

STEM Partnerships that Spill Over

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Introduction

In recent years the National Science Foundation and the U.S. Department of Education (DoE) have emphasized that universities have an inherent responsibility to assist the K-12 community in improving student academic achievement, particularly in the fields of science, technology, engineering, and mathematics (STEM). After a number of years of involving higher education in various ways in targeted and systemic K-12 reform, NSF and the DoE began to promote university-K-12 “partnerships” as the means to most effectively involve higher education in the process. However what this exactly meant in the STEM educational world, or how effective partnerships should be created and evaluated, was mostly left undefined, generating confusion among both educators and evaluators.

As part of an NSF-sponsored Research, Evaluation, and Technological Assistance project designed to help clarify the evaluative issues involved with partnerships, we are currently examining how the characteristics and operations of partnerships influence STEM educational outcomes.* Part of this project addresses the vexing issue of how to evaluate both the outcomes of a partnership, and the partnership itself. For, although a partnership is often viewed primarily as a vehicle or framework for conducting other planned STEM activities or interventions, it often becomes much more than that, leading to a multitude of unanticipated activities and outcomes. Evaluations that don’t directly address the partnership, and the unanticipated outcomes that result, may suffer from a weak formative assessment regarding the health of the partnership, and also may miss some of the most important results of that partnership.

The unintended consequences of the partnership, defined here as “spillover”, can become so crucial that they eclipse the original project objectives, becoming themselves a driving force in the program. Traditional evaluations, which generally seek to measure the numerical success of the original project objectives, often do not control for the impacts and influences of the partnership itself, and may miss both the project spillovers, and also possible alternative explanations for observed events or impacts. In this paper we will discuss the knowledge about partnership gained from the field of public policy, apply this understanding to the field of STEM

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university-K-12 partnerships using the Georgia Tech's Student and Teacher Enhancement Partnership (STEP) GK-12 program as a case study, and reflect on the ramifications for partnership evaluations.

Conceptualizing Partnerships

During the course of this research we have come to conceptualize the STEM partnership developed under sponsorship from the NSF GK-12 program as a *relational event* comprised of inter-organizational collaborations aimed at enhancing the performance of participating partners. A relational event is a set of interactions between collaborators whose intent is to achieve shared or complementary goals. This set of interactions includes the different types of actors and relationships that come together in making a partnership function: the interactions between STEM professionals (from both higher education and K-12) and students (from both higher education and K-12); the interactions of individual STEM professionals working together; the interactions of organizations in aligning rules and procedures; and the interactions of policies at the federal, state, and local levels. Inclusion of all of these relationships and actors in a single set makes a relational event a very messy concept for more structured forms of inquiry, such as social network analysis, because it mixes together multiple units of analysis and multiple modes of relationships. However, when human beings relate their experience in working with a partnership they blend these elements together easily in a narrative describing the relational event. Thus, we have developed the concept of a relational event to capture the richness of the narrative that we have observed as part of the case study.

STEM grant programs have begun to require prospective participants to develop partnerships. Thus, one can think of a grant program as a catalyst for stimulating both a relational event (i.e., a partnership) and the educational outcomes desired by policy-makers. The announcement of the grant program (in the form of a request for proposals (RFP)) is made to a larger institutional field comprised of K-12 institutions, those elements of higher education interested in STEM education at the K-12 level, and other interested groups from the business, non-profit and governmental communities. The funding agency generally identifies the boundaries of the types of institutions that are likely to be called upon to participate. The RFP may stimulate interactions between potential collaborators, drawing people from the various organizations together to discuss the opportunity. At times, these interactions will culminate in sufficient agreement among the participants to produce a completed proposal for submission to the sponsoring agency. This proposal is, in essence, a blueprint of the relational event in which the potential partners are likely to engage. If the proposal is successful, the resources provided by the sponsoring agency are to be used to enact the relational event planned for in the proposal and, consequently, give life to the partnership.

The frameworks and models that have been developed to study inter-organizational relations and networks rarely argue that partnerships are a necessary or sufficient condition to stimulate improved outcomes. While many STEM education programs seek to link partnership efforts to positive outcome variables such as increased student achievement, researchers and evaluators from several fields have noted that studies of inter-organizational relations (such as partnerships) rarely address outcomes^{1,2,3}. It is far more common for partnership studies to try and explain the reasons for the formation and structure of relationship rather than subsequent outcomes and

impacts to the partner organizations⁴. However, the professional wisdom of sponsoring agencies, built up over years of programs stimulating cooperative relationships between STEM educational organizations, has led to current grant requirements encouraging partnership as a means for improving the chances of achieving desired performance outcomes. This is an instance where praxis has run ahead of our theoretical understanding of the utility of partnerships.

The NSF GK-12 Program

The NSF GK-12 program, which provides the context for the case study addressed in this paper, provides support for institutions of higher education to place graduate and undergraduate students into K-12 classrooms for ten hours per week. The relational event common to all funded GK-12 programs is the cooperation among organizations to facilitate the use of STEM graduate and undergraduate students as a resource in K-12 schools. The relationships associated with implementing a GK-12 program generally require different types of interactions than what participants are likely to experience in their normal work lives. When a GK-12 Fellow (i.e. the university student) begins interacting with a teacher or set of students there is no natural model that educators or the Fellows can fall back upon. Most Fellows are not trained with the pedagogical skill set that a student-teacher might have; and frequently they have more advanced training in a science, math, or engineering discipline than the participating teacher. Thus, a good deal of adaptation and interaction is required for the Fellow-teacher relationship to develop.

However, the tasks in which Fellows are engaged within the K-12 schools often represent variations on activities and educational objectives in which teachers are already engaged. Fellows may introduce new pedagogical techniques, new curricula, new technologies, and/or extend the educational outreach to targeted groups of students. However, these activities are done in parallel with more tried-and-true approaches and are integrated into the existing lesson plans largely as a reinforcement of educational objectives rather than as a means of introducing entirely new objectives. Thus, the GK-12 program offers a new type of relationship between universities and K-12 schools, but is integrated into existing educational objectives. In forming these new relationships the individual participants are taken out of the comfort zone of routine activities and are required to adapt to a new potential resource. We have observed that the most effective relationships are those in which a significant amount of adaptation is exhibited by all parties.

Evaluations of Partnership

Evaluations that focus in a narrow fashion on defined program objectives are likely to miss the fruits of the adaptation by the participants in the partnership. Many of these adaptations lead participants to engage in an astonishing array of activities aimed at improving the quality of the relationships between Fellow, teacher, and student. Capturing these adaptations and the value created for participants is the motivation of this work on modeling spillover effects from the partnership.

We define spillovers as outcomes that partners accrue through participation in the partnership which are not articulated as part of the original program objectives or the anticipated relational

event. Spillovers may be positive or negative in nature in that a partner may experience additional value added from the partnership or consequences that are negative to their operation. In making the observations for this case study we found most respondents easily volunteered the distinction between events that were planned for as an element of the partnership and activities in which they were being opportunistic, or even inspired, to go beyond the bounds of what was planned as part of the partnership, and engaged in new or qualitatively different activities. It is this later set of activities that we capture as spillovers.

The conceptualization of a partnership as a relational event provides a basis for exploring three different dimensions of spillover effects. The first type of spillover is *expanded connectivity*. This can be observed through any new connections or interactions between partner organizations in areas that are outside of those originally specified to be part of the partnership. For example, a teacher participating in a GK-12 program may be inspired to pursue additional opportunities for relationships with the university. A second type of spillover is *enhanced quality of connections* between partner organizations. The relational events described in a partnership proposal identify the types of interactions anticipated between teachers, fellows and students. However, it is not uncommon for participants to see additional opportunities for improving the quality of their partnerships and so to go beyond expected performance standards. The added value of such enhancements to the quality of the interactions between partners should be observed as these often are sources for building and solidifying the trust that partner organizations have in one another. A third type of spillover is *new objectives* that partners adopt that go beyond the bounds of the original proposal. New objectives may be observed as an expansion in the scope of the sponsored project supporting the partnership or they may be seen in the new projects that the partners undertake as a result of their experience.

In the case study presented below we attempt to identify the spillover effects associated with a GK-12 partnership. We do so by identifying the relational event specified for the partnership through the objectives and the anticipated interactions between teachers, fellows, and high school students. Using this as a baseline we then identify the variety of spillover effects experienced by each of these participants in the partnership.

The Student and Teacher Enhancement Partnership (STEP) Program—Case study

The Student and Teacher Enhancement Partnership (STEP) program^{*}, funded for three years by the National Science Foundation as part of the GK-12 program, with a continuation for another five years (as STEP Up![†]), partners Georgia Tech graduate and undergraduate students with teams of teachers at six metro-Atlanta high schools. The discussion that follows applies the conceptual model of partnership spillovers to the STEP program, analyzing the program based on the theoretical concepts described. The findings for this study are drawn from the original STEP proposal, to determine original program objectives and stakeholders, and from the on-going evaluation of the STEP program. The latter provides evidence for project spillover in the form of expanded connectivity and enhanced quality of connections between the partners, and in a redefining of the program stakeholders and incorporation of new project objectives.

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A key STEP evaluation issue has been whether the program enhances university-K-12 partnerships, and what impact the actual partnership has on the project outcomes. Thus, several key relationships served as the focus for the larger evaluation:

- 1) Evidence of enhanced math and science partnerships between Georgia Tech, the school districts, and the high schools.
- 2) Evidence of effective working relationships between high school teachers and the STEP Fellows.
- 3) Evidence of benefits to teachers, Fellows, and high school students from participating in the STEP program.
- 4) Identification of factors that facilitate or hinder the achievement of the impacts identified in previous three points.

The principle evaluation method employed is to develop case studies of each of the high schools participating in the STEP program. The narrative in each case describes the implementation of STEP from the perspective of each of the partners, emphasizing the relational nature of the partnership. In addition to the case studies, the data is examined according to the roles that individuals play within STEP. Thus, aggregate narratives are developed for Fellows, Teachers, Coordinators, and Advisors. A variety of data sources are used in this study including:

- Semi-structured interviews with Fellows, teachers, advisers, coordinators, and STEP administrators.
- Surveys of Fellows following the summer training programs for STEP.
- Document reviews of the action plans for each high school.
- Document reviews of lesson plans and assessment tools developed by the STEP Fellows.
- In-class observations of the STEP Fellows.
- Review of journals maintained by the STEP Fellows of their experiences within the high schools.

The evaluation was specifically designed to analyze the types of connections formed between project organizations and stakeholders, and to assess changes in quality and quantity in these connections.

Original Program Stakeholders and Objectives

Analysis of the original goals, objectives and anticipated outcomes of STEP indicate three original primary stakeholders—the graduate Fellows, the teachers, and the high school students. The basic objectives and anticipated outcomes, defined by stakeholder, were:

- **For Graduate Fellows:**
 - Objectives: To train in educational pedagogy at Georgia Tech, and gain actual teaching experience through the school-year classroom practicum and by direct interaction with the experienced teachers.
 - Anticipated Outcomes: Improvement in teaching, communication, and leadership skills, and increase in understanding of diversity and the K-12 educational arena.

- **For Teachers:**
 - Objectives: To pair teachers with STEP Fellows to enhance teachers’ content and educational technology knowledge, including through the use of formal professional development given by the Fellows, and to develop mentoring relations with Georgia Tech faculty through field trips and electronic communication.
 - Anticipated Outcomes: Improved understanding of science, the scientific process, and the integrated nature of knowledge, and the development of valuable personal connections to scientists and engineers.
- **For High School Students:**
 - Objectives: To gain exposure to educational technology from the graduate Fellows, to have mentoring relationships with the Fellows, to participate in field trips to Georgia Tech, and have class visits by faculty.
 - Anticipated Outcomes: Benefit from improved science teaching by teachers, and increased enrollment of students at Georgia Tech.

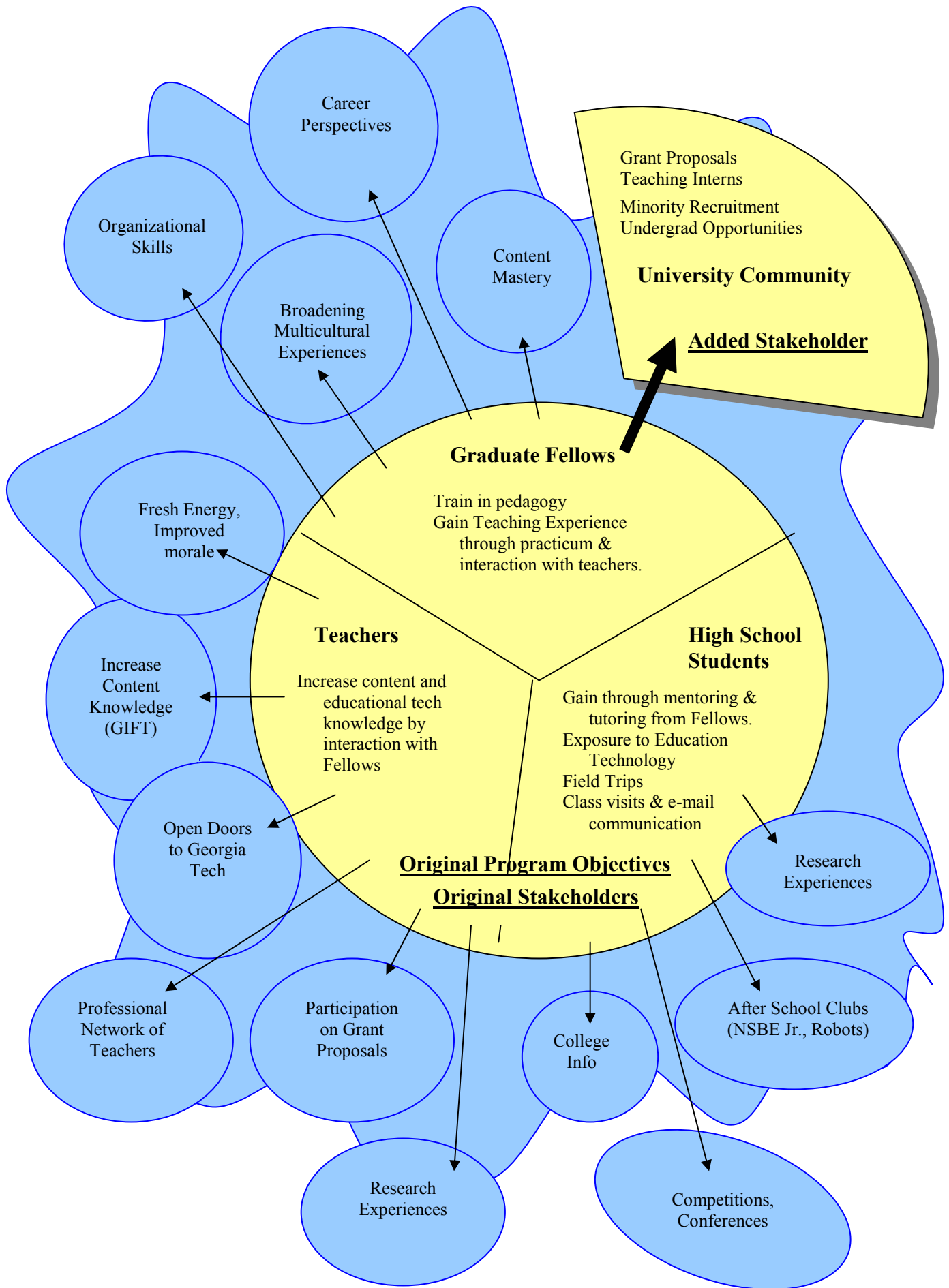
Four years and 50 graduate Fellows later, a much more complicated picture emerges that includes large amounts of project spillover, including the addition of an unanticipated major stakeholder—the broader University Community, including undergraduate students. The graphic on the follow page depicts the original project, and the associated spillover (stakeholders are in yellow, spillovers are in blue). The most substantial spillover involved teachers and university faculty, and are indications of greatly increased and improved connectivity between the university and the high schools.

STEP Spillover

Graduate Fellows

As anticipated, graduate students participating in STEP report improvement in their leadership, communication, and teaching skills. However other effects appear to be equally important, and were included as new objectives in the grant renewal proposal. The spillover effects include:

- **Academic Content Mastery:** Graduate students teaching high school students must convey knowledge so that it is comprehensible to students who come from varying achievement levels and backgrounds. This requires that knowledge be thoroughly understood, condensed and distilled to improve its efficacy.
- **Career Perspectives:** Hands-on teaching experiences provide graduate Fellows with early opportunities to elucidate their interests in teaching as a profession - whether at a high school or college level—and helps them better-define their future professional and academic goals and objectives. It also provides them with models of rewarding community service that are applicable to their future career, whether in education or industry.
- **Organizational Skills:** A graduate student’s skill at time management strengthens through time spent with students - both inside and outside of the classroom. Most graduate Fellows willingly spend more time contributing to the program than is required. To accommodate this, graduate students conduct their research and schoolwork in a more efficient manner.
- **Broadening Multicultural Experiences:** To date, 29 of the 50 graduate STEP Fellows have been African American. We attribute this to the strong involvement by black graduate students in community involvement and civic leadership activities, and to a powerful “word of



mouth” promotion of the program within the minority community at the institute. This has enabled us to create a truly multicultural environment in the program, fostering active discussions on race and the impact it has on education. In addition, many of the white graduate students have experienced, for the first time, being a minority face in a venue (in this case a school) that is 99% a different ethnicity.

Teachers

The anticipated outcomes for teachers had two prongs—increasing content knowledge and increasing connections to the university. It was anticipated that graduate Fellows would provide professional development workshops for the teachers concerning topics such as educational technology and science content. This has not occurred, primarily because the STEM graduate students are generally (and understandably) perceived by veteran teachers, and by the graduate students themselves, as novices in the classroom and not as professionals equipped to design and deliver teacher professional development. However teachers cite two very valuable ways that STEP Fellows directly improve the teachers’ understanding of science and technology:

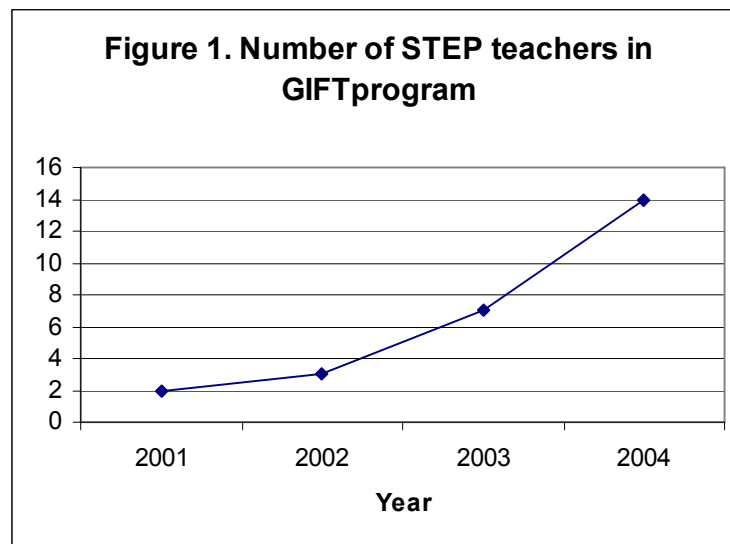
- Fellows help teachers to understand cutting-edge research that takes place at the university, and
- Fellows provide novel and different ways of thinking about, and presenting, science and mathematics content.

Fellows also enable teachers to have some “free” time to do other necessary school-related duties, and help teachers keep their “sanity” under difficult conditions, hopefully increasing the likelihood that the good teachers will stay at these challenging schools.

It was also expected that teachers would gain access to some resources from the university, in the form of materials, supplies, and equipment, and would develop connections with the STEP Fellows’ faculty advisors. However the degree to which the university partnership can open doors for high school teachers, expand their concepts of what is possible, and promote continued learning of STEM content was completely unanticipated. This is particularly true for the predominantly minority school partners that historically have not had the type of connections to universities seen in more affluent white schools. The connectivity spillover effects detailed below have come about because 1) teachers from partner schools are directly informed about other, non-STEP educational opportunities taking place at the university and encouraged to participate, 2) teachers who have participated in university-based programs and gained a sense of trust and respect for the institution, tend to recruit colleagues, thereby amplifying the effect, 3) the STEP administrative staff can tailor opportunities to the needs of partner schools and bring different resources to the program, and 4) university faculty appreciate the opportunity to develop grant-related educational initiatives in schools where strong partnerships already exist.

A powerful vehicle for promoting a strong, personal connection between K-12 teachers and the university are summer research internships for teachers. Georgia Tech’s Georgia Intern-Fellowships for Teachers (GIFT) program has been in existence since 1991 and places on average 75 teachers per year in 6-8 week research positions in academic and industry labs. GIFT participation by teachers in the four primarily minority STEP high schools since 2001, when STEP began, is shown on the following page in Figure 1. These internships, where teachers form close personal relationships with faculty, graduate students, and other laboratory staff members, lead to numerous spillover benefits. Teachers gain new and cutting edge STEM

content knowledge and laboratory skills directly from professors (in lab and by auditing summer courses), they gain a solid understanding of the process of STEM research, they network and develop independent partnerships with university personnel not connected to the STEP program, they participate on grant proposals, and they generally consider themselves a part of the extended university community. As teachers gain “ownership” of the university partnership, they become willing to request favors, and to direct events and activities in new directions that weren’t part of the original partnership objectives, but which can be mutually beneficial. This empowerment helps teacher morale, and gives them fresh energy to take back to the classroom. The teachers also form informal professional networks with teachers from other STEP schools that have led to cross-school mentoring and sharing of teaching strategies, activities, etc.



Georgia Tech faculty members and graduate students also initiate relationships with the GIFT teachers, usually for projects associated with educational initiatives on grant proposals, or graduate research projects that require high school piloting or student input. The STEP program thereby serves as the matchmaker and cheerleader for relationships that have the potential to take off and grow in unexpected directions, spilling over and out of the original project.

High School Students

High school students associated with STEP were expected to gain, in ways that are difficult to quantify, from their relationship with graduate student mentors and faculty, from field trips to the university, and from increased exposure to the use of technology. Interview data supports these anticipated outcomes. Teachers report that STEP Fellows have been able to transform the high school students’ thinking about science from a view that science is a bunch of facts, to an understanding that science is a process and a way of thinking. Fellows serve as role models, tutors and cheerleaders, introduce the students to educational enrichment opportunities outside of their school, exposed them to what the science and mathematics are used for at a higher level, and always fight against the ever-present pressures on schools to lower the bar for minority students. In addition to these anticipated outcomes, STEP, by enhancing the quality of the inter-

organizational connections between the university and the local high schools, has enabled high school students to:

- ❑ Participate in summer research internships at Georgia Tech, and submit research papers to the Siemens-Westinghouse competition,
- ❑ Participate in newly chartered junior chapters of the National Society of Black Engineers, and connect with the Georgia Tech “mother” chapter,
- ❑ Participate in academic enrichment programs at Georgia Tech,
- ❑ Interface directly with admissions officers from Georgia Tech, and
- ❑ Participate in regional and national STEM-related conferences and competitions.

University Community

The interests and missions of the university community, including the faculty, the undergraduate students, the office of admissions, and on-campus organizations such as the Society of Black Engineers and the Black Graduate Student Association, were only very tangentially included in the original objectives and outcomes. However one of the first lessons of educational partnerships is that initiatives must be mutually beneficial or else they won’t succeed, and that institutionalization of a program like STEP requires buy-in by many people who were not part of the original project. STEP has therefore spilled over into a number of unanticipated realms.

- ❑ Undergraduate students now participate in STEP, funded by the individual Georgia Tech colleges and academic departments.
- ❑ STEP and its partner schools and teachers have been included on many faculty research grants, in initiatives that address the broader educational impacts of the research. These grants have included plans to create and implement curriculum units based on faculty research, plans to mentor minority high school students and provide research internships, and plans to develop additional pipeline programs from STEP feeder schools.
- ❑ Plans have been developed for an institutionalized Teaching Interns program that includes graduate and undergraduate students and that is supported by the university administration.
- ❑ The Office of Admission has actively participated in an effort to educate minority students about college admissions, and to encourage early engagement in the academic process.

Ramifications for the Evaluation of Educational Partnerships

The evaluation of the STEP program has shown that the way that organizations interact with one another, and the quality of the connections between the organizations, is an integral part of the “treatment” under a GK-12 program. This is probably also true in other STEM education partnerships. By articulating the partnership as a relational event, with an emphasis on the quality of the interactions between the partners, we have a better basis for identifying the types of spillover effects generated by partnerships. In the case study we see evidence of each of the three types of spillovers, namely expanded connectivity, enhanced quality of connections, and new objectives.

In developing this case study we were struck by the potential utility of partnerships for STEM education. The high school teachers have demonstrated a high tolerance for the normal transaction costs that come with implementing a partnership. Participating teachers will make a significant number of adaptations to their normal work patterns in order to use the Fellows as an effective resource in the classroom. Frequently, the work of the Fellows is conducted as a

parallel activity designed to supplement and reinforce the educational objectives that were planned for the class. Yet teachers for the most part welcomed the break from the routine and embraced the partnership as a valuable addition to the resources being made available to their high school students.

In demonstrating a willingness to try new approaches, both teachers and Fellows were also willing to be experimental. This creates conditions that demand that the evaluation goes beyond the bounds of the program objectives (i.e. the planned relational event) and captures the range of activities and behaviors stimulated by the partnership. Because there are no specified routines associated with the STEP program, participants have been willing to explore alternative approaches to making the relationship work. These experiments do not always work and both Fellows and teachers do express frustration with the trials and the errors. But the benefits and the costs of engaging in these adaptations would be lost without a concerted effort to catalog the spillovers stimulated by the partnership.

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Brecca received her Masters degree in Public Policy from Georgia Tech in the fall of 2004. She served as the graduate assistant on the STEP evaluation.