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A Retrospective Study of a Scientist in the Classroom Partnership Program

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Abstract

The Scientist in the Classroom Partnership (SCP) is a unique, long-term program that partners STEM fellows with K-12 teachers. The SCP was adapted from the original NSF GK-12 model, with fellows and teachers working in the summer and academic year to build their partnership and design and coteach inquiry-based STEM curricula. The current study is a retrospective investigation of the first 10 years of the program to determine the impacts on university fellows and K-12 teachers and the implications for students in the participating classrooms. Results from surveys and focus groups showed that fellows gained communication, mentoring, and pedagogical skills and served as role models for students. Teachers gained STEM content knowledge, increased use of inquiry, and greater confidence in teaching science. The SCP represents an innovative model that enhances hands-on and inquiry-based teaching and learning of science through a unique partnership that brings together the university and K-12 systems.

Keywords: scientist, teacher, coteaching, partnership

Introduction

A major reform effort under way in U.S. schools is to better prepare students for jobs demanding STEM expertise. Most experts agree that meeting this goal calls for an emphasis on exciting students about STEM in early to middle grades to encourage them to choose STEM majors in college and ultimately enter STEM careers (*Maltese & Tai, 2011*). However, as reported recently by the U.S. Congress Joint Economic Committee (*2012*), too many students do not have access to quality STEM education and lack the interest and ability to enter or continue along the STEM pipeline. According to Bureau of Labor Statistics projections, STEM jobs alone will grow 17% between 2008 and 2018, much faster than the 10% growth predicted for all other job areas (*Vilorio, 2014*). In addition, the growing demand for STEM skills in jobs outside traditional STEM fields will further complicate this need (*U.S. Congress Joint Economic Committee, 2012*). Most agree that innovative strategies are needed to engage students at an early age so they are prepared with solid skills to enter STEM pathways.

At the same time that K-12 districts are looking for ways to excite students about STEM and enhance STEM literacy, increasing numbers of Ph.D. candidates in the STEM fields are choosing nontraditional careers rather than the typical route toward academic research positions (*Fuhrmann, Halme, O'Sullivan, & Lindstaedt, 2011; Laursen, Thiry, & Liston, 2012; Thiry, Laursen, & Loshbaugh, 2015*). According to recent reports, less than half of STEM doctoral students are employed in traditional faculty research positions (*Austin, 2013; Denecke, Feaster, & Stone, 2017; Kulis, Shaw, & Chong, 2000; National Science Foundation & National Center for Science and Engineering Statistics, 2012*). A recent study from the American Institutes for Research emphasized that there must be a "national effort to prepare more students for educational and career success in STEM by improving teaching and providing all students with the 21st century skills needed to thrive in the global economy" (*Turk-Bicakci, Berger, & Haxton, 2014, p. 1*). Several studies have found that STEM Ph.D. students are particularly interested in teaching and are more likely to express an interest in further training in this area than their peers in other disciplines (*Cyranoski, Gilbert, Ledford, Nayar, & Yahia, 2011; Shea, 2013; Stowell et al., 2015; Trautmann & Krasny, 2006*). However, much of the teaching experience that falls to graduate students is in the form of teaching assistantships, an approach that usually provides little if any actual training in the pedagogy of teaching (*Golde & Dore, 2001; Nyquist et al., 1999*). Additionally, many departments that have minimal interaction with university undergraduates provide essentially no opportunities for teaching. As Ph.D. students enter their careers—in traditional or nontraditional fields—most will require at least some teaching ability (*Meizlish & Kaplan, 2008*).

National leaders have called on STEM professionals to assist in the reform of STEM literacy and contribute to improving the quality of science education at the K-12 level (*Alberts, 1991; Colwell & Kelly, 1999*). In response to these calls, federal funding agencies have incorporated these efforts into their grant award mechanisms, and universities have begun to develop programs that partner K-12 classrooms with scientists and engineers (*Sparks, 2017*). The NSF-funded GK-12 program represented a convergence of these areas to provide a system in which graduate students are rewarded for their service to enhancing science literacy while gaining essential teaching, communication, and mentoring skills during the completion of their graduate training. As Laursen et al. (*2012*) have stated, "the intent was not just to support the education of individuals, but to have lasting institutional impact on both university–community collaboration and STEM graduate education" (*p. 49*). The resulting GK-12 program brought together three important groups in K-12 classrooms: scientists who could share their science content, research, and inquiry skills while acting as important role models for students; teachers who could provide pedagogical and classroom expertise; and students eager to engage in exciting STEM learning (*Mervis, 1999*). It has been suggested that these scientist–teacher partnerships have great potential to positively impact science learning and instruction at the K-12 level, with each partner contributing specific skills and expertise with the ultimate goal of improving the teaching and learning of science in the classroom (*Caton, Brewer, & Brown, 2000; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003*). The GK-12 program as designed by the NSF provided the exact model that allowed for building effective scientist–teacher partnerships.

In 2006, the NSF contracted with Abt Associates to conduct a comprehensive study of the GK-12 program to determine the impact on fellows' graduate school experiences and their career trajectories, and to describe teachers' perceptions of the resources provided by the fellows and the influence of the GK-12 projects on students and schools (*Gamse et al., 2010*). From a study of 865 former fellows the Abt study concluded that the program was "implemented and experienced as intended" *(p. ii)*. Interviews with teachers indicated that they spent more time teaching science, were more comfortable with the science content, and felt an enhanced collegiality toward other science teachers. Fellows reported that they gained important in-depth learning and understanding of science, providing them with the skills to present science to a broader audience. Further, in support of a report from the Council for Graduate Schools recommending that universities include a core set of skills in graduate education (*Denecke et al., 2017*), fellows felt their communication skills had improved and they were better prepared for the job market upon graduation. An interesting outcome of this study was the finding that program participants felt that a major contribution of the science fellows was their ability to act as "catalysts" for change.

In 2010, the NSF discontinued the GK-12 program, stating that the program "has been effective, but much of it is now being done by other programs" (*Mervis, 2011, p. 1127*). In 2012, only 19 of 188 funded sites had sustained in-class programs (*Ufnar, Kuner, & Shepherd, 2012*). Many of the funded sites discontinued their partnerships due to lack of sustainability plans. One of the original grantees has not only continued the scientist–teacher partnership model but has sustained the program for over 17 years. The program in its current form—the Scientist in the Classroom Partnership (SCP)—was adapted from the original NSF-funded program and places graduate students or postdoctoral fellows (both referred to as fellows) in classrooms to coteach with a partner teacher for one full day per week for the entire academic year.

During the first 7 years of the SCP program (during NSF funding), the basic program components included the academic year in-classroom coteaching for 2 days per week, a 4-week summer pedagogy and planning workshop for fellows and teachers, a bimonthly seminar for fellows, and two 1-day retreats for fellows and teachers during the academic year. In 2007 the program transitioned to the current SCP program, with several modifications that lowered the cost of the program and the time commitment required of fellows (Table 1). Four core components of the original GK-12 program were maintained in the SCP, including a 2-week summer workshop, the in-classroom coteaching by fellow–teacher teams (1 day per week), a monthly seminar for the fellows, and two 1-day retreats for further planning and reflection by fellow–teacher teams. The primary focus during the workshop was to pair the fellow with their partner teacher and provide time for planning for the upcoming 30–60 days in the classroom. Fellow–teacher teams worked with the program coordinator to develop coteaching strategies for the classroom. The goal at the end of the workshop was for each team to have their schedule of lessons planned for the upcoming year, matched to the curriculum and standards for the specific grade and subject that would be cotaught. Teams were also trained to use hands-on science kits provided either through the districtwide Hands on Science (HOS) kit program or by a student volunteer organization at one of the participating universities (*Joesten & Tellinghuisen, 2001*). During the academic year, fellows assisted teachers in implementing these curricula in the classrooms.

The current study examined the first 10 years of the GK-12/SCP program to determine the primary programmatic outcomes that led directly to long-term sustainability and integration of the SCP program into the STEM reform efforts of the partner universities and school district. The results showed that through this program effective partnerships were formed between university fellows and K-12 teachers that were built on their respective strengths and skills, with teachers providing critical pedagogical and classroom management knowledge coupled with the content and inquiry expertise of the fellows. Several key themes emerged from this research that support the SCP as a successful model both for connecting university scientists, K-12 teachers, and students to enhance the teaching and learning of STEM and for contributing to STEM reform at the K-12 level.

Table 1. Programmatic Changes in Transition from the GK-12 to SCP Program

		GK-12 2000-2007	SCP 2007-2009
Program Components	In-classroom coteaching	2 days per week	1 day per week
	Summer workshop	4 weeks	2 weeks
	Fellow Seminar	Bimonthly	Monthly
	Education coursework	Required (2000-2002) Optional (2003-2007)	Optional
Participants	Scientists	Graduate Students	Graduate students and postdoctoral fellows
	Teachers	Grades 5-12	Grades 5-8
Stipends	Scientist	$25,000-30,000	$5,000-7,500
	Teachers	$3,000-4,000	$1,000-1,500
Funding		NSF	School district plus universities

Methods

SCP Program Participants

Participants in this study included 83 former and current fellows and 74 former and current middle and high school partner teachers. The fellows were graduate students or postdoctoral fellows from a majority of the different STEM disciplines from four partner universities in the mid-South: a private Research I institution, a private minority-serving medical school, a historically Black state university, and a historically Black private university. The partner teachers were all employed by a large urban public school system with approximately 70,000 students, 5,000 teachers, and 130 schools. University faculty from science and education departments served as co-PIs. Program staff included a full-time program coordinator who was a former teacher, part-time liaisons/coordinators at each university, and a part-time program evaluator. The participation of one PI and two program coordinators for the entire duration of the project provided significant continuity during the 10-year period of study.

Fellows were placed with partner teachers in schools with varying levels of achievement, with the focus primarily on high-needs schools. The goal was to combine the needs of the schools, students, and teachers with partnerships that would provide teaching and pedagogical skills for the fellows and professional development for the teachers. Over the 10-year period of the study, teams were placed in 27 middle schools and five high schools. In 22 of the middle schools, more than 50% of the student populations received free or reduced lunch. The majority of schools participated for 1–2 years, with the longest time of participation at 7 years.

Fifty-one percent of the fellows were from minority populations underrepresented in STEM. The majority of fellows (61/84; 73%) were doctoral candidates, four students were still in a degree program, five participants were postdoctoral fellows, and 13 were in master's programs. Based on the large pool of postdoctoral fellows in STEM disciplines at the participating universities and their interest in gaining additional teaching experience, these fellows were added to the program in 2007.

A total of nine high school and 65 middle school teachers were recruited by the program coordinator in collaboration with the school district science coordinator, with a focus on those teachers who had strong classroom management skills. The majority of teacher participants taught seventh and eighth grade general science and eighth grade physical science. The teacher participants were predominantly female (74%) and White (70%), percentages in close agreement with results from other GK-12 programs *(Gamse et al., 2010)* and similar to estimates of the demographics of public school teachers in the United States at large, with 83% White and 75% female (*Feistritzer, 2011*). Among participating teachers, 46% had a master's degree in education, 29% had a terminal bachelor's degree, and 21% had a master's degree plus more than 30 hours of additional graduate credit. Less than 3% held a doctorate or Ed.S. degree.

Data Sources

Participant information form. Three primary sources of data were used for the study. First, information forms were designed to collect baseline data from program participants. A total of 92 fellows and teachers completed the form (Table 2). Participants provided basic information, including contact and demographic data, academic experience and degrees earned, employment information, teaching background (teachers), professional development activities (teachers), and involvement in outreach to K-12 schools (fellows).

Table 2. Fellow and Teacher Participant Response Rate

	Fellows	Teacher	Totals
Included in study	83	74	157
Consented	64	49	113
Survey completed	56 (67%)	37 (51%)	93 (60%)
Information form completed	50 (60%)	42 (58%)	92 (59%)
Invited to retreat	50	37	87
Attended retreat	39 (78%)	26 (70%)	65 (75%)

Participant survey. A total of 93 fellows and teachers completed an online or paper survey (Table 2). This high number of respondents (60%) was an important factor in conducting a robust study of participant impressions of the impact of the SCP program (*Fincham, 2008*). The survey consisted of Likert scale ratings, rankings, and open-ended questions that were adapted from instruments used during the first 10 years of the program and were designed to target issues regarding participant perceptions of the program experience as well as longer term impacts. To further refine the surveys, a pilot survey was completed by three fellows and three teachers who were in the 2010–2011 SCP program, and two follow-up interviews were conducted with one teacher and one fellow from this group. Based on feedback from their survey responses and interviews, the survey was modified, and the final survey was deployed in March 2011 to consented participants.

Both fellows and teachers were asked a series of general questions about their participation and were asked to rate each program component and the nature of the classroom instruction by fellow–teacher teams. The two groups were asked a series of open-ended questions, including: what was the most successful or most valuable part of the program; what was unique in the classroom; and what was one thing that could be changed about the program? Responses on the Likert scale questions regarding who strongly agreed or strongly disagreed on a scale of 5 to 1 were tabulated and analyzed.

Participant retreat. A 1-day retreat at the lead university hosted 65 participants from across the country (39 fellows and 26 teachers). This retreat was designed to bring together fellow–teacher teams who had cotaught in middle school classrooms to reflect on their past experiences in the program. In a series of focus groups, fellow–fellow, teacher–teacher, or fellow–teacher pairs were asked to discuss a series of prompts: such as, "what worked well; what didn't work; and what were critical challenges in your partnership?" Each group then came together to discuss themes that emerged from the conversations and take notes in response to questions on flip charts. Discussion points from each focus group were recorded, and the responses were transcribed for coding analysis (described below).

Coding Analysis

Qualitative analysis was used to develop a coding framework from themes that emerged from the survey short answers and focus-group transcripts (*Braun & Clark, 2006*). Two researchers collaboratively developed a preliminary scheme to capture each primary and secondary emergent theme from all data sources. Two authors randomly sampled 10% of the data set to test the coding scheme. The scheme was created and refined by categorizing participant comments, adding categories when emergent themes were not captured, and eliminating or collapsing categories when instances were extremely rare or it was difficult to make reliable distinctions between categories. After coders achieved over 80% agreement, the scheme was judged to be stable. Five primary themes emerged from this analysis, with a number of secondary categories within each primary category as shown in Table 3. Through fine-grained analysis, secondary categories were further subdivided into tertiary categories. This final analysis was conducted by examination of open-ended survey questions and focus group responses. The interrater reliability for the coding using the tertiary categories was greater than 85%, with 138 open-ended survey responses and 159 focus group responses analyzed.

Table 3. Coding Scheme Developed for Analysis of Data Sources

1° Code	2° Code	3° Code	Description
Program Model (PM)	Program component (PC)	Summer workshop/ planning	Participants refer to the program as a whole or to a specific component of the program
		Hands-on science	
	Program challenge (PCH)	Fellow-teacher relationship	Participants describe some obstacle or difficulty that was a part of the program or was an issue for them during their participation
		Planning/reflection	
		Scheduling/pacing	
		Materials	
		Teacher quality	
		Fellow quality	
		Content knowledge	
Partnership (P)	Fellow brings resources (FR)	Materials	The fellow brings materials, research experience, specialized knowledge, and/or lessons based on real research to the partnership
		Extra hands	
		Content knowledge	
	Teacher bring resources (TR)	Classroom management	Teacher brings knowledge of class-room management, pedagogical techniques, and/or understanding of student dynamics and needs to the partnership
		Pedagogical knowledge	
	Classroom collaboration (CC)	Coteaching	The teacher of fellow describes the value of their partner as a mentor or colleague, the importance of mutual respect,or how they learned from their partner
		Classroom relationship	
Inspiration (I)	Role model (RM)		The fellow is a role model for the students
	Student enthusiasm (SE)		The teacher or fellow describes a positive reaction among students due to program participation
	Renewal(R)	Balancing roles	The fellow or teacher describes how the program encouraged them to face challenges such as a burnout, isolation, lack of direction, or complacency in teaching methods
	Opportunities for children (OC)	School schedules	The fellow or teacher expresses a desire to provide opportunities for his or her students
Challenges (C)	Fellow challenges (FC)	Adaptability	The fellow describes difficulties arising from the graduate student experience
	Teacher challenges (TC)	Classroom management	The teacher expresses difficulties he or she has with the teaching profession

Insights (IS)	Fellow teaching (FT)	Pedagogical knowledge	Fellows describe how they learned about teaching or gained teaching experience through the program
		Adaptability	
		Content knowledge	
	Teacher professional development (TPD)	Content knowledge	The teacher describes how participation impacted his or her teaching, content knowledge, connection to the science/science education community, or confidence
		Pedagogical knowledge	

Confidentiality of Data

All participants in the study were consented through procedures approved by the lead university Institutional Review Board. All 83 fellows and 73 of the 74 teachers were located through a combination of Internet research, social media, and contact through former PIs or colleagues. Fellows and teachers were sent a letter and/or e-mail to request their participation in the study, clearly outlining the goals of the study. Of the original total of 157 participants who were contacted, 113 (72%) consented to participate in the study (Table 2). One participant was deceased, two fellows did not wish to participate, and the remainder (16 fellows and 24 teachers) did not respond or did not complete the process. Consent documents were scanned and maintained on a password-protected server. All paper records were maintained in locked file cabinets. Electronic files were kept on a secure server maintained by the lead institution and password protected.

Results

Likert Scale Survey Results

As shown in Table 4, fellows (F) and teachers (T) strongly agreed that use of hands-on science in the classroom was an important component of the program. This finding reinforces one of the primary goals of this program: to insert a scientist into the classroom to assist the teacher in increasing the time spent each week on inquiry/hands-on science. Fellows and teachers also agreed that getting to know their partner and the in-classroom partnership were important to create a strong relationship that would result in effective coteaching. Flexibility in scheduling was also valued by both in order to adapt their schedules to changing university and school district schedules. The greatest difference in responses from teachers and fellows was in the categories of planning for the year during the summer workshop and planning during the academic year. Fellows constantly felt time pressures and expressed difficulty in balancing responsibilities in the lab and the time required to complete the SCP program requirements (i.e., planning outside the classroom and attending the 2-week workshop). Overall, even with minor differences in answers between fellows and teachers, the overwhelming response was positive for all categories, and all participants strongly supported the SCP program components. The responses did not differ over the years: Fellows in Year 1 when the program was just starting still felt as strongly positive as the fellows in the mature SCP program in later years.

Table 4. Likert Scale Results of Impact of SCP Program on Participants

Question	Percent Responses									
	5: Strongly agree		4: Agree		3: Neutral		2: Disagree		1: Strongly disagree	
	F	T	F	T	F	T	F	T	F	T
Getting to know my teaching partner	88	88	8	12	0	0	4	0	0	0
Using hands-on teaching in the classroom	77	88	21	12	2	0	0	0	0	0
Teacher/Fellow partnership in the classroom	78	82	18	15	4	0	3	0	0	0
Planning lessons for the year	53	91	31	9	8	0	8	0	0	0
Flexibility in scheduling	70	79	24	18	6	3	0	0	0	0
Learning inquiry teaching strategies	58	76	38	21	4	3	0	0	0	0
Planning and revising lessons during the school year	44	74	41	24	15	2	0	0	0	0
The summer workshop	36	74	47	23	11	3	6	0	0	0
Flexibiity in choice of science activities	61	63	27	31	7	6	5	0	0	0

Fellow and Teacher Open-Ended Survey Question Responses

Results of coding analysis of open-ended survey questions are shown in Figure 1. In response to the question about the most valuable or successful part of the program (Figure 1A), both fellows and teachers overwhelmingly named implementation of hands-on science activities in the classroom as the number one component. As one teacher commented, "The most valuable part was the hands-on learning! Kids learn so much more by doing than the same old textbook." Also highly ranked by all participants were the relationships between partners in the classroom and the opportunities that the program provided for students. One fellow wrote, "The most valuable component of the program was the relationship established between the fellow, the teacher, and the students." Another participant stated that the most valuable component was the "early exposure of advanced science projects for young students (the students really became engaged with the more hands-on experience)." Teachers found value in the content knowledge that fellows brought, as well as in simply having an extra adult in the classroom. Although it increased the fellows' time commitment, fellows as well as teachers gave the summer workshop high ratings. Fellows also noted that their gain in pedagogical knowledge was important for strengthening their teaching skills for future careers.

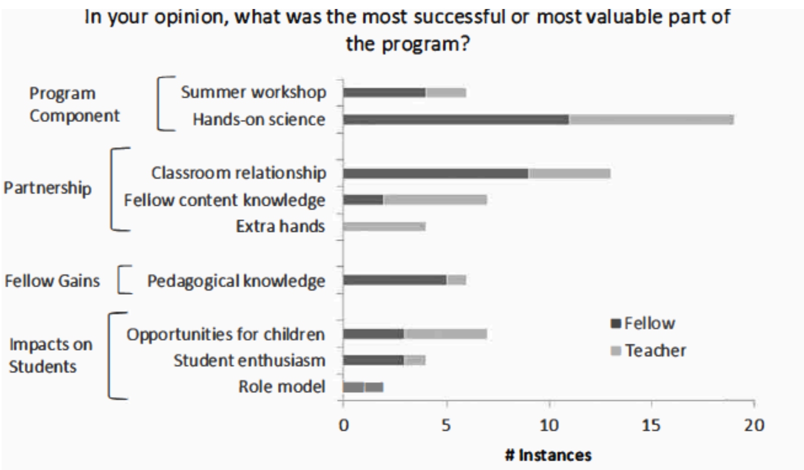

Figure 1A.

Regarding what was unique in the classroom (Figure 1B), again both fellows and teachers named hands-on science as the top category. Example comments included "We would not have nearly as many hands-on science activities had I not had a fellow in the classroom" and "The students were taught skills through hands-on experience that I did not have the content knowledge to teach by myself." Opportunities for children and student enthusiasm were

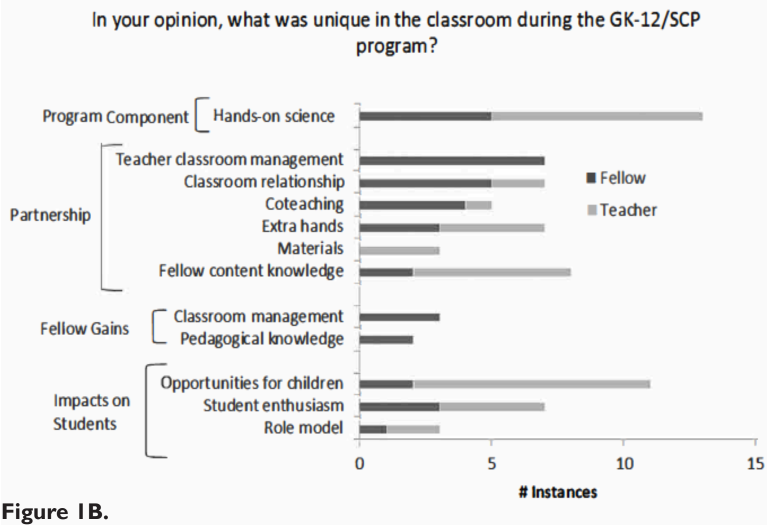

Figure 1B.

also ranked highly (especially by teachers). Fellows commented that the classroom management skills that teachers brought were essential, as well as the classroom relationship and coteaching between fellows and teachers: "The classroom management was great and would have possibly been a challenge if it were not for the partner teacher." The resources that fellows brought were regarded highly by teachers, including their science content knowledge and "extra hands" (for managing hands-on activities).

Fellows and teachers also responded to the question "What is one thing that could be changed about the program?" Almost all the responses (84%) related to program components. Six fellows and 12 teachers suggested that the program should be expanded. For example, several fellows commented that the program could be expanded to other universities. Other suggestions included expanding the professional development time for fellows and increasing the availability of hands-on science kits. Only five of 39 fellows stated that the time commitment was a challenge: "the time needed to participate . . . interfered with research." Three of 26 teachers mentioned that they would have wished to be involved in the pairing of fellows and teachers. Five participants simply stated that nothing needed to be changed: "I really enjoyed the program."

At the end of the survey, participants were asked to provide any additional comments. A total of 24 fellows and 13 teachers provided comments in this section. Over 90% of the responses were highly positive about the program. One second-year teacher wrote, "I cannot say enough about how valuable and needed this program is. . . . the program made what could have been an extremely difficult year into a very rewarding and fun one for both me and my students." Another teacher in her tenth year stated, "This program is amazing. . . . My organization and planning skills have greatly improved. The lessons we are given time to develop in the summer are well thought out and meaningful." A fellow currently on the faculty at a small college responded:

> Without a doubt this program was the most influential and important experience of my professional life. The skills that I learned (teaching, classroom management, time management, knowledge of resources, etc.) were invaluable. . . . This program simply changed my life.

Another fellow in a university faculty position stated:

> This was the single most effective training I have had in my entire career on how to be a good teacher. Were it not for this program, I honestly feel I would not be an effective teacher, but instead would have been 'one of those professors who can do research but doesn't know how to teach.' It truly was among the most positive and fulfilling years of my life.

Focus Group Analyses

Each focus group at the 1-day retreat was given approximately 45 min to record their responses to two questions on flip charts. The responses were then coded as described in the Methods section. In response to "What worked well" (Figure 2A), comments from fellows-only groups (dark bars) most frequently cited hands-on science, the summer workshop, the classroom management that teachers provided, and the coteaching that occurred in the classroom. One fellow commented that what worked well was the fellow–teacher dynamic in the classroom. Comments from teachers-only groups (light bars) mentioned the workshop, the fellow providing "extra hands" in the classroom, and the coteaching in the classroom. One teacher stated that what worked well for her was the "blending of teaching strategies (metro teacher) and scientific knowledge (fellow)." Groups with both fellows and teachers (medium bar) emphasized hands-on science, the workshop, coteaching, and the classroom relationship. It's interesting to note that by far the highest ranked category was coteaching, and when fellows and teachers were together as a group, this category was mentioned the most.

In the category of challenges and barriers (Figure 2B), fellows mentioned both teacher quality and the fellow–teacher relationship as a challenge. As one of the comments emphasized, "A mutual respect and base understanding of the roles for the partners is necessary. When two members do not align behind this idea, class-

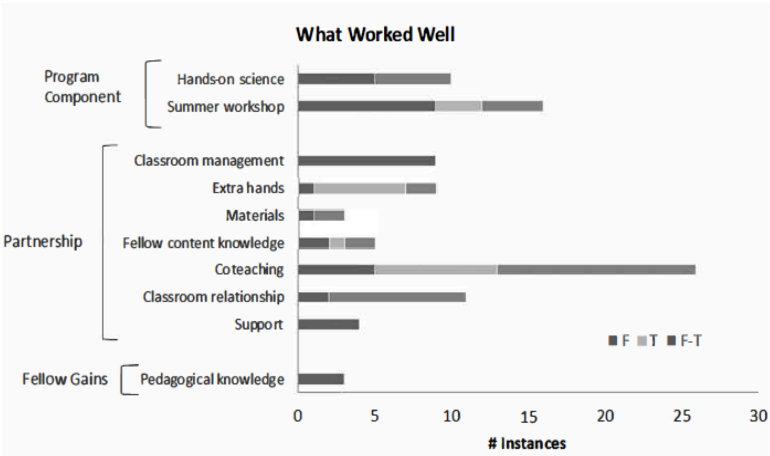

Figure 2A.

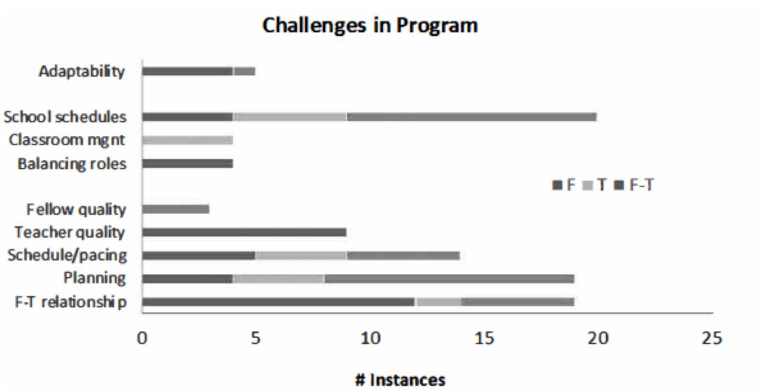

Figure 2B.

room lessons suffer." Another comment stated, "If the relationship between the fellow and the teacher isn't conducive [to learning],the co-teaching suffers." Fellows and teachers both commented that school schedules, scheduling, and instructional planning at the school level were by far the biggest challenge. After spending 2 weeks in the summer to plan a year's activities, often there had to be adjustments to allow for snow days, testing, school events, and so on. Fellows also commented that balancing their time was a challenge; they were trying to complete their laboratory responsibilities while also teaching for 1–2 days in a secondary classroom.

Discussion

This study is the first to examine the impact of a long-standing, sustained scientist-in-the-classroom program derived from one of the first NSF-funded GK-12 projects. This program has not only continued for over 17 years but has created a remarkable partnership that has had far-reaching impacts on students, teachers, and scientists. In examining the beliefs and attitudes of almost 100 participants over 10 years, results have supported the many conference proceedings and research studies in the literature showing incredible impacts on students, teachers, and scientists. The current study goes beyond these findings to examine this long-term intervention strategy and its impacts on student, teacher, and fellow participants. Through surveys and focus groups involving over 80% of the 157 teachers and fellows who participated from 2000 to 2009, a clear picture has emerged demonstrating the positive impacts of placing a scientist in a middle school classroom and how this program can transform the lives of the teachers, fellows, and students.

The Value of Scientist–Teacher Partnerships in the SCP Program

The value of the partnership formed between scientists and educators was highlighted by both fellow and teacher participants as one of the most important features of the SCP. These partnerships were formed through intensive summer workshops with continued development during the in-classroom coteaching. Several partnership themes were mentioned by participants in the focus groups:

- The collaboration between the teacher and the fellow, combining strengths from both parties, creates a unique experience for students.
- Building off each other's strengths leads to something bigger than the sum of the parts.
- Collaboration led to the sharing of each other's expertise: teachers gained confidence in content and fellows gained confidence in teaching.

- Ultimately the success of the program depends on the strength of the relationship between the teacher and the fellow. If the relationship is mutually respectful with admiration then many problems and issues are resolved.

Both scientists and teachers brought specific strengths and needs to the development of the SCP partnerships. Scientists brought their depth of content knowledge as well as an understanding of scientific research and inquiry. Teachers brought their understanding of pedagogy, the challenges facing at-risk students, classroom management techniques, and how to make the science content understandable to a diverse audience. Activities in the summer workshop focused on helping the teachers understand university-level science through research talks by the fellows and visits by teachers to their partner fellows' laboratories. During the workshop and academic year, teachers helped the fellows learn how to unpack the science content knowledge in lesson planning and understand the challenges encountered in urban K-12 classrooms. The summer workshop and academic year provided over 200 contact hours for building successful partnerships between fellows and teachers. As a result of the partnerships developed during the SCP program, teachers gained confidence in teaching using inquiry while strengthening their content knowledge, and fellows gained teaching skills. One middle school student commented, "The best thing about having a GTF [fellow] in my science class this year was learning in an interesting way. They made learning about things that were unknown to me fun." A participating teacher stated:

> I have more confidence in the way I teach. I always tell students that I am learning the same way that they learn when we are in the classroom. We learn by doing. A lot of times when the students are doing, I am doing as well.

A fellow responded that the value of the partnership was "teaching me, the fellow, to teach in a real-world situation."

Effective scientist–teacher partnerships are challenging at best to create, involving far more planning and preparation than simply walking into the classroom on Day 1 and "teaching" (*Caton et al., 2000*). A successful and productive scientist–teacher partnership must be built on trust, with an understanding of the needs and strengths of all partners, continual open communication, and a definition of specific roles and responsibilities for all partners (*Gomez, Bissell, Danziger, & Casselman, 1990; Hall-Wallace & Regens, 2003; Moreno, 2005; Sussman, 1993; Tanner, Chatman, & Allen, 2003*).

In addition, scientists and teachers work in very different environments, with different expectations, vocabularies, knowledge, and behaviors. For example, scientists who work in research laboratories without significant teaching responsibilities may have little understanding of the K-12 world. Similarly, teachers may have little or no experience with the content and research base of university-level science (*Tanner et al., 2003*). As a result, there can be a mismatch between the professional practices of scientists and K-12 teachers (*Moreno, 2005; Tanner et al., 2003*). Resolving these differences between the worlds of the scientists and teachers is essential for the development of effective partnerships (*Caton et al., 2000*). The current study showed that the SCP program was successful in creating and maintaining mutually beneficial partnerships between K-12 teachers and university scientists. Both teachers and fellows indicated a greater understanding of their partners' strengths and challenges, and that the partnership-building experiences within the SCP program led to the development of lifelong friendships between the teachers and fellows. As one fellow stated, "The most valuable component of the program was the relationship established between the fellow, the teacher, and the students." A teacher underscored the importance of the partnership with the comment that "the most important component of the program was the teacher/fellow partnership in the classroom."

What Fellows Bring to the Partnership

Results from the current study as well as a number of other scientist–teacher partnership models have suggested that scientists play a variety of roles in the classroom to enhance inquiry-based STEM learning, including STEM expert, a resource for materials and curriculum enrichment, and STEM role model (*Bledsoe, Shieh, Park, & Gummer, 2004*). The importance of the fellows' roles in the SCP was highlighted in the current study, in which their contributions were acknowledged as critical components for the success of the program. Fellows brought their training as researchers to assist teachers in engaging students in "authentic science" using hands-on, inquiry-based labs (*Barab & Hay, 2001*). Most researchers agree that learning science through an inquiry approach not only increases student achievement in STEM but also promotes a positive attitude toward STEM studies. In a recent study, Blank (*2012*) reported that aggregated state and national data showed that more time spent on science correlated with higher National Assessment of Educational Progress (NAEP) science scores and that more frequent use of hands-on science resulted in higher NAEP scores

(*Blank, 2012*). Additional studies have provided further evidence that the frequency of hands-on experiences is strongly related to science achievement (*Ruby, 2006; Stohr-Hunt, 1996*). In addition, teachers report that performing hands-on activities in their classrooms results in more students scoring at or above basic on the NAEP assessment (*O'Donnell, 2007*). Extending hands-on by integrating the "development of understanding through investigation, i.e., asking questions, determining appropriate methods, gathering data, thinking critically about relationships between evidence and explanation, and formulating and communicating logical arguments" can be a powerful strategy for changing how students learn science (*Marshall, Horton, Igo, & Switzer, 2009, p. 591*). As stated by Bower (*2005*), fellows bring the "real scientific skills of investigation, critical thinking, imagination, intuition, playfulness, and thinking on your feet with your hands that are essential to success in scientific research" (*"What Can I Do," para. 5*). With the addition of appropriate preparation to understand the K-12 community and science classrooms, the fellows can easily apply these skills to any area of science (*Bower, 2005*).

Despite the growing consensus that inquiry-based teaching is critical to building STEM knowledge and skills, the implementation of inquiry instruction in middle school classrooms remains a challenge (*Trautmann & MaKinster, 2005*). Two hands-on science programs available through the lead institution and the school district assisted the fellow–teacher teams in implementing inquiry instruction in the classroom. The kits that were provided not only served as important curriculum enhancement and activities but provided a framework for building fellow–teacher partnerships in the summer workshop as teams worked together to integrate the kits into the grade-specific curriculum. Students therefore experienced at least 1 day per week when fellows cotaught inquiry-based lessons with the teachers.

One theme to emerge from our analysis was the important role fellows played as role models for students who may have little idea of who can be a scientist and who scientists are (*Bledsoe et al., 2004; Bruce, Bruce, Conrad, & Huang, 1997*). This outcome may have been attributable in part to the composition of this group of fellows: 51% were from populations underrepresented in STEM careers. Since the classrooms served in the SCP have a high percentage of underrepresented minority students, these fellows likely provided models of successful minorities who had entered graduate-level STEM programs and were on their way to pursuing a career in a STEM field. Echoing our findings, in the Abt study of the GK-12 program, teachers reported that the greatest impact of their GK-12 experience was the positive effect of fellows on the students' perception of STEM professionals (*Gamse et al., 2010*). These young scientists are also still developing their own understanding of inquiry through their research, making them even more empathetic toward the successes and failures of research-based science *(Gengarelly & Abra, 2009)*. As stated by Cacciatore and Sevian (*2011*), "STEM education is most successful when students develop personal connections with the ideas and excitement of STEM fields" *(p. 248)*.

What Teachers Bring to the Partnership

One goal of the current study was to examine the efficacy of the SCP program through the contributions of both teachers and fellows in the classroom. One of the primary goals stated in the original NSF GK-12 program solicitation was to partner STEM graduate students with teachers in K-12 classrooms to improve the teaching and communication skills of the graduate students *(NSF, 1999)*. As expected, much of the research of the program has focused on the impacts on the fellows and their gains in pedagogical skills and preparation for teaching and research careers (*Thompson, Metzgar, Collins, Joesten, & Shepherd, 2002a*). There have been relatively few reports on the impacts of in-classroom partnerships on teachers (*Cormas & Barufaldi, 2011; Mitchell et al., 2003; Thompson, Metzgar, Collins, Joesten, & Shepherd, 2002b; Willcuts, 2009*). The research conducted in the current study showed that SCP partner teachers brought their love of teaching, an understanding of students in high-needs schools, a strong understanding of pedagogy, and a grasp of classroom management to the program. As suggested by Hill et al. (*2008*), K-12 teachers bring specific skills and attributes to partnerships with scientists, including knowledge of content in terms of student learning and teaching the content, as well as in-depth knowledge of the curriculum.

These strengths were evident in the self-reported fellow data in which fellows discussed learning classroom management techniques from the teachers and how that the teachers' classroom management allowed the fellows more time to focus on the science. The fellows in this study consistently described the importance of the teachers' classroom management skills and understanding of instructional strategies in their understanding of teaching as a profession, in agreement with previous reports (*Thompson et al., 2002a*). The fellows reported that they gained knowledge of student needs and strengths, the curriculum, standards, and differentiating the learning for individual learners from their teacher mentors. As one fellow stated, "The teacher's knowledge is much more than the materials; much of the leadership skills, patience, and joy of teaching that they show really transfers to the fellows." A key realization from this study was the respect that the fellows gained for their teachers and the teaching profession. The understanding of how to teach gained from the teachers was an invaluable component of the fellows' professional development (*Gamse et al., 2010*).

Implications for Students in Participating Classrooms

Although this study focused on the impact of the SCP program on teachers and fellows, a primary goal of the program (and of the teachers and fellows who participated) was to improve the STEM learning experience for students. It is without question that student enthusiasm and positive attitudes are increased when students have the opportunity to explore and discover (*Ornstein, 2006; Simpson & Oliver, 1990; Van Hook, Nurnberger-Haag, & Ballone-Duran, 2009*). In preliminary work in the current study, students in classrooms with fellows were asked to describe the best thing about having a scientist come to their school. Almost all students responded that they were getting to do more hands-on experiments and that they were having more fun in science class, learning new things, and gaining a better understanding of science *(Ufnar & Shepherd, n.d.)*, affirming that students demonstrate overwhelming positive attitudes and excitement when an SCP scientist is present in the classroom. Teachers also commented that students had higher attendance rates and fewer discipline referrals on days when scientists were present, supporting the findings of Caton et al. (*2000*) that participation in inquiry science resulted in increased satisfaction and fewer disciplinary issues in class.

When students have the opportunity to engage in inquiry investigations, generate their own hypotheses, and draw conclusions, they exhibit more positive attitudes about science (*Ornstein, 2006*). Gibson and Chase (*2002*) reported that students participating in a summer inquiry science program who were followed into high school exhibited a significantly higher interest in science careers than the comparison group. When students do not have positive experiences in science during middle school, they will likely avoid science and by the end of high school have little interest in or knowledge about science (*Maltese & Tai, 2011; Simpson & Oliver, 1990*). In spite of these reports supporting inquiry-based science as essential for students' persistence in science studies, achievement in the STEM disciplines continues to decline. In 2009, only 34% of eighth-grade students and 21% of 12th grade students performed at the proficient level on the NAEP (*National Center for Education Statistics, 2012*). More important, a significant gap exists in achievement between students in classes that rarely do hands-on science versus students who experience hands-on at least weekly (*Stohr-Hunt, 1996*). Placement of scientists in classrooms alongside teachers may be the solution that is needed to increase student interest in STEM. Both fellows and teachers consistently mentioned the opportunities that they were providing for students, as well as the noticeable enthusiasm by the students. One fellow stated that the program provided scientists with the opportunity to "interact with the children in the classroom to help inspire, teach and motivate them to view science as fun." And a partner teacher commented that "the partnership provided more opportunities for learning and one on one time for students."

Conclusion

In this article, we have described how the SCP program can contribute to building partnerships between higher education and the K-12 environment, enhancing K-12 STEM education, and providing unique opportunities for graduate student and postdoctoral fellow training. Focusing on the partnerships and impacts on students, teachers, and university fellows, we have addressed the limited nature of university–K-12 partnerships and opportunities for graduate students and postdoctoral fellows to participate in STEM reform. We have noted the challenges presented by declining student achievement as compared with international peers, as well as national STEM reform efforts to enhance teacher professional development and increase student engagement and achievement in K-12 schools. Our research has studied the SCP program and the literature to offer recommendations for enhancing those STEM efforts through partnering university fellows and K-12 teachers. Our results show that the SCP program has gone beyond other university–K-12 partnerships in the scope of the program, number of teachers and students impacted, and duration of partnership. We have shown that the SCP program, now in its 17th year, has adapted and evolved to become one of the most successful sustained partnership programs between a university and an urban K-12 school district. Since its inception, the SCP program has resulted in over 200 professional development hours per teacher per year for over 120 teachers in 35 schools; has positively impacted the STEM learning of almost 20,000 students; and has contributed to the professional training of more than 150 fellows. The program has been incorporated into the STEM reform initiatives in the partner school district and has been institutionalized at the partner universities. In conclusion, our research shows that the SCP program can act as a model for connecting universities and the K-12 community to enhance STEM education while providing unique training opportunities for fellows.

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Methodological Addendum

The research described in this manuscript was a retrospective study of ten years of an ongoing scientist in the classroom program, using self-reporting by participants through online Likert-scale surveys with open-ended questions, as well as in-person participant focus groups. Survey responses and focus group discussions were analyzed using coding as described by Braun & Clark *(2006)*. This approach was chosen to provide both qualitative and quantitative data to support the study conclusions. Qualitative data collected in this study provide a rich and detailed picture supporting the conclusions reached. However, all qualitative studies are limited by the generalizability to different settings.

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