Impact of a University-School Division Partnership on Professional Development of Graduate Students

Abstract

This paper documents the development, implementation efforts, and results of SUNRISE (Schools, University 'N' (and) Resources In the Sciences and Engineering-A National Science Foundation (NSF)/George Mason University (GMU) GK-12 Fellows Project), a unique graduate Fellowship program at GMU that targets graduate students working in the grade 4-6 school environment. SUNRISE is a new GK-12 project aimed at partnering STEM (Science, Technology, Engineering, and Mathematics) graduate students (fellows) with school teachers from three different school divisions in Northern Virginia. The project builds a unique model of collaboration among elementary and middle schools, school division administration, and GMU to foster systemic efforts in implementing Information Technology (IT) rich STEM content-knowledge into grades 4-6 education by graduate fellows, with the potential to enhance the delivery of science instruction and provide long term professional development for teachers. This is achieved by constructing a framework that provides training, exchange of information, and integration of scientific research from diverse STEM disciplines with teaching to make science exciting for students. Sponsored by NSF's GK-12 program, the GMU implementation serves as an exemplary model for the emerging trends in STEM education at the elementary school level. One of the objectives of this project is to provide professional development opportunities to fellows, particularly, communication and teaching skills. This paper presents project evaluation evidences (quantitative and qualitative) of the impact of the project on the professional development of its participants, particularly the graduate fellows. The data and the results indicate that the fellows significantly improved their communication skills, which include communicating their research to public including K-12 children, confidence in public speaking, and writing skills. The project serves as one source of evidence that demonstrates the importance and the process of building partnerships among university's engineering/technology departments, schools of education, and the K-12 STEM education that would strengthen the nation's educational enterprise.

Introduction

Several reports indicate lack of proficient performance of America's children in science and mathematics. The reports also indicated the need to give teachers the tools they need to enrich the learning opportunities for K-12 students in science and mathematics. Particularly, these tools include the professional development and training on content materials to the teachers. Below, we first summarize a few of the findings from these reports which motivate our educational research. Further, we provide details of our research and observations.

"Recent reports of the performance of America's children and youth from both the Third International Mathematics and Science Study (TIMSS, 1999[1] and 2004[2]) and the National Assessment of Educational Progress (NAEP, 2000[3]) echo a dismal message of lackluster performance" [4]. For example, TIMSS (2004 [2]) report "suggests that the performance of U.S. fourth-graders in both mathematics and science was lower in 2003 than in 1995 relative to the 14

other countries that also participated in both studies". According to the National Commission on Mathematics and Science Teaching for the 21st Century, the learning shortfalls are due in part to a shortage of qualified science and math teachers (Sterling, 2004[5]). Another report by the National Science Board notes that in the period 1990-2003, most students in grades 4, 8 and 12 did not reach proficient performance levels in both mathematics and science (NSF 2006[6]). Furthermore, under the No Child Left Behind (NCLB) act of 2002, policy makers have relegated science to the backburner by directing a majority of the resources to reading and mathematics-the first areas to be assessed and reported with adequate yearly progress (AYP) (Slutskin, 2005[7]). Science is slated for testing only in 2007-2008, and only a few school divisions have started monitoring their competency in science. In the State of Virginia, only 48% of school divisions met the AYP requirement for 2004-05[8].

A recent report by the BHEF[9] (Business-Higher Education Forum 2007) states "…chronic low student interest and achievement in mathematics and science poses an acute challenge to American economic competitiveness." The BHEF membership is made up of members from business and academia.

"Now three decades old; it is time that the nation heeded it - *before it is too late*" [4]. A National Research Council panel (Brunkhorst and Lewis, 2000[10]) issued a report that urged increased cooperation between universities and GK-12 schools in teacher education and professional development for teachers of science and mathematics. The NSF GK-12 program offers a unique opportunity to address this need.

Implementation

The implementation started with the recruitment of Fellows and Teachers in 2007. The program supports eight Fellows from STEM disciplines who are paired one-on-one with eight teachers, one pair per school. 65% of the Fellows are women graduate students. One of the eight spoke a language other than English at home. The fellows were given a two month long training program by the project co-PI from the College of Education and Human Development. The training included an understanding of the Virginia State Science Standards of Learning (SOL) [11], preparing and delivering of sample lessons, and discussing general topics on pedagogy particular to elementary school teaching. The Fellows worked out a schedule with the teacher. The Fellows began their visits to classroom, identified the science needs with the teacher and began contributing to the enrichment of the lessons and discussing the science behind the lessons. The Fellows were introduced to the children as Scientist, Researcher, or an Engineer. Thus, a strong foundation was laid for a long-lasting partnership between the school and the university.

Ongoing Activities

One of the key activities of the Fellows is the enrichment of existing curriculum and leading the discussion of the science behind the experiments. The Fellow and the teacher plan the activities a week ahead so that there is sufficient time to enrich and test the lesson before they are presented to the classroom. Another activity consists of bringing lessons from their engineering and science research, and graduate education into K-12 environment. These new lessons are tied to the SOL and the IT theme is emphasized where applicable. Fellows also act as guest lecturers in other

science classes who are not participating directly in the SUNRISE project. The Fellows help with field trips, judge science projects, and answer general science questions that are dropped in a question box.

Examples of lessons that were enhanced with a deeper understanding of the science behind it include waveforms, light's electromagnetic spectrum, alternative fuel energy, earth science and so on. Some highlights of the advanced engineering and science lessons that are not part of the textbook include discussing and showing videos about Sun's electromagnetic spectrum and solar winds while discussing Earth science lessons, demonstrating protein bonding forces while introducing lessons on force and motion, demonstrating an infra-red camera and night vision while discussing light and sound lessons, and discussing RADAR and its uses along with lessons related to weather.

Observations from Program Evaluation on the Impact of the GK-12 program on Fellows

The data in the following observations is based on surveys administered in May 2009 to research advisors, participating teachers, and fellows. The focus of the three surveys was to assess the growth by the fellows over the year in the acquisition of new skills in the area of communications and teaching. Triangulation of the findings on fellow professional growth is provided by the self assessment of growth in the fellow's survey and independent assessment by the research advisors and participating teacher in their surveys. The questions for the surveys focused on the specific themes of:

* Ability to communicate research to diverse audiences
* Increased comfort level in public speaking
* Enhanced teaching skills
* Fellow pedagogical innovations
* Strengthening of abilities in curriculum development
* Ability to write concisely and clearly for non-scientists
* Enhanced awareness of global perspective
* Increase in fellow interdisciplinary knowledge and communication
* Increase in the ability to work in heterogeneous teams
* Impact on fellow research
* Increase in GK12 awareness and advocacy

The surveys were designed by the external evaluator with input from the PI and a CO-PI. The three surveys did not present identical questions but differed in order to reflect the particular perspectives on fellow growth as seen by fellows, teachers and advisors. In addition to 1-14 quantitative responses, those surveyed were asked to comment on one or more of their responses in the last question.

The response rates and N were as follows: Fellow N=8, Response Rate=100% (8/8); Research Advisors N-7, Response Rate=78% (7/9); Participating Teachers N=8, Response Rate=100% (8/8). One of the fellows has two advisors. Surveys were sent as an attachment to an email letter requesting participation. Quantitative responses were indicated by the responder underlining or

making bold their choice. Tabulation and data analysis were carried out by the evaluator with input from the PI.

Quantitative Findings

The responses to fellows, advisors and teachers to the target themes in the surveys are shown below. Key: GX= to a great extent; S= somewhat; N= not at all or don't know. Percentages shown in all columns may not add to 100% due to a rounding error. The responses have been grouped as shown by question clusters. The questions from the survey are given below each table for easy reference. The question numbers are prefixed with alphabets F, A or T to indicate whom the question was asked (Fellow, Advisor or Teacher).

1. Fellow Gains in Professional Communication

* Ability to communicate research to diverse audiences.
* Increased comfort level in public speaking
* Ability to write concisely and clearly for non-scientists

Fellows	Fellow Q1	Fellow Q2	Fellow Q3	Fellow Q4
	GX=7/8 88% S=1/8 13%	GX=3/8 33% S=4/8 50% N=1/8 13%	GX=5/8 63% S=3/8 33%	GX=5/8 63% S=2/8 25% N=1/8 13%
	Fellow Q11			
	GX=6/8 75% S=2/8 25%			
Advisors	Advisor Q1	Advisor Q 2	Advisor Q3	Advisor Q4
	GX=5/7 71% S=2/7 29%	GX=4/7 57% S=1/7 14% N=2/7 29%	GX=4/7 57% S=3/7 43%	GX=2/7 29% S=3/7 43% N=2/7 29%
Teachers	Teacher Q1			
	GX=6/8 75%			
	S=2/8 25%			

F Q1: To what extent do you feel you have gained in your ability to present your research to a lay audience of different ages in a simple and understandable manner?
F Q2: To what extent do you feel you have developed an increased ability to present research at departmental meetings, in your research group and other professional meetings?
F Q3: To what extent have you noticed a greater confidence in your comfort level in public speaking since you have taken part in the Sunrise project?
F Q4: To what extent do you feel you abilities to present at research conferences has increased?
F Q11: To what extent do you feel you have developed an increased ability to present research at departmental meetings, in your research group and other professional meetings?

A Q1: To what extent has your advisee gained in his or her ability to present her research in a simple and understandable manner?

A Q2: To what extent has your advisee shown an increased ability to present research at departmental meetings?
A Q3: To what extent have you noticed a greater confidence in public speaking by your advisee since she has taken part in the Sunrise project?
A Q4: To what extent have you seen an increase in your advisee's abilities to present at research conferences?

T Q1: To what extent has your Sunrise Fellow improved in his or her ability to communicate her research to the students in a simple and understandable manner?

Discussion:

It is evident that the fellows and advisors see gains (to a great extent) in communicating research to diverse audiences (Q1.) Advisors see larger gains than fellows in the fellow's abilities at departmental meetings (Q2.) Teachers see gains in the ability of fellows to communicate to their students in a clear and understandable manner (Q1.) Fellows and advisors are more cautious about the degree of gains in presenting at research conferences (Q4) which could reflect the fact that some fellows have not yet made presentations and that advisors may not be aware of performance in this area by fellows.

Illustrative quotes from the survey on Professional Communication:

From a fellow: "I have also been able to better explain what it is I do to my friends and family. This is an idea from which I feel I went from near zero ability to a solid proficiency during my time as a fellow."

From another fellow: "The SUNRISE GK-12 has really made a difference in my ability and comfort level for public speaking, especially in the area of science. I was always a good public speaker, but I found that once I got into graduate school and was expected to speak confidently about science, I was nervous. However, speaking publicly so often in the school and learning small nuances about science that I had long forgotten increased my comfort level. I am very proud to say that just this week, I went to the Virginia Academy of Science Annual Meeting and presented my scientific manuscript to a group of fellow microbiologists. I really realized the impact of the GK-12 program when, out of a large number of other presenters, I won the honor of Best Student Presentation in the Microbiology category."

From a third fellow whose education in the US started in the 10th grade: "My vocabulary has increased tremendously as well as my communication skills through interaction with diverse students and fellows, most importantly my students. Having to explain my research to a younger audience has improved my ability to explain my research to non-science audience in the future. I have thus gained a deeper understanding of my research through explaining it to fellow teachers and my fifth grade students."

From a fellow: "In my GK-12 experience, I feel that my communication skills have strengthened and I have a greater appreciation for different perspectives towards science. The GK-12 project forces us to communicate to a younger audience which proved to be a challenge at first. But

perhaps just as rewarding of an experience lies in communicating with the various educators I have been working with throughout the year. Teachers and teaching aides also challenge me to explain topics more clearly and tell me they are gaining from this experience as well."

Another fellow commented: "I used to get very nervous to give presentation in front of audiences. After I started this program, my confidence level has increased and I don't get nervous to present. I also feel like I am more prepared for the questions from audience members, and I can come up with answers at the spot. I would give this credit to my experiences at my school and to this program. At school, standing in front of students and giving them directions to conduct experiments as well as presenting various topics has helped me gain communication skills."

From a research advisor speaking of one of his advisees: "She recently presented her research to the department as part of our seminar series. Her talk was well organized and well thought out (even before I made my edits), and her presentation went smoothly and her confidence was clearly evident. She did a very good job explaining her project in language that was accessible to the diverse audience. Furthermore, she handled the ensuing questions with confidence and was not rattled by them. I think that the quality of her presentation and her ability to effectively handle questions and discussion is in large part the result of her experience in the GMU SUNRISE program."

From a teacher: "This experience has been wonderful for my students, my fellow and myself. The fellow has done a lot to increase enthusiasm and interest in science-related topics. In addition, this placement has provided the fellow with knowledge and experience in adapting her scientific knowledge into understandable and relatable means for fifth graders and myself."

From another teacher illustrating some of the obstacles involved: "My fellow's science area was so specialized that communicating her research to my 5th grade students and making it relevant to our science curriculum was awkward. I'm sure priority given to Virginia SOL science curriculum inhibited activities she would have liked to do."

2. Fellow Gains in Teaching Skills

* Enhanced teaching skills
* Fellow pedagogical innovations
* Strengthening of abilities in curriculum development

Fellows	Fellow Q5	Fellow Q11	Fellow Q12	
	GX=7/8 88% S=1/8 13%	GX=6/8 75% S=2/8 25%	GX=7/8 88% S=3/8 33% N=1/8 13%	
Advisors	Advisor Q5			
	GX=5/7 71% S=1/7 14% N=1/7 14%			GX=2/7 29% S=3/7 43% N=2/7 29%
Teachers	Teacher Q3	Teacher Q4	Teacher Q5	Teacher Q7

	GX=8/8 100%	GX=7/8 85% S=1/8 13%	GX=8/8 100%	GX=7/8 88% N=1/8 13%
	Teacher Q8			
	GX=8/8 100%			

F Q5: To what extent do you feel your teaching skills have improved since you have been a part of the Sunrise project?
F Q11: To what extent do you feel you have developed an increased ability to present research at departmental meetings, in your research group and other professional meetings?
F Q 12: To what extent do you feel your ability to listen more carefully to questions from non-scientists such as students and teachers has improved?

A Q 5: To what extent have you noticed improved teaching skills by your advisee?

T Q3: To what extent have you noticed a greater confidence in your Fellow's ability to relate to the students?
T Q4: To what extent have you seen an increase in your Fellow's abilities to develop their own innovative hands on STEM lessons?
T Q5: To what extent have you noticed improved teaching skills by your Fellow?
T Q7: To what extent have you seen an increase in the ability of your Fellow to work in a collegial relationship with you, other teachers and administrators?
T Q8: To what extent do you think your Fellow's understanding of STEM teaching in elementary or middle schools has increased?

Discussion:

Fellows self-report increases in their teaching skills, advisors report a similar increase although are somewhat less clear on the increase, teachers overwhelmingly have seen an increase in these skills.

Illustrative quotes from the survey on Fellow Gains in Teaching Skills:

From a fellow: "In particular, I've found that the most useful skill that I have developed through my work in this fellowship is the ability to distill concepts into their essence, allowing them to be expressed in a way that people without technical background in my field can understand."

From another fellow: "My ability to listen more carefully to questions posed by non-scientists such as students and teachers has improved to a great extent by participating in the Sunrise program. Many questions from professionals without field-specific knowledge and lay people alike are not posed well and lack focus and direction. Some questions are simply outside my knowledge-base. And other questions have no clear answer or are just "spat out" for a response. Participation in Sunrise has helped improve and refine my listening (and visual clues) skills to better filter, interpret, and understand the content and context of a question. Decomposing, clarifying, and reconstructing the question orally, in writing, by drawing either a picture or a diagram or a combination of the three has increased my understanding of the question, the

understanding of the person asking the question, and the understanding of others listening to the interaction."

From another fellow: "The SUNRISE (GK-12) fellowship has enormously improved my pedagogy skills, and given me the privilege to exercise my teaching and mentoring skills to a younger generation. Prior to the fellowship, I was a Teaching Assistant but the way the fellowship increased my pedagogy skills is not even comparable to the TA position."

Another fellow had this to say: "I feel the greatest improvement to myself as a result of this program is in the areas of teaching ability and being able to bring my research to non-mathematicians. When I taught a calculus recitation before taking this position, I merely went through difficult problems with the students and took questions. The next time I teach a course I would like to try more simple teaching techniques, such as in-class group discussions and more hands on activities."

From a research advisor: "I think G. (fellow's names suppressed) has benefitted most from the SUNRISE program in her ability to present her research to a diverse audience and in her public speaking skills. As an example, earlier this spring the College of Science hosted a group of talented undergraduate students they were attempting to recruit into the graduate programs at Mason. As the coordinator of the Chemistry graduate program, I attended a meeting with these students and was asked to bring a graduate student with me. I selected G. because of her passion for science and her ability to communicate that passion. She did just that in her interactions with the students. One of the members of the COS graduate admissions office later told me that G. was the highlight of the recruitment effort. I am certain that her experience in the SUNRISE program greatly contributed to her ability to communicate effectively to this diverse audience of undergraduate students."

A fellow said that: "In particular, I've found that the most useful skill that I have developed through my work in this fellowship is the ability to distill concepts into their essence, allowing them to be expressed in a way that people without technical background in my field can understand."

One of many of the positive comments from the teachers: "My fellow has done an outstanding job developing STEM lessons that are engaging and informative for my students. One example is when we where teaching the students about sound waves. J developed a lesson that compared the sound waves of different sea creatures. She integrated technology by creating a web quest and allowing the students to hear, see, and measure the sound waves.
J's ability to support and enhance the curriculum had a great impact on my students' ability to access and enjoy both science and math this year. My students loved working with her and have developed a greater appreciation for science and the work of scientists. I really think that having J in our room has opened many of my students' eyes to the world of science and made the subject come alive."

A teacher had this to say: "My fellow has been able to gain more confidence through the STEM research. She has really grown in her ability to speak and present in front of others. This has

allowed for a better understanding of the content being presented to the students. The students are now able to really recognize her as a scientist first, then a teacher."

A teacher said this about her fellow: "The fellow has also served as an outstanding resource for students, myself and other teachers within the school. When faced with a challenging science question, teachers do not hesitate to ask her. Students also have a box where they can write down their many science-related questions to be answered by our fantastic fellow. This has sparked an interest in questioning content and an ever- continuing quest for more knowledge from our students. I would highly recommend this program for any teacher who wants her students, faculty and staff to gain a better understanding of science and how exciting it can be!"

A quote from a teacher on another note: "My fellow was engaged in lessons when present, but he had absences. He worked with the teachers as much as they would allow, but many of them weren't interested in spending as much time on science this year as other subjects. Overall, I find him to be an asset to the school."

From yet another teacher: "She was instrumental in creating informational interactive activity sheets that required higher end thinking, linking science to math, and in creating a scientific inquiry environment for our students to experiment in."

A teacher spoke about her fellow's relationship with her students saying: "Students make comments, asking and answering questions, engaged in self assessment activities, and they now think Science is cool. Many parents have made positive comments about the program. Seldom have I seen a person as dedicated to growth of themselves, their students, and school as a whole. I am proud to have worked with Mr. B., and feel very strongly that students have benefited from this experience."

3. Fellow Growth in Global Perspective

* Enhanced awareness of global perspective

Fellows	Fellow Q6			
	GX=3/8 33% S=4/8 50% N=1/8 13%			
Advisors	Advisor Q6			
	GX=3/7 43% S=2/7 29% N=2/7 29%			
Teachers	Teacher Q9			
	GX=6/8 75% S=2/8 25%			

F Q6: To what extent has your global perspective increased as result of your visits to schools and work with other fellows?

A Q6: To what extent has the global perspective of your advisee been increased during participation in the Sunrise GK-12 project?

T Q9: To what extent has your Fellow's global perspective as been strengthened as a result of teaching in your classroom and school?

Discussion:

Fellows and advisors are in the middle on this one. Teachers see a greater increase in the global perspective of fellows, perhaps indicating the fellow's successful encounter with the culturally diverse student body in the schools.

Illustrative quote from the survey on Fellow Growth in Global Perspective:

From a research advisor: "The resources provided to the students to attend conferences and purchase books and reagents for their studies has greatly strengthened my advisee's ability and desire to attend scientific meetings. Thanks to the NSF GK-12 Sunrise project, she will have attended at least 3 major meetings that otherwise would not have been possible. This is a wonderful opportunity.

I answered the "Global Awareness" question with a "somewhat" because the terms of the NSF money make it difficult for the advisee to attend international meetings held outside of the United States. In this age of global science, it is very limiting that students seem only to be able to attend US meetings."

From a teacher: "Furthermore, the fellow has also learned much about the diversity of students and how to differentiate to their needs. With students from all over the world, she has shown an interest in getting to know each and every one of them and valuing their opinions, thereby expanding her global perspective."

4. Fellow Growth in Ability to work in Interdisciplinary Teams

* Increase in fellow interdisciplinary knowledge and communication
* Increase in the ability to work in heterogeneous teams

Fellows	Fellow Q7	Fellow Q8	Fellow Q13	
	GX=3/8 33% S=4/8 50% N=1/8 13%	GX=6/8 75% S=2/8 25%	GX=4/8 50% S=4/8 50%	
Advisors	Advisor Q7	Advisor Q8	Advisor Q11	
	GX=3/7 43% S=2/7 29% N=2/7 29%	GX=5/7 71% S=1/7 14% N=1/7 14%	GX=2/7 29% S=3/7 43% N=2/7 29%	
Teachers	Teacher Q6	Teacher Q7		
	GX=5/8 63%	GX=7/8 88%		

	S=3/8 38%	N=1/8 13%		

F Q7: To what extent have you seen an increase in your ability to work in heterogeneous teams such as research groups?
F Q8: To what extent do you feel your ability to communicate with Fellows and faculty who are in different disciplines than your own been strengthened?
F Q13: To what extent do you feel your knowledge of science topics in disciplines other than yours as increased as a result of participation in the Sunrise project?

A Q7: To what extent have you seen an increase in the ability of your advisee to work in teams such as research groups?
A Q8: To what extent has the interdisciplinary communication and awareness of your advisee increased?
A Q11: To what extent do you feel your advisee's knowledge and awareness of science topics outside her or his own field has increased?

T Q6: To what extent have you noticed an increase in your Fellow's ability to work with you on planning and curriculum?
T Q7: To what extent have you seen an increase in the ability of your Fellow to work in a collegial relationship with you, other teachers and administrators?

Discussion:

All three groups see a significant ability of fellows to communicate in groups and to work in collegial relationships in diverse and interdisciplinary settings. Teachers report gains in the fellow's ability to work collaboratively on curriculum. Teacher Q7 reflects the ability of fellows to work across professional disciplines, in this case fellow-teacher. Fellows self report an increase in their knowledge of science topics in other fields, advisors do not see the same degree of increase but do see some. Somewhat surprisingly, advisors don't report a lot of gains in the ability to work in teams such as research groups as reported in Advisors Q7.

Illustrative quotes from the survey on Fellow Growth in Ability to work in Interdisciplinary Teams:

From a fellow: "I think our fellowship group dynamic is great. I would never have met the other fellows if not for this experience. Our discussions have fostered cross-discipline collaboration, such as when we created lessons over the summer during our training, and have provided us with a new appreciation for and understanding of the different sciences. I think this collaborative experience alone has been helpful and has shown us the importance of teamwork and networking."

From a teacher: "Personally, I feel this program has helped me grow as a teacher and allowed my fellow the opportunity to work with a very diverse group of students while implementing her research. I feel the students have benefited from the program since they are trying to think critically and use their creativity while performing a hands-on science lab."

From another teacher: "We have collaboratively planned instruction based on curriculum guides to make science inquiry-based and hands-on."

5. Fellow Participation in GK-12 and the Impact on Fellow Research

Fellows	Fellow Q10	Fellow Q14		
	GX=3/8 33% S=4/8 50% N=1/8 13%	GX=4/8 50% S=4/8 50%		
Advisors	Advisor Q10	Advisor Q12		
	GX=1/7 14% S=5/7 71% N=1/7 14%	GX=2/7 29% S=5/7 71%		

F Q10: To what extent have you seen an increase in your ability to manage your time more effectively?
F Q14: To what extent has your participation in Sunrise caused you to deepen your knowledge of your research topic and major area of investigation?

A Q10: To what extent have you seen an increase in the ability of your advisee to manage her time more effectively?
A Q12: To what extent do you feel your advisee has deepened knowledge in his or her own field as a result of participation in the NSF GK-12 Sunrise Project?

Discussion:

Both fellows and advisors see some increase in the fellows ability to manage time. Fellows report a deepening of their knowledge of their research topic as a result of participation as shown in Fellow Q14. Advisors are less certain of the gains in depth of knowledge of the fellow's field but recognize some gains.

Illustrative quotes from the survey on Fellow Participation in GK-12 and the Impact on Fellow Research:

From a fellow: "With regards to my research, I think the GK-12 experience has helped me focus. If for no other reason, I feel obligated to inform my class about what my research is and how things are going which helps keep me on task. But more than that, I retain my excitement for my research when I see the kids excited about it. The students are very interested in ocean science and really enjoy learning about it. I am impressed with the information they retain and love their questions and our discussions. This experience has helped sustain my motivation and interest in my research."

Another fellow said: "I also better manage my time, since I have to be at the school at certain times and days and gained a stronger responsibility for younger students."

A fellow said this of the way she has come to see her research: "The SUNRISE project has likely completely changed the way I approach my research and the way I envision my career. First, in having to explain my research to people who aren't familiar with it, I have learned invaluable lessons about what I need to know about it. For example, I considered it outside of the scope of my research to understand the exact mechanics of how the spacecraft collects the data I use, but since presenting my research at the NSF conference, I've realized that it's imperative that I understand that facet and many others of my research. In fact, the things that I think are secondary to my problem are likely the things that the layperson will connect to or find interesting!"

A research advisor said that: "The main improvement is in his ability to explain to other students technical issues he has faced in his research and thus help a beginning graduate student and an undergraduate to get started with their projects.
Another benefit is his improved ability to decide independently to investigate new directions in his research."

Another advisor was concerned about the time demands: " I think she is stretched too thin to make significant progress on her research. ... She has excelled in this program. I am concerned about her actually finishing her PhD and becoming a researcher. It would be interesting to look at each mentee and see how they each are doing with respect to 3 issues: research, this program, family."

6. Increase in GK-12 STEM Outreach Awareness and Advocacy

Fellows	Fellow Q9			
	GX=8/8 100%			
	Advisor Q9			
Advisors	GX=5/7 71% S=2/7 29%			
	Teacher Q8	Teacher Q10		
Teachers	GX=8/8 100%	GX=5/8 63% S=3/8 38%		

F Q9: To what extent have your views and appreciation of science outreach activities in the schools been strengthened?

A Q9: To what extent has your advisee's views on science outreach activities been strengthened?

T Q8: To what extent do you think your Fellow's understanding of STEM teaching in elementary or middle schools has increased?
T Q10: To what extent have you seen an increase in your Fellow's appreciation and understanding of STEM outreach in the schools?

Discussion:

Fellows see a large increase in their awareness of STEM K12 outreach, as do advisors. Teachers see that fellows have had large gains in their understanding of STEM teaching in K-12 (Teacher Q8). Teachers see significant gains of a more modest proportion in fellows' understanding of K-12 STEM outreach as shown in the responses for Teachers Q10. This might indicate disjuncture in how the university and the fellows see outreach and the ways in which the teachers view needs and opportunities in this area.

Illustrative quotes from the survey on Increase in GK-12 STEM Outreach Awareness and Advocacy:

A fellow wrote: "Teachers and teaching aides also challenge me to explain topics more clearly and tell me they are gaining from this experience as well. In particular, a teaching aide who helps the fifth grade class I am assigned to during science constantly asks me questions about the lessons which contribute to our class discussions. Her interest in science has noticeably increased over the past year. My patience towards questions has also increased upon realizing the level of understanding teachers and students have of certain topics. Communicating to various audiences is invaluable and I am more confident about doing so."

Another fellow said: "Also, the SUNRISE program has opened my eyes to the difficulties that teachers face in teaching science. Not only are they limited in time, but they are bound by standards, fearful of teaching science incorrectly, and at a loss with students who do not speak English as a primary language. Because of my experience with these struggles, it's much more likely that a part of my career as a scientist will involve helping teachers learn how to teach science, implement scientific design in their classrooms, and work with students who present additional challenges to science education."

Conclusions

Surveys to three groups were used to identify indicators of fellow professional growth. The questions on the three surveys provide triangulation of the findings. This method allowed for the self reporting by the fellows concerning their own professional growth to be seen in the context of responses by advisors and teachers. The qualitative data in open ended, and the narrative format in the last survey question provided specific examples of the effect of participation in GK-12 on fellow growth. The quantitative evidence drawn from the three groups surveyed indicate significant gains in communicating science to diverse audiences, greater confidence in public speaking, and the ability to work in teams made up of diverse team members. The results from the survey also indicate increased awareness of the cultural diversity in the schools, a deepening of knowledge about how science is taught in K12 classrooms, and gains in developing innovative hands on teaching materials and integrating these lessons into an overall curriculum. The fellows have become more aware of the importance of STEM outreach in the schools. Gains have also taken place in how the fellows conceptualize their own research, time management, and the ability to think more broadly as well as deeply about their own discipline and other STEM disciplines. The narrative comments made by advisors, fellows, and teachers on the surveys in the last question provide additional fine grained information on the positive impact on the fellows' career growth as professional scientists. We can conclude that this growth has taken

place in a large part as a direct result of participation in the GMU NSF SUNRISE GK-12 experience.

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