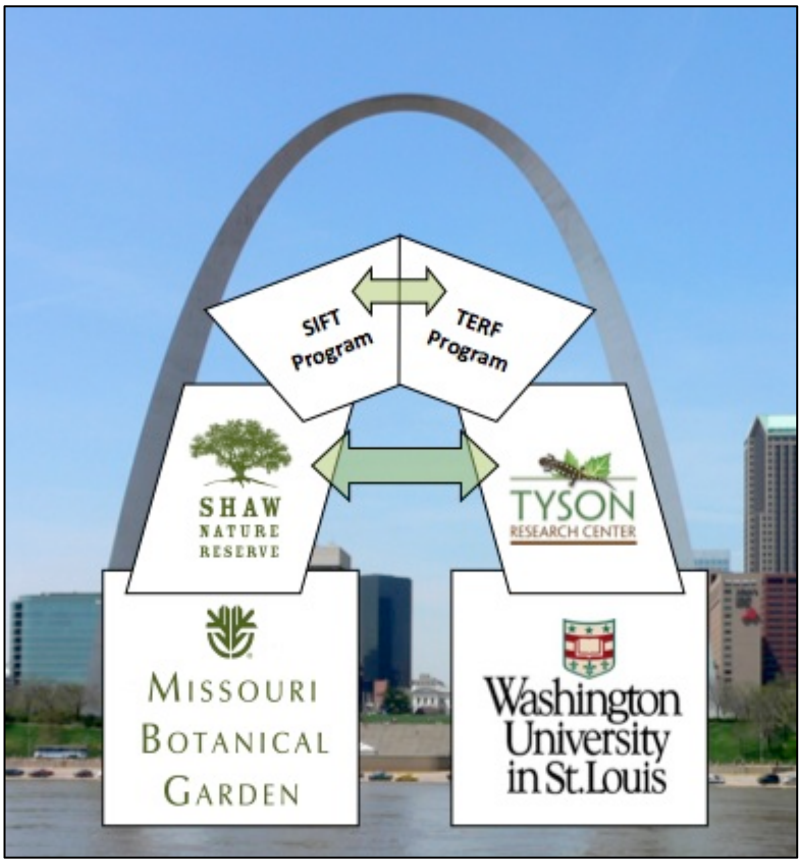
# NSF DRL-0739874
# Making Natural Connections: An Authentic Field Research Collaboration

**March 1, 2008 – February 28, 2015**

## Summative Evaluation Report

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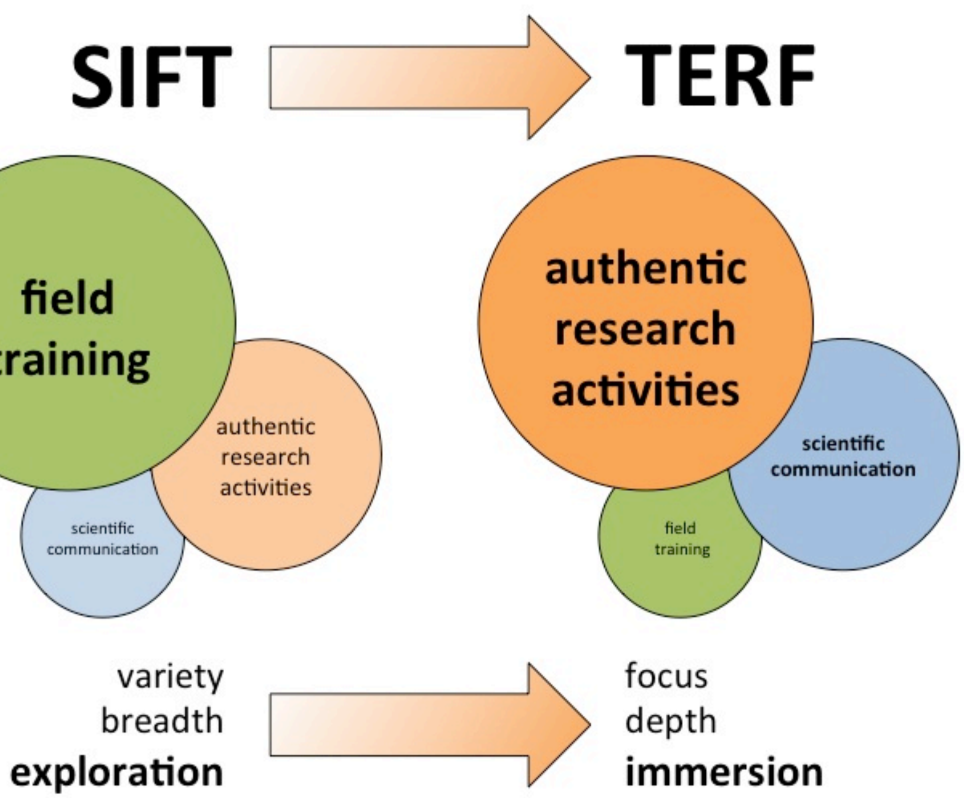
This project has developed a highly successful model for integration of pre-college youth career exploration into authentic environmental research and restoration activities at Washington University's field station, Tyson Research Center, and the Missouri Botanical Garden's Shaw Nature Reserve (Flowers & Beyer, 2015). The Shaw Institute for Field Training (SIFT) and Tyson Environmental Research Fellowships (TERF) programs provide access to field research for St. Louis, Missouri area high school youth interested in careers related to environmental biology. SIFT is an introductory field skills training program that engages participants in scientific exploration of the natural world and includes opportunities to assist with field work. TERF is a more advanced field research internship program that provides SIFT graduates with an immersive and extended work experience on current research projects at Washington University, as well as training in scientific communication via research posters and presentations. In both cases, youth have the opportunity to directly assist scientists with their ecological research.

While SIFT and TERF are separate programs, they fit together in an educational progression specifically designed for pre-college youth. Throughout the program progression, exploration activities serve as preparation for more in-depth immersive experiences, and direct access to research scientists is extensive. We have found our model provides benefit to both the youth participants and the research scientists who mentor the youth. The long-term investment in program development, evaluation, and research on outcomes with these participants has resulted in institutional commitment to program permanence at Shaw Nature Reserve and Tyson Research Center.

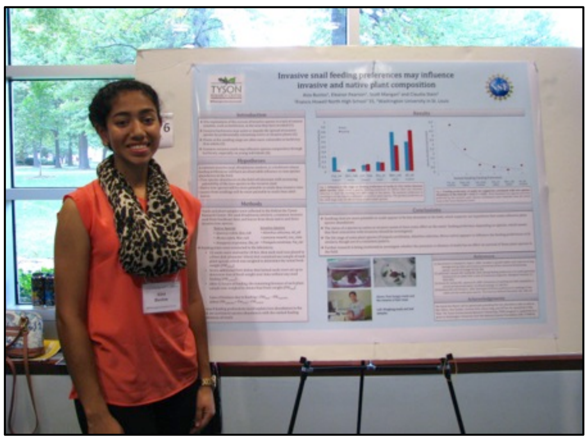


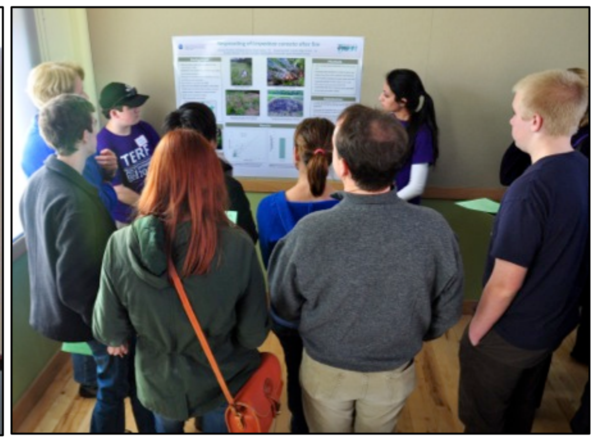
The SIFT program includes the following: (1) a five-day summer field training experience, (2) opportunities to assist in field-based research and restoration projects, (3) two all-day Saturday training sessions (fall and spring), and (4) one winter weekend overnight training session, including attendance at an annual TERF symposium and informal discussion with TERF participants. The staff at Shaw and the researchers at Tyson leverage the enthusiastic engagement of SIFT participants to make progress on large-scale restoration activities and research projects.

The TERF program includes the following: (1) a four-week summer research internship at Tyson (or longer for some participants), (2) training in scientific communication (how to read journal articles and prepare for research seminars), (3) collaboration with mentors and peers on development of posters and presentations, and (4) presentation of field research projects to the community.

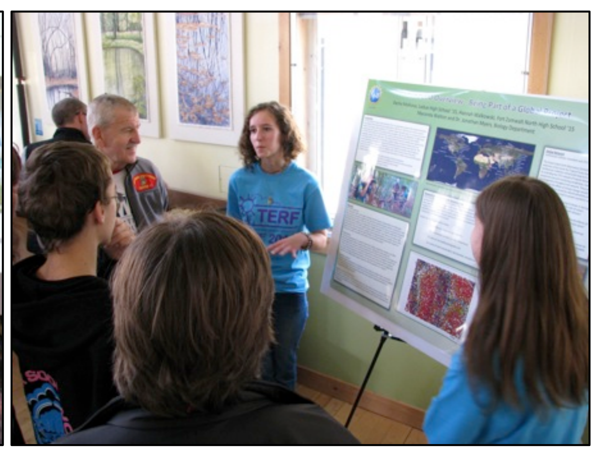
As communities tend to have interest in the accomplishments of their young people, a considerable number of communities have been touched by the engagement of their youth in the SIFT and TERF programs. Participants in seven groups of youth were from 65 different high schools plus homeschool, representing 21 urban, 28 suburban, and 16 rural geographical locations. By project end there were 288 SIFT participants and over 1,000 field work opportunities with scientists. Sixty-three percent of SIFTers were female and 35% were from ethnic groups underrepresented in science, technology, engineering, and math (STEM). Twenty-three percent were from urban geographical areas, 50% from suburban, and 27% from rural.

While there were 91 individual TERF participants, the request from scientists for TERFers to extend their participation within a summer field season and also return for an additional field season resulted in 103 4-8 week TERF internships provided during the project. Sixty-two percent of TERFers were female and 23% were from ethnic groups underrepresented in STEM. Thirty percent were from urban geographical areas, 41% from suburban, and 30% from rural. The total number of TERFer posters (collaborative or individual) presented during the project was 53. The total number of TERFer formal slide presentations (collaborative or individual) given was 27.







## Methodology

To assess the impact of this two-stage model on youth participants, we developed a longitudinal mixed-methods study (Creswell & Clark, 2011; Lieber, 2009) to assess interest, confidence, and personal context during progression through the programs. Using mixed methods to capture participant thinking and/or behavior in differing formats affords the opportunity to triangulate emerging patterns and findings (Miles & Huberman, 1994; Guba & Lincoln, 1994). Derived from Bandura's social cognitive theory (1984), Lent et al.'s social cognitive career theory provides a framework for this kind of assessment (1994, 2000). As Quimby, Seyala, and Wolfson have explained (2007), social cognitive career theory "illustrates the interplay of personal, environmental, and behavioral influences on career development and focuses on processes by which individuals (a) develop academic and career interests, (b) create academic and vocational plans, and (c) attain varying levels of performance and persistence in educational and career pursuits". Follow up measures of reflective thinking and documentation of specific courses of action towards an environmental STEM career path were also implemented, as some science-enrichment program impacts may not manifest until participants have separated from the experiences and had time to reflect (Stake & Mares, 2005).

The sources of data included two types of participant surveys, observations, and structured and semi-structured interviews. Quantitative analysis of data derived from a repeated measures environmental science career interest survey and repeated program climate surveys were contextualized by the qualitative analyses of survey responses, interviews, social media communications, and observations.

The science career interest survey is based on a previously validated instrument adapted with permission of originating researchers (Quimby, Seyala, & Wolfson, 2007) and consists of 5- and 10-point Likert-scaled level of agreement items. It provides a measure of cognitive (self-efficacy/confidence and outcome expectations), contextual (role model influence, social supports, and perceived barriers), and outcome (interest in environmental science) variables (Quimby, Seyala, & Wolfson, 2007; Quimby, Wolfson, & Seyala, 2007). While originally used to assess youth interest in environmental careers at a single time point, we used this survey to measure changes in youth participants' thinking during an immersive environmental career apprenticeship program. We examined at baseline (pre SIFT) the factor structure of each survey section using exploratory principal components analysis with varimax rotation for the purpose of data reduction. We used Lautenschlager's parallel analysis criteria (1989) to determine the number of factors and Cronbach's alpha (Bravo & Potvin, 1991) to measure the internal consistency of items on each measure. Repeated-measure analysis of variance (RM-ANOVAs) examined change over time for each factor during the first three time points (pre, mid, and post SIFT). Separate RM-ANOVAs were used to determine if youth who only completed SIFT reported different scores over time as compared to youth who went on to TERF. Lastly, separate RM-ANOVAs for each factor were run using all four time points (pre, mid, post SIFT plus post TERF) to determine significant outcome changes over time for youth who completed both SIFT and TERF.

Climate surveys were designed to assess the personal experience of the youth participants at regular points during SIFT (pre, mid, post) and TERF (mid, post), and also six months to one-year post participation in either program. The surveys consisted of 5-point Likert-scaled level of agreement items and free response to open-ended questions. Free response to open-ended survey questions was treated as text and coded and analyzed using discourse and conceptual analysis methods (Herrera & Braumoeller, 2004; Hardy, Harley, & Phillips, 2004). The final climate survey captured additional information on final college major choices, longer-term reflection on benefits of having participated in SIFT and TERF, and whether additional research activities were pursued before and during college. Data on final college major choices and additional research activities was also collected through personal communication with program staff that occurred via email and social media.

Observations and semi-structured interviews were completed during SIFT and TERF activities. The observations often informed the structure of interviews. SIFT participants completed online work project reflections after assisting a scientist with a field research project. Each of these data points was treated as text and coded and analyzed using discourse and conceptual analysis methods.

## Evaluation findings

This project serves as a model for engaging pre-college youth in applied science through an informal cultural apprenticeship setting. The following questions were explored over the course of SIFT and TERF program development.

1) ***Does a 1-week immersion in field science techniques and participation in a program of mentored fieldwork (SIFT program) encourage engagement of urban, suburban, and rural teenagers in the field of environmental biology?***

> *SIFT was the greatest factor in determining where I am now. Before I participated in SIFT I knew I wanted to do a science of some kind but didn't know what. Through participating in all the projects and diverse activities, I realized I wanted to do field research and delve into as many projects as I could in my future.*
>
> *Program alum, follow-up survey response*

2) ***Does a 4-week immersion in mentored field research and scientific culture and participation in a program of research communication (TERF program) encourage participation of urban, suburban, and rural teenagers in pursuit of environmental biology studies and research opportunities in college?***

> *I loved many fields of science including biology, but I didn't think I was going to have a career in it. I started college thinking I was going to be an astrophysicist but I started missing the "hands on" kind of feel field biology had when I did the SIFT and TERF programs. Now I know that that is what I really want to do!*
>
> *Program alum, follow-up survey response*

> *My SIFT and TERF experience has actually helped me a lot in my college career. My field experience helped me get a position in a biology lab as a freshman student where I was able to begin my own research on a topic that I was passionate about in TERF.*
>
> *Program alum, follow-up survey response*

The project has developed an effective two-stage environmental field research career exploration program partnership for pre-college youth based at a nature reserve and a field research station. Youth participate in exploratory environmental field research training and application and expansion of these skills and knowledge with scientists in their field research work. The program partnership supports youth career interest clarification and pursuit of an environmental field research career if that direction is pursued.

Our study indicates the SIFT and TERF programs have influenced youth participants' entry into the science career pathway, providing for earlier recognition of affinity for a scientific research or field research related career (Flowers, Beyer, Pérez, & Jeffe, 2015; Beyer, Flowers, & Galluppi, 2015). Youth gain realistic views of the obstacles and supports within such a career journey as demonstrated by changes in their perceptions of social cognitive career variables (for example: career benefits, confidence in scientific practices, view of the deeper meaning and context of the work) during the course of their participation in SIFT and TERF. The youth have made gains in self-knowledge and scientific knowledge and related skills, and developed important relationships with role models in scientific research careers. Our results indicate education and career-oriented benefits for youth participants and influence on college major choices and engagement in research activities during college. Participating youth develop a clearer understanding of the realities of pursuing a particular major that guides either toward or away from an environmental science career. Early access to a university-based research environment and actual participation in research influence youth to pursue additional research experiences as they proceed on to college.

**Additional research**

In addition to the two evaluation questions described above, this project included the following research questions related to participant outcomes:

A. What does it take to attract and sustain the interest of teenagers who are growing up disengaged from the natural world in households that are disengaged from the natural world?

B. What factors exist that impede or support participation of each teenager?

C. How much does belonging to a “special” project and willingness to commit to a special project impact teenagers’ overcoming barriers to follow-through?

D. How does the quality of the team experience support the teenagers’ level of commitment to field research and what does it teach them about environmental biology?

More detailed findings related to first two project evaluation questions and the above research questions are to be reported in the following manuscripts:

Beyer K.M., Flowers S.K., Balcerzak P. & Galluppi C.R. (2015). Changing perceptions: Mentoring and research practice progression among scientists engaged with pre-college youth. Manuscript in preparation.

Beyer K.M., Flowers S.K., & Galluppi C.R. (2015). Is Environmental Field Research a Career for Me? A case study analysis of impacts on pre-college youth participating in apprenticeship immersion programs. Manuscript in preparation.

Flowers, S.K. & Beyer, K.M. (2015). Early entry into ecology: Authentic field research experiences for high school youth. Manuscript in preparation.

Flowers S.K., Beyer K.M., Pérez M., & Jeffe D.B. (2015). Early environmental field research career exploration: An analysis of impacts on pre-college youth participants. Manuscript in preparation.

### 3) *Do presentations describing teenagers’ engagement in environmental biology research projects, and presented by teenagers, effectively communicate research science to community audiences?*

### 4) *Does a series of interpretive displays describing teenagers’ engagement in environmental biology research projects, designed by teenagers, and installed at a nature reserve, effectively communicate research science to public audiences?*

The research communication portion of the project evolved from our original proposed design of interpretive displays at Shaw Nature Reserve based on current ecological research projects. We found that mentoring research scientists were less comfortable with this plan and felt more inclined to bring the TERFers further into their world with collaborative work on traditional scientific posters. This unanticipated development proved to deepen the scientist mentor/youth mentee relationships and also the authentic career exploration experience of the youth. The scientists recognized this was the time when the big picture coalesced for youth interns and they wanted to mentor the TERFers through to that point. This change in approach to, completion of, and presentation of scientific posters gave youth an opportunity for competitive submission to science fairs and important citations for college entrance applications and resumes. It also contributed to increasing youth confidence in pursuit of additional research before college and early in the college experience.

Research symposia audiences were not the general public, but others related to the youth who were interested in the research work (family, friends, teachers). This did bring a wider audience to the Washington University Undergraduate Symposium and gave these program participant families and their youth a pre-college view of the undergraduate college research culture at one university. The TERF winter symposium does include youth participant presentations of the TERF experience as well as presentation of the scientific posters – thereby providing SIFT participants with a view of the next step in a two-stage exploration of environmental field research. This symposium also offers youth and accompanying family and friends a more intimate interaction with mentoring scientists who are present.

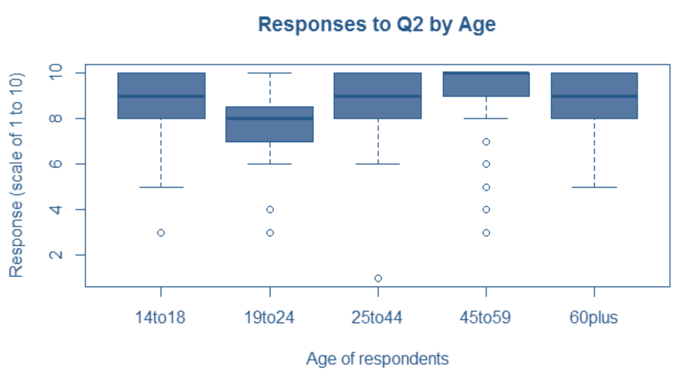
Voluntary public audience surveys were conducted during symposia, and data from 296 surveys were analyzed. The survey allowed respondents to provide personal demographic information and then respond to six questions. The questions were formatted using a 10-point Likert scale. On questions 1 through 3, the scale used represented 1 (not at all) through 10 (very much). On questions 4 through 6, the scale was 1 (not at all) through 10 (definitely). Overall, audience response at university-based and TERF program-based research symposia shows high value for hearing about scientific research from both scientists (9.49) and youth (9.62). Respondents expressed high interest in environmental issues (8.81) and felt that posters better helped them to understand scientific research about the environment (8.62).

| **Audience Survey Questions** | **Mean score** (N = 296) |
|---|---|
| Q1: How interested are you in environmental issues? | 8.81 |
| Q2: Did the information in the poster help you better understand current scientific research about the environment? | 8.62 |
| Q3: Did you learn anything new about the skills and knowledge needed to do this kind of scientific research? | 7.98 |
| Q4: Will you do anything differently as a result of the information you learned? | 6.43 |
| Q5: Do you think it is valuable to hear about scientific research from scientists? | 9.49 |
| Q6: Do you think it is valuable to hear about scientific research from teenagers? | 9.62 |

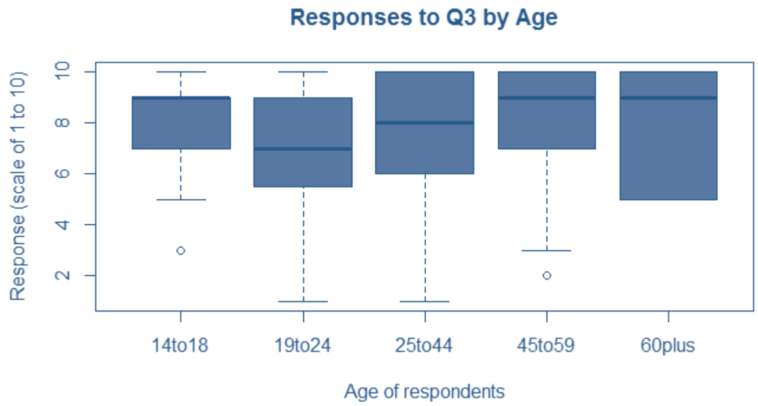
There were differences in response for questions 2, 3, and 4 by age.

| Age | Sample size | Percent of sample |
|---|---|---|
| 14 to 18 years | 50 | 17.24% |
| 19 to 24 years | 48 | 16.55% |
| 25 to 44 years | 27 | 9.31% |
| 45 to 59 years | 145 | 50.00% |
| 60 plus years | 20 | 6.90% |

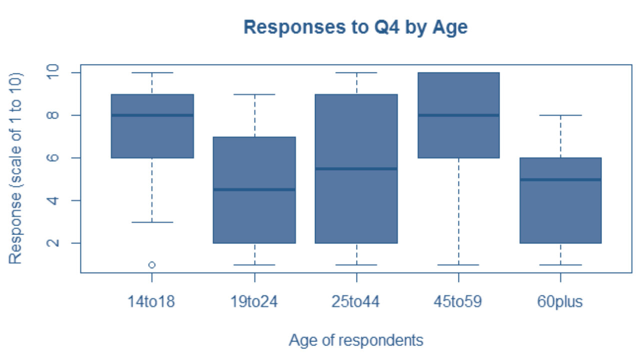
For question 2, “Did the information in the poster help you better understand current scientific research about the environment?”, the 19 to 24 year old age group (mean = 7.55) had a lower mean than the 14 to 18 group (mean = 8.51), the 45 to 59 group (mean = 8.99), and the 60 plus group (mean = 8.80). This is likely a result of attendees in the 19 to 24 age group having previous experiences as undergraduates mentoring TERFers at Tyson, or they were students in an Washington University environmental studies class. Therefore, they might already have a good grasp of current scientific research about the environment through their coursework or other involvement with research projects. It should be noted that the “lower” mean was still a relatively high number (7.55 on a 10-point scale).




For question 3, “Did you learn anything new about the skills and knowledge needed to do this kind of scientific research?”, the 19 to 24 age group (mean = 6.6) again had a lower mean than the 14 to 18 group (mean = 8.18) and the 45 to 59 group (mean = 8.48). Most of the respondents in the 19 to 24 group are probably undergraduate researchers at the field station, so they might already be aware of the skills and knowledge needed to do the research. In addition, the 25 to 44 group (mean = 7.26) had a lower response to question 3 than the 45 to 59 group (mean = 8.48).




The last question with interesting differences in answers between age groups was question 4, “Will you do anything differently as a result of the information you learned?” The 14 to 18 age group (mean = 7.14) had higher responses than both the 19 to 24 age group (mean = 4.57) and the 60 plus age group (mean = 4.32). The 45 to 59 group (mean = 7.15) had higher responses than the 19 to 24 group (mean = 4.57), the 25 to 44 group (mean = 5.54), and the 60 plus group (mean = 4.32). It is possible the 14 to 18 group has higher responses because they are optimistic about their ability to change. The 19 to 24 group, which is mostly comprised of college students with an environmental interest, might have lower responses either due to the fact that they are not yet completely independent or due to the possibility that they are already doing a great deal to reduce their environmental impacts. The 24 to 44 group has a large amount of spread, most likely due to the variety of ages included in the group as a result of combining two smaller respondent pools. There is a large difference in potential lifestyles of this group, including home ownership and whether they have a family, that might impact how much they consider behavior change. It is difficult to interpret these differences in response without knowing more about lifestyles and behaviors.




We contend that youth in the programs are likely improving public knowledge about environmental biology research, and possibly changing attitudes about the value of this research.

***5) Is this model of informal science education collaborative programming suitable for replication by other similar institutions and organizations via a national dissemination workshop?***

The two national dissemination workshops during summer 2012 were very successful at sharing the SIFT and TERF model with others interested in integration of field research and high school level science education. The workshop participants were convinced that having high school level youth working alongside scientists on real research projects is a very powerful interaction. They saw the influence on future college and science career decisions and also the benefit to the scientists' research agendas. They found the testimonials of both SIFT and TERF mentoring researchers and youth participants to be compelling arguments for investigating ways to incorporate or adapt similar models into their own science education and/or science research practice.


High school teachers, field research scientists (university, government agency, field station), and field/research/nature center directors were invited to attend one of the two national dissemination workshops held at Shaw Nature Reserve and Tyson Research Center. Having two workshop options (June or July) was necessary to accommodate the schedules of the participants. Attempt was made to bring educators and research scientists from close geographic regions together to enhance possibilities for collaboration. While some participants were not in close proximity to potential collaborators in the participant groups, the program model and interactions with others spawned new ideas and possible applications in adapted ways (making connections with researchers or teachers via technology versus in person, getting researcher expertise to inform set up of authentic research experiences for high school youth within communities that are not near universities or colleges). Both workshop groups were very dynamic and inspired each other as they engaged in the possibilities and problems of replicating programs similar to SIFT and TERF. Many used the time exceptionally well to connect with each other and to build on ideas that might work in their own settings.

All aspects of the workshop experience were highly rated (above 4.44 on 5-point scale). For most participants the highlights seemed to be the testimonials from research team leaders at Tyson who had TERFers on their teams and from the SIFT and TERF program alumni. This highlight was closely followed by the many opportunities provided for discussion with program staff and participants and, with each other as workshop participants with similar interests in enhancing science education at all levels. Hearing impacts directly from researchers and SIFT and TERF alumni and hearing needs directly from youth, teachers and researchers, convinced workshop participants of the need for such project collaborations.

**Workshop survey Q7**
**What in this workshop experience inspired you to consider some new directions, plans or collaborations?**

***Workshop 1 participants***

- It allowed me to consider the approach/direction that we are currently pursuing within our district.
- 1. Maturity and experiences of previous SIFTers, TERFers. 2. Insights, experiences, ideas and enthusiasm of HS Biology teachers.
- Speaking with the teachers and finding they were interested in collaborating.
- Meeting HS teachers, meeting HS students and researchers involved in the program.
- Linking high school to college-seeing this in action. Sharing experiences/thoughts with other teachers or same positions and having people in immediate proximity to ask questions about feasibility - fantastic!
- Collaboration with fellow teachers and SIFT/TERF. Communication with research scientists on what they are doing and how we can help them.
- The networking with everyone was a great springboard.
- Obvious success of SIFT/TERF and the great alums.
- Value of engaging students in research. Undeniable benefit.

***Workshop 2 participants***

- Student panel, interaction with other workshop participants.
- Visiting with scientists and this perception of high school science and field science.
- The testimonials of the students and researchers.
- The enthusiasm of the group and of local colleagues.
- The TERF student testimonies and researcher testimonies were especially powerful.
- It does take a lot of work, but building your network and relationships with other professionals would make it easier. It is attainable with middle school students.
- Lessons learned, conversations with TERFers, conversations with other workshop participants.
- The excitement of the students and mentors was infectious.
- Importance of front loading with a program like SIFT.
- Learning that researchers see and experience and support the involvement of HS students. Mentor development is crucial for success.
- Testimonials from students and mentors were inspiring.

A particularly powerful experience during one session occurred after the TERF alumni panel presentation when an informal discussion continued. TERF alumni (some about to be seniors in high school and others about to enter their freshman, sophomore or junior years in college) discussed with participating teachers how their high school science classes were not providing or had not provided them with real science experiences and, in fact, were mostly out of the context of real inquiry. The experience seemed to inspire more resolve in the high school teachers to find more ways to engage their science students in authentic research.

**Workshop survey Q9**
**How feasible do you feel it is for you and your institution to implement some type of related field scientist/high school student career exploration program?**

***Workshop 1 participants***

- Very much so but the person must be persistent and passionate to drive the program to completion.
- Feasible but I am thinking beyond my institution to mount an inter-institutional program as part of a large-scale, long-term collaborative research program.
- Extremely feasible.

- I think we could implement something pretty different from SIFT & TERF - small scale, fewer students.
- A mini version, yes! Would love to work on this large scale with DCPS (DC public schools) but that would be a full time job. :-)
- Very easy now.
- Very feasible on the classroom scale.
- Definitely maybe. Depends on finding the right outreach people.
- Depends on researcher availability and interest.

***Workshop 2 participants***

- I am excited that we have specific steps to implement student/scientist interaction immediately as well as some longer term.
- I don't know yet, it's up to the researchers and if they need help.
- It is feasible but requires unique problem solving to make it appropriate for a diffuse setting.
- Very feasible - something I had not considered.
- I think that we have all of the resources in place except for funding. I'm not sure that finding funding is feasible.
- It's a little up in the air for me. I have to see what resources are available within the school. If not, reaching out to professors and parks for potential research opportunities.
- Already exists - this will improve in key directions mentioned in [question] 3.
- The Forest Service is exploring new ways to engage high school students in our work and this type of program could work.
- Very feasible. Hope to begin/implement a version this academic year.
- On a small scale - very likely, most components are in place. On a large scale funding is needed for a coordinator.
- I am moving institutions so it is difficult for me to answer.

Participants were sent a link to an online follow-up survey inquiring about any progress they had made on the ideas and plans they took away from the workshop experience. Fifty-five percent of the workshop participants responded to the follow-up survey (12 of 22). Their updates are presented below.

**Workshop follow up survey Q1**
**What is still fresh in your mind and active in your thought about the implementation of a similar kind of program?**

- Importance of social context, how mentoring should be encouraged within participant types as well as between.
- That a similar type of program, but dispersed among institutions, is still part of my long-term goals for biodiversity research and education in the Chicago region.
- Mostly the structure of accomplishing such a task. I thought it was a great case study, a model, for what can be done to connect high school students with scientists.
- Connecting with a researcher to find valuable research that students can help with.
- The collaboration with researchers and students - building an outdoor awareness in young people as well as an understanding of data collection and research.
- Collaboration between High School and University partners is essential.
- I would love to use this as a model for all sciences to get pre-college students exposed to real life opportunities in scientific research, making connections with real scientists and provide them with opportunities to further their scientific experiences.
- I certainly remember just how successful these programs were. In terms of implementation, I am still sorting out my own position so I have made little progress in that direction.
- That students need hands on practical science research skills.
- The current programme is an excellent example to follow. One improvement I could see is more attention to high achievers from deprived or underprivileged schools and students.
- I have still been thinking a lot about how to implement a similar program in a rural area where students and researchers that might benefit from partnership are more dispersed. The testimony of both scientists and students of the effectiveness of the program still stands out clearly in my mind.
- That high school students can be great research assistants - that it is probably much easier to implement a system like yours when you have field sites and infrastructure in place.

**Workshop follow up survey Q2**
**What actions or steps toward some kind of planning or implementation have you been able to take?**

- Conducted over 15 videoconferences between classrooms and scientist mentors this fall using Skype and Adobe Connect software. Conducted training videoconferences with cohort of scientist mentors and encouraged communications between scientist mentors. Committee of scientist mentors formed to test feasibility of audio or video introductions to students. Integrated lessons learned into training materials for students, scientists, teachers. Planning a workshop for the International Teacher-Scientist Partnership Conference on improving online communication/collaborations.
- None.
- Little at this point. The dynamics of my position and the mission and vision of our school are in flux at this point. I am not in a position to create and implement this type of program (yet!).
- We are working (with Phyllis B.) on a collaborative project on water quality across multiple assessment criteria. The project will encompass student research that can be shared with students from across the nation.
- Mostly thought - I considered trying to implement my own nature study using a place called Camp Goddard, to spend a couple of days with students exploring the out-of-doors and doing simple data collections and observations. I met a couple of people from the Noble Foundation who are working on science outreach and talked to them about the SIFT/TERF program. Perhaps something might come of it - they were encouraging me to bring students on a field trip to the Noble Foundation (about 1.25 hours away from my school) or they were also willing to come speak with students at school. It is a small start - it will take time.
- Unfortunately, none. Our school (Jefferson City High School) has chosen to drop our Science research program and I was unable to convince them to try a new approach.
- Very little. I have had conversation with my colleagues about the idea and what we'd like to see happen but no action.
- Beyond a few conversations with people in permanent positions, none.
- We were ready to implement during our biweekly advisory period, but admin and counseling failed to schedule it
- I am already aligned with the St. Louis programme and so am not looking to start anything new, but help build on what is here.
- I have taken no steps toward implementation, but my research has continued.
- I have been considering working with high school teachers, and through them having high school students act as citizen scientists who can help us collect data. I have been talking to some people and looking at NSF funding sources that would help with this.

**Workshop follow up survey Q3**
**What obstacles or support have you encountered?**

- We've seen a much closer community as a result of videoconferences. Scientist mentors are able to model off of each other and new mentors are thus learning by example from more experienced mentors. The students have responded positively to being able to communicate in real time and to see the scientist mentors they will later interact with asynchronously online. Obstacles include technology issues with videoconferencing, and scheduling mentors to fill classroom time slots. Ideally, the same mentors would videoconference with students and answer teams' questions online, but in practice that has been hard to schedule.
- No obstacles, -- no support sought.
- I have been unable to progress due to time limitations and my focus on additional directives that my district is currently involved in. I think there may be opportunities in the coming years.
- Choosing what data to collect and finding a platform that will enable that collection and sharing of data.
- Right now, time is a huge obstacle - still have to keep on with my busy teaching schedule and all the new mandates coming down the pike!
- Administrative inability to schedule time for students to participate in a program similar to yours. Our bureaucracy has a lot of inertia and does not change direction easily.
- Most colleagues are very supportive and love the idea... as well as admin. There is plenty of enthusiasm for it but the difficulty is implementation (time) -- there are so many projects!
- My main obstacle has been my recent shift from UMSL to George Washington University. I have yet to become established there, so I am not familiar with existing programs or other opportunities.
- Scheduling and lack of support from our administration.
- I had the opportunity to share my research on this topic at the conference on public participation in scientific

research in Portland, OR in August. This conference made it very clear to me that the field of engaging the public in scientific research is growing rapidly and that both the education and scientific community are beginning to recognize its value. I encountered a lot of different types of support at this conference such learning about projects that are underway in facilitating data management (dataone), I received excellent feedback on my research project, and I learned of plans and hopes for developing a professional society that will help to support people working in this field.

- Neither.

It is evident from participant response that the workshops provided a new vision of what was possible in the development of scientist/youth field research partnerships. Participants grasped the power of the program model and were inspired by the enthusiasm and passion of the SIFT and TERF program staff, mentoring scientists, and youth. As is the case with any such significant program model development, seed money and support structures are often needed to get fledgling ideas off to a start. Developing a grant proposal with these components would give rise to an exciting incubator project in a region or across the country. On a small scale, as a result of the workshops, the SIFT and TERF programs have provided a connection for the US Forest Service in Mark Twain National Forest to experiment with ideas engaging their scientists in outreach. SIFT and TERF youth have since participated in several forest research project days with US Forest Service scientists.


***6) Is this model of collaboration between an informal science institution (Shaw Nature Reserve) and a science research institution (Tyson Research Center) successful for engagement of teenagers in environmental biology?***

This project has shown that environmental biology field research can be conducted with pre-college student involvement without significantly altering the methodology or diluting the quality of the data. Participating scientists have received more productive assistance with their research than originally anticipated. Research projects of larger scale, greater breadth, and increased depth have been conducted because of the inclusion of well-trained pre-college youth. Our model points to a strategy in which scientists can execute high quality outreach and high quality research at the same time. Additionally, the scientists have gained deepened mentoring skills that transfer to other areas of their careers and the ability to simplify their communication of research. We are seeing undergraduates, graduate students, technicians, post-doctoral scientists, and faculty placing value on pre-college youth mentoring – essentially a paradigm shift in preparation of future environmental field researchers (Beyer, Flowers, Balcerzak, & Galluppi, 2015).

The expanded breadth and depth of research activities among mentoring scientists includes collaborative research between Tyson and Shaw scientists at both sites. The educational programs at both sites have been enhanced in participation numbers and in structure and quality of experience. Both scientists and educators have increased knowledge of the other's professional practice and the benefits of incorporating strategies from each other's practices as well.

Program staff and participating scientists recognize their own enhanced mentoring skills and research practice as experience is gained working with pre-college youth. This new learning is expanding these beneficial impacts to the whole continuum of scientists involved at both sites – undergraduate interns, graduate students, post docs, technicians, staff scientists and faculty. In addition education program staff at the nature reserve have gained closer relationships with and knowledge of current environmental research at both sites.

> *It definitely challenges us to explain research on terms that a high school student can grasp, which helps us learn to talk clearly and simply about our research to others.*
>
> *Undergraduate survey response, 7.27.2014*

> *I believe the mere fact that us undergrads are now going through the process of choosing majors, attending college, working at the research center, etc., makes us good mentors for the high schoolers. There is a wide range of experience (and age, relatively) within the ecology field, and undergrads have experience in other fields, too. I believe that this range helps the TERFers to ask questions.*
>
> *Undergraduate survey response, 7.31.2011*

> *What a chance for education staff to get deeper experience and knowledge than by organizing and tagging along on the SIFT projects with local field researchers. Not only are these excellent professional development opportunities, but also information gained from some of these projects can then be shared with (other) staff or volunteers at trainings.*
>
> *. . . These changes in (program) activity included engaging students in developing a research proposal based on initial data collected in an ant observation study and presenting these small team proposals for review by the other teams and SIFT project staff. Such program changes in SIFT better prepare students for the more formal analysis, application, synthesis and evaluation that occur in TERF, and particularly in the posters that students develop for the fall and winter research symposia and in some cases for the St. Louis Science Fair.*
>
> *SIFT program staff, interview, 11.15.2011*

> *I decided to carry two (TERFers) over for half of the second session along with two new ones for the whole session. Yes, they will help teach the new TERFers. I will have a fulltime research tech also. So along with the undergrads, it's a huge crew and hierarchy. I am really excited! Everyone works in teams, two or three of them together. They keep each other in check . . . I rotate people every day and changing partners because you may not notice something that your partner would. I am striving for the best way of reducing error in the field. I think I figured it out last summer. I ask them a lot of questions when we are in the field like, "Why do I not want to know the*

*treatment when I am out here?" It's about not being biased . . . We learn a plant a day. The two crews finished before I did the other day so I told them they could go look for geodes for ten minutes . . . just a little reward like that goes a long way for them. They were all excited.*
*Post-doctoral research scientist mentor, interview, 6.21.2012*

*The other thing, let's not wait and analyze all the data in the fall but start now. Otherwise you lose sight of the project. It gave me time to talk with them. I could see what you are finding. I'm not in the field with them so looking at data allows you to talk with them about what they are finding. It was good training for high school students and undergrads. I did this with prairie (team) last summer and tried to do a bit more this summer with the glade team.*
*Faculty research scientist mentor, interview, 11.15.12*

The Missouri Botanical Garden education administrator has committed continued support for keeping the SIFT stage of this career exploration partnership in place as part of the educational program offerings at Shaw Nature Reserve. Change in Tyson Research Center leadership has led to policy changes in support of new and expanded mentoring strategies for undergraduate and pre-college youth in the field research career pathway. These policy changes include:

- Commitment to continuing TERF and broadening the impact of changed mentoring strategies and educational support structures to the undergraduate internship program.
- Commitment of funds to establishing the permanent role of the education specialist.
- Commitment to mentoring meetings as a priority for all scientists doing research at the site – three times each field season (pre/mid/post) – recognizing the value of this part of the community's culture. This has essentially solidified the developing professional learning community by giving it some formal structure.
- Commitment to creation and maintenance of an integrated educational research and evaluation agenda across undergraduate and pre-college internships.

The development of a professional learning community at Tyson as a direct result of the presence of a pre-college career exploration program is noteworthy, as is the growth in the relationship with Shaw Nature Reserve staff. There is more mentoring scientist research work across the two sites involving pre-college youth as well as undergrads, graduate students, post-docs, technicians, staff scientists, and faculty. Mentoring scientists have embraced the idea of incorporating more educational strategies within their research teams and mentoring practice. Educational staff at Shaw have incorporated new activities in the SIFT training week as insights have been gained about what supports are needed to better prepare participating youth for work with scientists in the field and thus better prepare the youth for understanding their own capacity and interest in an environmental field research career. These kinds of continual refinements and maintenance of the essential components of the pre-college career exploration model are important to the successful continuation of the two-stage partnership.

The benefits and burdens to Shaw educational staff in continued integration of new environmental field research practices into SIFT educational activities, and in continuing the evaluation practices that inform the effectiveness of these refinements, are parallel with how Tyson mentoring scientists initially viewed the continuing professional practice refinements of mentoring pre-college youth. The Shaw education staff deals with the demands of continuous informal science programs of which the SIFT program is only one small part, albeit one of the more extensive and longer term programs in terms of involvement with participants over time. As hard as it has been for Tyson mentoring scientists to make mentoring meetings during field season, it appears to be equally as difficult for Shaw staff to either join in with the Tyson community's activities or to institute and maintain their own reflective practice structures.

The benefits to both Tyson and Shaw in the continuation of their parts of the partnership are enhanced by how well each contributes to the other's needs. Thus it is recommended that the importance of and commitment to all aspects of the SIFT and TERF model be clarified between the collaborating organizations' staff and administrators regularly, in order to sustain the identified benefits for all stakeholders.

The consistency in tenure of project director leadership throughout the grant has enabled continual project and program refinements based on data collected, despite changes in PI leadership (three total) across the seven years. This is a demonstration of how well the initial program concept was conceived and how committed program staff and mentoring scientists have become in continuing the two-stage environmental career exploration partnership for pre-college youth.

## Final conclusions

With continued population growth and expansion of urban and suburban areas in the United States, we have pressing need to train scientists interested in studying our rapidly changing natural environment. The engagement of science research institutions and professional scientists with pre-college youth is critical in bringing real and dynamic context to the exploration of environmental field research as a career option. The results of this project provide a feasible way to involve the next generation of scientists in finding solutions to human impacts on the environment and influence entry into environmental research careers.

Based on our longitudinal study of SIFT and TERF participant outcomes (Flowers, Beyer, Pérez, & Jeffe, 2015), we recommend the following components be included in the development of pre-college STEM research career exploration experiences:

1. *Ability to see the next steps and the big picture*: First, programs must include support to enable youth to get beyond any discomforts created by lack of experience in the particular STEM career environment. Second, program activities must help youth find comfort and confidence in the authentic practices and culture of a STEM career. Our data indicates that a two-stage structure with exploratory (SIFT) and immersive (TERF) experiences is effective. Additionally, the visibility of the hierarchy of career progression and ability to interact with all of those levels helps youth form a big picture of the career and how to get there.

2. *Relationships with professionals within a community of practice*: Youth access to professionals at multiple levels in a career pathway provides realistic views of the career at various stages and time points. And importantly, it allows for relationships to form. We recommend youth explore STEM careers through the apprenticeship model. Our data indicates that the experience of trying out a career influences the persistence of pre-college youth in the career pathway.

3. *Reflection on the experience*: An interactive reflection process with peers and led by program staff is recommended for youth to achieve deeper understanding of how they fit or not within a STEM career. In our study, youth participants were provided with reflective discussion sessions as a part of both SIFT and TERF activities. We do think it is important for reflection to be a face-to-face group discussion format. We also recommend STEM career professionals working with pre-college youth be provided with a framework for reflection, sharing, and feedback on their mentoring experience.

4. *Involvement of a STEM education specialist*: This specialist can play a key role in design of educational activities in the first stage (exploration) so that youth are well positioned for work with professionals during the second stage (immersion). Likewise, the specialist can work with the mentoring professionals to set realistic expectations of youth involvement in their work and strategies for scaffolding of tasks within the apprenticeship experience. And importantly, the specialist provides support for youth understanding of the next steps and

big picture, mediation of the relationships between youth and mentors within the community, and facilitation of reflection.

If our pre-college youth program model of authentic career exploration activities followed by immersive apprenticeship is transferred to other STEM disciplines, there is possibility of greater numbers of STEM professionals leveraging integration of pre-college youth for expansion of research scope while facilitating early entry of new future scientists into STEM career paths.

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