Creating a Pipeline to STEM Careers through Service Learning: The AFT Program

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Setting

The Academy for Future Teachers (AFT) is a STEM education and career recruitment program for Metro Atlanta high school students, hosted by Georgia State University in Atlanta, Georgia. This program was developed in response to the changing demographics of our students: shifting much more quickly than the demographics of our teacher populations in the United States. Minority students are increasing in number while the majority of teachers continue to be white and female. In Georgia, 83% of the teachers are female, and this percentage has been relatively stable over the years (Scafidi, Sjoquist, and Stinebrickner 2006). Research suggests a direct relationship between the lack of highly qualified minority science and mathematics teachers and the lack of minority students who choose science or mathematics careers (Toolin 2003). Additionally, the underrepresentation of racial and ethnic minority teachers (including mathematics and science teachers) and the underrepresentation in STEM and STEM-related careers leads to students having difficulties being able to relate and identify themselves in these STEM roles. Researchers and educators are trying different approaches to increase interest and competency in STEM with the intent of increasing the numbers of underrepresented populations in these fields, as well as recruiting future teachers from this pool.

AFT approaches the challenge of increasing underrepresented groups in STEM fields by creating supportive service-learning experiences for high school students, facilitated by exemplary high school science and mathematics teachers and college professors. The service-learning component consists of high school students teaching STEM content to preschool and middle school students. Scaffolding for this experience is provided within the three-week intensive summer experience, focusing on building participant capacities related to attitudes and knowledge in STEM areas. This is purposefully constructed with the goals of developing student long-term interest in STEM and STEM careers, including careers in STEM education. In the unique model of the AFT program, student capacities are built in their understanding of the nature of science and science learning and teaching, the nature of mathematics and mathematics learning and teaching, and the significant understanding of certain science and mathematical concepts. Additionally, this understanding is put into action as they apply what was learned by teaching mathematics and science lessons to preschool and middle school children in concurrently held summer programs. The AFT program provides a means to develop students' identity in thinking of themselves as scientists, mathematicians, or as science and mathematics educators. In addition, we have found that the experience gives students a sense of agency in that they feel that they can do science, do mathematics, and teach a child a lesson. They become empowered through the mathematics and science learning experiences they created for younger students.

Funding for the AFT Program

For several years (2004–2009), the AFT program received support from the National Science Foundation as it was included in a large Mathematics and Science Partnership in Georgia called PRISM (Partners in Reforms in Science and Mathematics). With that initiative, AFT focused strictly on recruitment of future science and mathematics educators with an additional goal of attracting students to STEM careers. The current AFT model has continued with that focus and has been supported through several state and private grants with no charge to the participants. Recent funding agents include The University System of Georgia Board of Regents (USG-BOR) through their Science, Technology, Engineering and Mathematics (STEM) funding and the American Honda Foundation. All individuals, instructors, mentors, and students received a stipend for their AFT involvement. The individuals overseeing the project forged partnerships with local metro Atlanta school districts, as the recruitment effort required school counselors to inform high school students of this summer opportunity and teachers to provide letters of reference.

Recruitment of Students Into the AFT Program

The AFT program recruits participants from Metro Atlanta by sending out informational flyers, brochures, and application kits to principals, counselors, and science and mathematics department heads throughout the area school districts. Because of the limited capacity of the program, during some years the AFT program only sent recruiting material to select school districts. Students applying to the program, in addition to completing a standard application form, were required to have a GPA of 2.5, submit an essay on why they wanted to participate in the AFT program, and submit two letters of recommendation from their high school teachers. Because of the limitations on the capacity of the AFT program, not all qualified applicants are chosen. Participants are chosen from the pool of applications based on GPA, the quality of the response to the essay prompt, and teacher recommendations. It should also be noted that in addition to the AFT program being offered free of charge to the participants, they are also provided passes for public transportation, money for lunch, and a stipend of $200 at the completion of the program.

In 2004, 34 high school students participated in AFT, and since then it has grown in capacity each year. In 2010, AFT served about 60 high school students. Since one of the goals of the AFT program is to encourage students belonging to underrepresented groups to consider STEM for their postsecondary studies and STEM-related occupations, the AFT program actively recruited in districts with large numbers of underrepresented groups. When AFT began in 2004, the program only recruited students from Atlanta Public Schools, and the first cohort of students were all African American. Now the AFT program recruits students from a number of school districts in the metro Atlanta area. Students in the most recent cohort represented 26 schools from nine school systems. In 2010, AFT received 131 complete student applications for 60 openings for the program. This created a rich pool of student candidates. Of the 60 students selected for the 2010 AFT program 13% identified themselves as non-African American, with females comprising 82% of applicants. While this high number of females is not surprising to us, we would like to see greater numbers of African American males participate in the program. Historically and at present, African American males are underrepresented in STEM professions.

The AFT Model

The summer AFT experience at Georgia State University is constructed by the director, the Associate Dean of School and Community Partnership, and the faculty from higher education and K–12 education. In the three-week AFT program students have weeklong mini content-pedagogy hybrid courses in secondary science, secondary mathematics, and elementary science and mathematics. The intent of the courses is to provide students experiences in authentic ways of learning science and mathematics through modeling and peer-teaching.

The Teaching and Support Staff

Teachers from local school districts were hired to co-teach in AFT with higher education faculty. The three teaching teams—elementary science/mathematics, secondary science, and secondary mathematics—work together to create engaging and authentic experiences for the students. The teaching teams have expertise in the particular content and pedagogy that they taught the AFT students. In addition, three GSU graduate students act as mentors to each cohort of AFT students, and also support the teaching staff. The mentors talk with students about career goals, assist the instructors with classroom management, and generally support students by clearing up questions related to assignments and being available as a contact for questions about the program and questions about Georgia State University. It should also be emphasized that much like the AFT students, the teaching and support staff are predominantly African American. For example, in our most recent year of the program, all K–12 teachers were African-American. One of the higher education faculty members was African American, while the second member was South Asian, and the third member was Caucasian. All GSU graduate student mentors were African American.

The Curriculum

The AFT model is organized into three discrete cohorts of students: two cohorts of first-year (Y1) AFT participants and typically another cohort of second-year (Y2) participants who progress through a series of one-week experiences with three different emphases (secondary science, secondary mathematics, and elementary mathematics/science). In each of the weeklong experiences, students learn science and mathematics content through engaging and inquiry-oriented activities. In addition, the students learn about philosophies and methods related to teaching and learning in K–12 settings. As students learn content, they also learn how to teach content and learn about the pedagogical rationale for teaching the content in a particular way. In each of the weeklong programs, the AFT students get opportunities to create reform-minded lessons, receive feedback on the lesson from instructors, and then teach (field experiences) these lessons to preK–8 students. The AFT students' in-class and out-of-class experiences are organized so that they experience both STEM learning and teaching in authentic and meaningful ways. In Table 8.1, a general description of what students learn in each week of experience is highlighted. The Y2 students are also provided with a curriculum focusing on mathematics and science content as well as pedagogical learning, which is similar to what is learned in Y1, but with more application in terms of teacher behaviors (questioning) and investigation into different types of lesson designs. We also present a detailed daily activity overview for the secondary science program in Table 8.2 (p. 116).

The innovative design of the AFT program is buttressed by the collaborative activities (team teaching) and a service-learning component that is found in each discrete experience in the program. AFT students also teach young students in other programs. The instructors team-teach while the participants are learning mathematics and science content as well as pedagogy. This is how one can construct experiences for others that make that content accessible and interesting. The participants knew that they would participate in the service learning portion, where they are responsible for teaching younger students a mathematics or science concept and doing so in an interesting and engaging way. This *need to know* helped to generate the intrinsic need to have an idea of how to communicate effectively beyond simply telling someone about a concept. By teaching students how people learn, AFT provide them with tools to be successful in their own future STEM learning experiences. Past participants have commented on how knowing their own preferred learning style has been helpful as they are often faced with learning situations that do not fit well with how they feel they learn best. AFT helps them to realize that they can use tools such as diagramming, drawing, working in a small group, or searching out online interactive tutorials to add visual or interactive ways of learning when those types of experiences were provided as part of a course that they are taking during the school year.

NSES Goals and Student Experiences in the AFT Program

The National Science Education Standards (NSES) listed four goals for school science (NRC 1996). The AFT program aligns closely with these goals of student engagement in a variety of rich STEM experiences (Table 8.3, p. 118). In many different ways these experiences help students move toward increased scientific literacy. Students experience STEM in contexts that are linked to everyday life issues. They are asked to communicate in several ways, with peers as well as younger students to express mathematics and science ideas as they discuss and make claims about evidence. It is the intent of this program to inspire students to pursue STEM careers, thereby "increasing their economic productivity through the use of knowledge, understanding, and skills of the scientifically literate person in their careers."

Table 8.1. Summary of Activities Within Each Weeklong Program

Program Structure	Students are divided into three groups or *cohorts*: two groups are Y1 participants and one group consists of Y2 participants Students cycle through three, weeklong experiences for a total of three weeks of AFT experience.
Elementary Mathematics, Science, and Pedagogy (1 week)	Mathematics and science content are addressed in the elementary section with specific emphases on the processes of science and mathematics (problem-solving, exploring scientific phenomenon, manipulating a variable). Students learn about the importance of exploration and curiosity involved with science and mathematics. Students also have experiences in learning through play, an appropriate pedagogical approach for elementary students. *Service learning component:* Students create and teach pedagogically and developmentally appropriate science and mathematics lessons to children (3–5 years old) at our college-run child development center. Students then share and reflect with each other their teaching experience and offer suggestions from improving and or modifying the lesson.
Secondary Mathematics and Pedagogy (1 week)	Students learn the importance of mathematics processes through explicit connections of mathematics concepts to real-life contexts. For example students apply technology for data gathering and analysis in real-life mathematics contexts. The students also learn how to plan and implement engaging mathematics lessons that teach both mathematics concepts and processes. *Service learning component:* As a culminating activity, the students create and teach a mathematics lesson to a group of middle school students attending a summer school program at a neighboring school. After teaching the mathematics lessons, students share their reflections on their experience and provide feedback to their peers.
Secondary Science and Pedagogy (1 week)	Students learn pedagogies and pedagogical content knowledge appropriate for teaching science to older children and young adults. They develop their understanding of nature of science and learning science as inquiry. The students also learn to develop science lessons using the 5E learning cycle model. *Service learning component:* As part of their week, the AFT students observe and provide feedback on science lessons taught by a cohort of preservice science teachers in the Master of Arts in Teaching program at our college. As a culminating activity, the AFT students prepare and teach a 5E-based science lesson to a class of middle school students attending a summer school program at a neighboring school. After teaching the science lessons, students share their reflections on their experience and provide feedback to their peers.

Table 8.2. AFT Daily Activity Overview for the Secondary Science Program

Activity/Lesson (Description Optional)	**Why This Activity? (Rationale)**	**Goal(s) 1: Content, 2: Pedagogy, 3: Attitudes/Interests in STEM**
Nature of Science: 1. Myths about NOS 2. Tricky Tracks 3. Nature of Science Tubes: Students in groups are given a mystery box; they are to determine what's in the box without opening it	• Through discussion of the activity students learn about the various tenets of nature of science. • Students learn about the importance of making observations in science and the difference between observation and inference.	1. Science Content: Nature of Science, Processes involved in science 2. Pedagogy through watching the teacher model the lesson 3. Increased interest in STEM
Physics (Force and Motion) 1. Choosing a safe vehicle 2. Speed and collisions 3. Mass and collisions	• Revisiting the physics concepts and linking them to everyday life. Students learn the importance of learning physics concepts and its importance of applying them in their real lives. This brings in the ideas of developing habits of mind and developing scientific literacy.	1. Science Content: Physics, Processes involved in science 2. Pedagogy through watching the teacher model the lesson 3. Increased interest in STEM
Earth Science (Topography) 1. Where should we build a house? 2. Making topographical maps 3. Studying topography 4. Making decisions based topographical maps	• Revising the Earth science concepts and linking them to everyday life. Students learn the importance of learning about topography and how that information can be useful and helpful in making decisions about new housing development. This brings in the ideas of developing habits of mind and developing scientific literacy.	1. Science Content: Earth Science, Processes involved in science 2. Pedagogy through watching the teacher model the lesson 3. Increased interest in STEM
Fundamentals of Teaching 1. Characteristics of "good" and "bad" teachers 2. Dispelling stereotypes of instruction 3. Importance of communication	• This activity requires the students to examine their preconceived notions of teaching and how they tend to label instructors as "good" or "bad." • Participants are faced with a challenge to "teach" their partner how to complete a task without using speaking and while their partner cannot see.	1. Science Content: Nature of Science; Science Inquiry 2. Pedagogy: Creative means to overcome instructional obstacles 3. Attitude and interest in STEM through problem solving

Activity/Lesson (Description Optional)	Why This Activity? (Rationale)	Goal(s) 1: Content, 2: Pedagogy, 3: Attitudes/Interests in STEM
Biology (Carrying Capacity) 1. "Look who's coming to dinner": Students participate in a competition based on density dependent factors and environmental resources. 2. Global Footprint Network: As a community, students calculate ecological footprint and consider different methods to reduce impact on the earth.	• As per Laurie's request to include eco-friendly lessons, this activity personalizes the limited availability of Earth's resources. • By participating in an activity that requires the students to compete for food and sacrifice members of their family for survival, students recognize the need to limit the consumption of resources and the production of waste.	1. Science Content: Biology/Ecology 2. Pedagogy: Teacher demonstration of lesson differentiation 3. Attitude and interest in STEM through critical thinking and discussion of a global concern
Biology (Enzymes) 1. Investigative lab to evaluate the role of enzymes in detergents and foods	• Students develop a lab protocol to test the influence of acids and bases on the activity of a specific enzyme. The activity represents research lab methods in that the directions for the experiment are not provided; students must determine which procedure would be most appropriate to meet the needs of the experiment.	1. Science Content: Biochemistry and Science Inquiry 2. Pedagogy: demonstrated through modeled instruction 3. Attitude and interest in STEM through problem solving and critical thinking
Differentiated Instruction 1. Bloom's Taxonomy and Multiple Intelligences 2. Gardner's Taboo: Students must have their partners guess the teaching activity using a specific learning style.	• Review of Bloom's taxonomy and Multiple Intelligences for instruction. • The activity encourages the students to use simple activities such as tying your shoe or teaching doubles.	1. Science Content: Nature of science 2. Pedagogy: Using various learning styles to address the needs of students 3. Attitude and interest in STEM through problem solving

Table 8.3. Goals for Science Education Within the National Science Education Standards Document (NRC 1996, p. 13) and Its Alignment With the AFT Program

NSES Goals …Educate Students Who Are Able To	Student Experiences in the AFT Program
experience the richness and excitement of knowing about and understanding the natural world	Students in the AFT program learn through hands-on and minds-on experiences in various STEM topics. The students learn by both experiencing reform-based STEM lessons modeled by STEM educators and by developing and delivering their own STEM lessons to preschool and middle school students. Students explored topics associated with local geological and hydrological formations, pollution, and climate change.
use appropriate scientific processes and principles in making personal decisions	Students in the AFT program gain experience in using scientific process and principles in making personal decisions as they explore such topics like implications of local geological and hydrological formations to the availability and access to affordable drinking water and making decisions based on scientific evidence.
engage intelligently in public discourse and debate about matters of scientific and technological concern	Students in the AFT program use scientific evidence in supporting their claims. For example, AFT students debated about 'water wars' among Georgia, Alabama, and Florida using various artifacts and scientific evidence.
increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers	Through their overall experience in the AFT program, capacity was built in the students to become economically productive citizens where they increasingly use their scientific knowledge to make personal and work-related decisions.

Summary

In AFT program design, all players actively create engaging, meaningful, and authentic learning experiences. Those creating learning experiences in the AFT program include the K–12 public school teachers, university faculty, MAT science students, and the AFT participants themselves. The teaching duos (higher education and K–12) plan and implement the summer experiences, modeling science and mathematics pedagogy through the teaching of science and mathematics content. AFT students learn content and pedagogy by doing as they create and teach engaging lessons for both preschool students (in the elementary section) and middle school students. Additionally, MAT Science students at GSU teach three lessons for AFT students, while AFT students provide the MAT students with verbal and written feedback on the lessons. This experience is mutually beneficial for both groups of students. MAT students are able to practice teaching "real" high school students and receive feedback from the same students. AFT students are able to learn science content, experience reform-based pedagogy, learn to provide constructive feedback, and have experience (although short) being in a Master's level methods course.

The AFT program addresses the need for reform when creating experiences that allow students to view themselves as mathematicians, scientists, and mathematics or science educators.

This is a novel take on recruitment for STEM and STEM careers. We have found that the most powerful component of the design is the active role students take in creating and implementing mathematics and science lessons for younger students. The lessons are implemented with pairs or small groups of AFT students as instructors, and the students (preschool or middle school) work in small groups with the instructors. The secondary science lessons, using the learning cycle format, focus on engaging students in hands-on and minds-on science experiences. In this case, the model promoted is a 5E learning cycle (engage, explore, explain, extend, and evaluate). The high school students then construct their own 5E science lessons and teach middle school students participating in a summer program. The AFT participants are encouraged to structure secondary mathematics lessons for middle school students with an emphasis on problem solving in algebra and number theory. The elementary lessons for preschool students focus heavily on engagement and exploration of science phenomenon through hands-on learning and learning through play.

Evidence for Success

As mentioned earlier, the intent of the AFT program is to inspire students to continue to learn STEM and to motivate them to pursue STEM and STEM-related careers. Special emphasis in the AFT program is to encourage and empower high school students to consider STEM as a career option. It comes from our understanding that appropriate decisions on career pathways can only be made by students when they get opportunities to explore STEM content in engaging and authentic contexts. With this in mind, we collect several types of qualitative and quantitative data to inform us on the nature and the experiences of the student participation in the AFT program.

The Program Evaluation Team

We (Anton and Lisa) were retained by the AFT program to provide data collection, analysis, program evaluation, and other research-related support. Three graduate research assistants, who are all PhD students in STEM education, assisted in our work. While the evaluation work is independent concerning the AFT program, we work closely with the program coordinator to manage data collection activities. The AFT model and its impacts have been shared at regional and national conferences. The program has received recognition through continued funding from government agencies, nonprofit foundations, and corporate donors.

Data Sources for AFT

- *Application forms.* Student demographic and academic data are obtained from the application forms for the AFT program. For example, we obtained information about student race, gender, school, grade level, and GPA from the application forms.
- *Science and mathematics attitude survey (SAM Survey).* We administer the SAM survey pre- and post-AFT experience. In the SAM survey, a four-level forced response 60-item (30 science and 30 mathematics) Likert survey is used to get students to rate their attitudes, motivations, identity, and future intentions within science and mathematics. The

presurvey is administered on the first morning of the AFT program during the student orientation. The postsurvey is administered the last day of the program.

- *AFT exit evaluation forms.* At the end of the three-week AFT experience, students complete a mostly open-ended/free response questionnaire concerning the AFT experiences and their future academic and career aspirations. More specifically, we ask in the evaluation form for students to comment about their: (a) overall experience in AFT, (b) AFT learning experiences, (c) perception of how well the instructors facilitated learning, and (d) future college and career plans regarding STEM and STEM education.
- *Science and mathematics content knowledge pre/posttest.* In an attempt to measure student learning of science or mathematics content, each teaching team is asked to construct a pre- and postassessment of expected learning goals. Learning goals include both science and mathematics content.
- *Individual interviews.* We also conduct a 15–20 minute semistructured individual interview with 45 students. In the interviews, the students are asked to describe and compare and contrast their high school science and mathematics experiences with their experiences in the AFT program. The researchers make several observation visits to various AFT classes and took notes concerning student engagement in the activities. These observations allow us to examine the aforementioned data with greater understanding of the context for student participation.
- *AFT instructor written reflections.* Two of us (Lisa and Geeta) offer our reflections on our experiences in teaching in the AFT program.

Findings

Science and Mathematics Content Understanding

When students' science and mathematics pre- and postassessments are compared, we found that they scored significantly higher on the postassessment than the preassessment ($p < 0.002$). In science, 89% of the students showed improvement from pre- to postassessment. In mathematics, 91% of the students also showed improvement from pre- to postassessment. One may think that the improvement may be obvious and expected. We agree. However, we note that from our experiences in looking at our preservice and inservice teachers' pre- and postassessments of science and mathematics content in the classroom, the pre-to-post improvement is normally observed to include about 55–75% of the students. The improvement in the AFT program is higher than this. The science and mathematics content that the students learn in the AFT program is based on the state standards. A majority of them have had at least some exposure to the content in the schools. The relatively high percentage in improvement is also indicative of high student disciplinary (science and mathematics) engagement in the cohort experiences. Although the content exams show significant growth, it should be noted that the secondary science section was the only set of instructors to use NAEP and TIMSS released test items in the construction of their pre- and posttests. The mathematics and elementary science and mathematics sections had purely instructor-created exams and thus may not have been as reliable. It is hoped that in the 2012 session, that the evaluators can play a more integral role in assisting in the construction of the pre- and posttests, allowing for more reliable data to be gathered.

Science and Mathematics Attitude and Affinity

While the pre/post SAM survey consisted of 60 items (30 science and 30 mathematics), we first share aggregate results relating to student attitude shift toward science and mathematics after participating in the AFT program. We then share results from some interesting individual items from the survey.

Students' positive attitudes about science and science careers increased ($p < 0.001$) at the end of the AFT program, with means changing from 14.26 (pre) to 17.26 (post) with a maximum possible score of 24. While students indicated increased (17.93 to 18.24) positive attitudes about mathematics and mathematics careers at the end of the AFT, this increase was not statistically significant. It should be noted that the students already had relatively high positive attitudes for mathematics and mathematics careers when they entered the AFT program. The pre/post SAM survey revealed that certain student notions about science and mathematics shifted by the time they completed the AFT program. Table 8.4 highlights this.

Table 8.4. Comparison of Select Pre/Post Item Scores From Science and Mathematics Attitude Survey: An Indication Affinity Toward STEM Careers

(Maximum possible score 4. n = 42)

Item	Prescore	Postscore	Difference in Mean	Standard Deviation	*T*	*p*-value
Doing well in science is important for my future	2.88	3.24	–0.357	0.958	–2.416	0.020
Science is hard for me	3.00	2.67	0.333	0.954	2.264	0.029
Learning science requires special abilities that only some people possess	2.40	2.10	0.301	0.869	2.308	0.026
I am sure of myself when I do mathematics	3.05	3.26	–0.214	0.606	–2.291	0.027
Learning mathematics requires special abilities that only some people possess	2.43	2.07	0.357	0.850	2.722	0.009
Mathematics is an important life skill	1.40	3.52	–2.119	1.152	–11.922	< 0.000
I would like to avoid mathematics in college	3.17	2.98	0.190	0.594	2.007	0.044
Teaching is an easy career	2.14	1.69	0.452	1.041	2.817	0.007

From Table 8.4 we see that by the end of the AFT program students increasingly agreed that doing well in science is important for their future. Students indicated that science seemed less difficult for them after the AFT program. On the postsurvey, students agreed less with the idea that learning science or mathematics required special abilities that only some people possessed. Student confidence in doing mathematics also increased after the AFT program ("I am sure of myself when I do mathematics; I would like to avoid mathematics in college"). At the beginning of the AFT program, students largely felt that mathematics was not an important life skill (1.40), however, after the AFT program there was a relatively significant shift in this view (3.52). It is also important to note that after the AFT program, students agreed more with the notion that teaching mathematics and science was not as easy as they had initially thought. The results presented above reflect the nature of the students' mathematics and science experiences in the AFT program. Students learned science and mathematics through engaging and relevant activities. This enabled them to envision and experience science and mathematics in real and authentic ways. Incorporation of strategies to teach and learn science and mathematics into the AFT program and students' participation in teaching others science and mathematics also influenced their visions of science and mathematics. As students learned how to teach, learn, and find meaning in their experiences, they were able to have greater appreciation for the fields of science and mathematics and feel that they had greater access in the these fields. We also feel that greater appreciation for the fields of science and mathematics allows students to have greater affinity toward careers in STEM and that they need not fear that a career in STEM is inaccessible for them.

Choice of Major in College Affinity

Student evaluation forms revealed their preferred choices for an intended college major. While we do not know the degree of impact AFT had on student preferences for college majors since this was assessed only at the exit (and not upon entry), 46% of the students indicated that they would like to pursue some form of STEM major in college, indicating that these students are serious about following a STEM career path. Table 8.5 shows the percentage of students choosing a particular college major.

Interview Responses

When we conducted interviews with students, we focused upon several areas including their impressions about the program, suggestions to improve the experience, and the most beneficial experiences. Additionally, we asked the AFT students to compare their AFT experiences with their high school experiences.

It was found through one-on-one interviews that students had varying school experiences in learning science and mathematics in school. As the interviews took place near the end of the AFT experience, there are hints as to how the AFT experience affected the participants. Participants often commented on how the experience in AFT, steeped in active learning, resonated with them. They often reflected upon their high school learning experiences with a critical lens after participating in AFT. The responses below highlight some of the student ideas about their prior high school learning experiences.

Table 8.5. Frequency Distribution of College Majors as Indicator for Future Career Choice to be Pursued by AFT Participants

STEM Fields		Non-STEM Fields	
Major	**Percentage (%)**	**Major**	**Percentage (%)**
Education – Mathematics	8	Accounting	2
Education – Science	4	Art	4
Engineering	8	Business	8
Forensics	1	Education – Other	13
Mathematics	7	English	9
Medicine	4	Graphic Design	2
Physical Therapy	2	History	2
Physics	5	Journalism	2
Science	7	Law	2
		Music	6
		Social Work	1
		Sociology	1
		Undecided	2
Total Percentage (%)	46		54

Miley: The math that I took, we had a lot of umm activities that were following the lesson plans, like hands-on and using the graphing calculator, so it just wasn't paperwork. We had other work so we can get a further understanding of the umm activity. And in chemistry, we did a few experiments, too, and a lot of worksheets. It was alright.

Amina: I took analysis last year with Mr. Dawson and it was a very rigorous, very difficult class, but I enjoyed it because he challenged us a lot and he really ... he helped us but he didn't just give us the answers. He made us figure it out on our own. I definitely liked that about my analysis class.

An additional theme dealt with the challenging or lack of challenging expectations or coursework in their high school learning. Often, students saw worksheets and lectures as being boring and less engaging and saw active and interactive learning like group inquiry and problem solving activities as being fun, engaging, and meaningful. The AFT program enabled the students to critically examine, and communicate how they are taught science and mathematics.

Shiyara: Yeah it's [changed] more of how I interacted with my teachers. I kind of got to see their perspective of us because I taught here and I saw kids and I'm like ok this is how they see us. Like this is how difficult we are and so annoying we are. So I tried to become a better student more understanding, get my work done on time, don't talk too much in class and all that stuff.

Jacquelyn: I also have the same teacher I've had two years in a row, 10th and 11th grade. Uhm, we did a lot of lab experiments, lot of hands on things and I really enjoyed that. In 9th grade we really didn't do any labs and I was really bored so I appreciate the labs that we did.

Aisha: The last math class I took was statistics and it basically talked about the way surveys are taken and how to choose groups of people, the questions that they ask and stuff like that. We got to interview each other, it was fun. My last science class was chemistry and we talked about atom theory, reactions, we did a lot of worksheets.

Cordell: Um, well I have had the same math teacher my freshman year and sophomore year and what he does is lecture a lot. Like he would just stand at the board and go over the book. And he'll be just like if we need help, he'll be like "look at the examples in the book."

One of the interview questions asked AFT participants ways to think back to their learning in high school and to make suggestions about what teachers might do to improve the learning experiences. Often, students commented on how important they felt learner engagement was in the lesson. Additionally, the real-life connections, making science and mathematics more *real* and *accessible,* resonated with the students.

Markice: Especially with math, instead of coming in and just start talking … more hands-on activities, or like more practical real-life examples, you know, like how it relates to everyday life.

Amelia: I would tell them to basically ask a lot of questions and to get the students to think and analyze different things. Like why does this happen when we do this? Why is it when we balance out this side we have to change on this side of the chemical equation? And I will also have them encourage the students to ask questions, but don't always answer the students questions. Have the students go through a certain process so they can answer the question on their own.

Theo: I feel maybe [his former high school teacher] needs to get us to do like class activities or group activities where we can talk with each other and not just look at him write on the board the whole time.

Poly: I would say maybe more labs with groups because chemistry we didn't do a lot of labs and like we kinda got kinda jealous because other classes did labs every week and we did, we didn't do many; and in AP Biology we do a couple but they're not really interesting so maybe we can do more labs. That will help us with the things we're learning.

When reflecting upon the entire AFT experience, students shared their general AFT experience on the end-of-program evaluation forms. Comments were overwhelmingly positive. Students stated that the activities of the AFT program were engaging and rewarding and that their AFT experiences were enjoyable.

Terrel: I think [high school students] should take the AFT program because it helps your social skills as well as your learning skills, um it's really good for you and I really like this program, so yeah.

Tiara: AFT was full of life, fun, and creative. I truly enjoyed my teachers, peers, and advisors. They made a huge difference.

Rodrick: I'm more confident and prepared.

Ariel: I loved the program! And WILL be applying next year!

Bashu: It's fun. It's nothing like school.

Arthur: Pushed me outside my comfort zone and made me think critically.

The students in AFT felt that the experience provided active learning experiences that engaged them in science and math learning. Positive aspects included that they felt more confident and prepared for college learning.

Voice of Teachers

In the AFT model, the student participants are not the only ones who report learning from the experience. Two former instructors, also authors of this chapter, described their experiences from teaching in the AFT program.

Geeta Verma, Secondary Science

In AFT, Geeta was a university faculty instructor for the high school science team. She co-taught the 3-week session with a high school science teacher from Atlanta Public Schools. The two teachers planned their teaching together and took turns facilitating science learning experiences for the students. The AFT experience enabled her to implement the pedagogical strategies she uses in her methods courses (with preservice teachers) and with inservice teachers. The direct experience of working with students was beneficial to her professional growth. She wanted to explore if there was a shift from adult pedagogy to working with adolescents and what it would mean for her preservice teachers. Geeta also shared that her high school teaching partner, "did an excellent job of mediating this gap." The high school teacher truly was a partner in the teaching process with the university instructor.

Geeta reported that she chose to participate in AFT because, "I knew of the [AFT] at GSU and found it a great opportunity to work with underrepresented high school students at GSU. I wanted to participate in it to find out what it is to teach high school students coming from metro-Atlanta area on a university campus and how the students felt about it." She thought that it was a great opportunity to work with high school students, as it had been several years since she had taught students of that age.

When Geeta thought about how the AFT experience had affected others, she spoke about students she had worked with directly:

> It was really interesting to find out that they have a certain image of university professors and I think they enjoyed working with various professors during the program. For me, having the high school teacher was really helpful since she was able to "unfold" the university experience for the students and I (as the university professor) was able to add more to that information. I could tell that the students were really interested in university life (courses, programs, etc.). It was nice to hear many of them talk about pursuing a degree program on a university campus related to STEM areas.

Lisa Martin-Hansen, Elementary Science and Mathematics and Secondary Science

In AFT (2007), Lisa was a higher education faculty representative who co-taught with an elementary teacher from Atlanta Public Schools. Later, she also taught in the secondary science section (2009). Lisa was a former elementary and middle school teacher with 12 years of experience teaching in public schools (eight years in elementary grades). Lisa said that she chose to participate in AFT because she felt strongly about the need for greater representation of people from underrepresented groups in STEM careers and STEM education. By participating in this program, she hoped that AFT could convince young participants that science could be interesting, exciting, and important to them personally, and become a possible field to pursue in college and as a career.

Lisa felt that she would have many learning opportunities as she participated in AFT:

> By teaching in AFT, I've had the chance to learn from my students and from my co-teacher. Additionally, I received some reassurance that many of my teaching strategies also work well with students from underrepresented groups. I try to implement reform-based teaching strategies that include student-centered learning, which is definitely a good fit, as those strategies are often recommended in culturally relevant pedagogy.

Lisa said she had overheard an AFT participant say, "I wish science was taught like this at school. I would really like it then." That seemed very revealing, as Lisa and her colleague worked to use reform-based curricula (Science Education for Public Understanding Program) to model reform and standards-based pedagogy as well as to teach science content. Lisa thought that if the general experiences of students were not engaging and thoughtful, AFT then played an even more critical role in helping students to see how science and mathematics can be both interesting and challenging. Lisa shared that AFT was a "very rewarding teaching and learning experience" both for herself as a university faculty member and also for the way she saw students embracing the challenge to immerse themselves in learning about science and mathematics, becoming interested in science and mathematics, and reaching out to younger children in the process.

Next Steps

Our team still has hopes for a longitudinal perspective, where past, current, and future AFT students will be contacted after high school graduation to determine their postsecondary education and career choices. We have approval to locate graduates of the program and are delving into the process of finding them and inviting them to participate in an interview regarding their career choices and their perceptions of the effectiveness of AFT. One way that we've started to keep in touch with past AFT participants is through our AFT Facebook page.

Student interaction with the AFT program was short in duration (three weeks). It would be interesting to explore how more sustained (and more frequent) interactions in an AFT-like program throughout the school year may affect students' affinity for STEM-related careers, including science and mathematics teaching. In future iterations of the study, we hope to refine the nature of pedagogical and content experience the students receive by better aligning and complementing their secondary science, secondary mathematics, and elementary science and mathematics experiences with each other. Additionally, we hope to further develop the pre/post content quizzes for a better measure of student content learning. We have offered to assist the instructors with that particular task in order to help foster greater reliability and validity of the items.

Ties to Other Specific Reform Efforts

The AFT program aligns with other reform efforts as there is a concerted effort at the federal level to increase numbers of college students pursuing STEM majors in the United States (Business-Higher Education Forum 2010). Additionally, an NSF–funded project focusing on increasing the number of African American Males in STEM (QEM Network 2010) by increasing the number and retaining the numbers of minority males in those fields exists to bring together and support several institutions working toward these particular aims. In the state of Georgia, several universities were granted STEM funding from the USG-BOR for establishing programs similar to the AFT program at Georgia State University in order to generate interest in STEM and STEM education. Lastly, with the development of the Common Core Standards in the United States, there is a healthy emphasis on STEM, including new emphases on engineering and technology. The goals and aims of the AFT program are in concert with all the aforementioned initiatives.

Questions Raised From This Program

Several questions emerge from the existing program, which provide direction for future research. These include:

1. How has this program affected underrepresented students (positively or negatively) as they consider their options in a STEM career? What other ways might we explore student ideas and beliefs about their future careers?
2. What type of long-term effect does AFT have in increasing the number of underrepresented students pursuing STEM careers and teaching?
3. What are the influences of the partnership between the K–12 instructor and the university instructor as they partner in co-teaching to implement the model?

4. What does the innovative co-teaching partnership mean for students' experiences in the AFT program?

Additionally, as we consider the effectiveness of the program to meet the goals of the project, the following questions may be raised:

5. What might AFT do differently to capitalize and institutionalize the positive aspects of this program (that increase the STEM interest for underrepresented students) in either university courses or by taking ideas back to the high school?
6. Should there be even more of an emphasis on science and mathematics content within the AFT? If so, how should that take place?

Lastly, as we consider scaling up the model, we would need to think about what aspects are unique to Atlanta, Georgia, and what other models might be developed in other regions of the United States. Especially, we can ask the following question:

7. Can other universities replicate or modify this program to recruit underrepresented students successfully into STEM and STEM education careers? How might the model need to change based upon institutional and personnel needs?

Currently, this is a grant-supported program. If there is strong merit in the program, how could the state support this type of program at several locations? As this model results in an increase in positive attitudes among underrepresented groups of students regarding STEM, we propose that this model has promise and should be replicated at several locations. This will help to address the needs we have in STEM to increase the number of underrepresented students aspiring to STEM careers.

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