Graduate Teaching Fellows program is to increase the use of computer technology by the participating teachers, to what degree has this occurred in your situation thus far?

3) In what area(s) has the increased use of computer technology been most apparent, during instruction, for record keeping, or in some other manner?

4) Your Graduate Teaching Fellow is a member of a learning community of scientist. How has your involvement with the Graduate Teaching Fellows program impacted your communication with this learning community?

5) How has your professional development been impacted by your involvement with this program? Explain.

6) What recommendations would you make to a teacher who is considering working with a Graduate teaching Fellow next year?

7) In what ways has this program been a benefit to your students?

8) In what ways has this program been a detriment to your students?

9) Describe the students' reactions to working with a scientist.

Appendix B

Initial Formal Graduate Teaching Fellows Interview Questions

1) How has your training as a scientist prepared you for this experience as a teacher?

2) What has been the greatest obstacle or obstacles in transforming your science knowledge into an appropriate form that your students can understand?

3) Pedagogical Content Knowledge is, briefly stated, a name given for the ability of a teacher to make subject matter understandable to students. In what ways has this experienced impacted your Pedagogical Content Knowledge of science?

4) Describe how you and your cooperating teacher communicate about subject matter issues.

5) Has this program impacted you view of teaching? How?

6) What has been the biggest surprise so far regarding teaching?

7) One of the goals of the Graduate Teaching Fellows program is for the Graduate Teaching Fellows to develop an appreciation for the professionalism of teachers. Describe what impact you think this program has had on you regarding this goal.

8) What recommendations would you give to a future GTF to help her/him make the transition to a secondary science (middle or high school) classroom?

Appendix C

GTF Observation Form

Date________________________

Grade ________________________

Subject Area___________________

Describe the content covered during class.

List the types of activities implemented during class.

Describe how computer technology was used during this class.

Describe the role of the Partner Teacher during class.

Describe the interaction between the Partner Teacher and the Graduate Teaching Fellow.

Describe the interaction between the students and the Graduate Teaching Fellow.

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Title: Proceedings of the 2002 Annual International Conference of the Association for the Education of Teachers in Science

Editors: Peter A. Rubba, James A. Rye, Warren J. DiBiase, & Barbara A. Crawford

Organization: Association for the Education of Teachers in Science

Publication Date: June 2002

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