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Assessing the Impact of a K-12 Engagement Program on Graduate Learning Outcomes for Communicating with Diverse Audiences, Pedagogy, and Community Engagement

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Abstract

A large midwestern university has developed a program that places graduate students in middle school classrooms to enhance the graduate students' communication skills with diverse audiences, develop pedagogical knowledge, and provide a foundation for effective future K-12 engagement. After observing and co-teaching, participants develop and implement a standards- and inquiry-based lesson that brings their graduate research theme into the classroom. To provide insights into impacts on graduate students, qualitative methods were used to identify emergent themes in narratives written by graduate student participants. Major themes included new awareness of challenges in effective teaching for diverse audiences, insight into effective strategies for communicating research to teachers and students, and experiences that support future professional responsibilities. These results suggest that this type of engagement program is an effective approach to meeting several outcomes for graduate education, in addition to its value for teachers, K-12 students and college-community relationships.

Keywords

Learning Outcomes, Graduate Student, K-12 Engagement, Communication, Pedagogy

Introduction

Developing a student's ability to complete research that advances the frontiers of knowledge has long been the core of doctoral programs. However, given the wide range of career goals of doctoral students, there has been increasing awareness of the importance of enhancing opportunities for graduate students to achieve additional learning outcomes, while maintaining a strong emphasis on research excellence. Professional organizations, such as the Council of Graduate Schools, and national accrediting bodies emphasize a holistic approach to graduate education that combines excellence in research with other critical skills, including areas such as communication, ethics and engagement (Council of Graduate Schools, 2011). This approach provides the opportunity for students to acquire skills and knowledge of value in non-academic careers, for example:

> *Check any online job-hunting website for science, technical, pharmaceutical, biotech, and medical jobs, and among the hundreds of listings, you'll find one common requirement: 'excellent communication skills'.* (Barnard and St. James, 2012, preface, quoted in Grant et al., 2013)

However, such skills are also increasingly important for faculty careers in colleges and universities, and not only for faculty who have a primary emphasis on teaching. We suggest that this approach also produces a well-rounded student who is even better prepared to succeed as a faculty member in a research-oriented university; this observation is based on the experience of one of the authors of this paper who has extensive experience hiring and evaluating faculty at a leading research university, and is consistent with Feldman et al. (2011)'s finding that teaching experiences also improve graduate students' methodological research skills (see also Trautmann and Krasny, 2006).

Given the importance of helping graduate students achieve learning outcomes that are in addition to those traditionally

assessed by research products (such as publications in peer-reviewed journals and presentations at prestigious conferences), it is important to assess the outcomes of new programs that are being developed to support the development of these additional skills. For over a decade, the National Science Foundation (NSF) GK-12 program has funded fellowship projects at universities across the United States with the goal of enhancing graduate education while at the same time providing innovative support for K-12 education organizations, teachers and students. These NSF programs have focused on science, technology, engineering and mathematics (STEM) disciplines and have included a range of assessments of the impacts of the programs on participants. Summarizing much of the available research, George and Tankersley (2013) emphasized the impact of GK-12 programs on graduate students' communication, teaching and teamwork skills. They noted that teachers experienced an increase in content knowledge and skills, increased awareness of research, and elevated confidence in teaching. Students impacted by GK-12 programs, in particular those from underserved or underrepresented groups, had outcomes that included enhanced understanding and interest in content, skills, and careers. NSF funding for GK-12 projects has typically been for 3 or 5 years, and has included an expectation that recipient colleges and universities develop and implement sustainability programs to continue key elements of the projects without further NSF funding.

GK-12 Program Overview

In the project that is the focus of this paper, a large midwestern university transitioned from an NSF-funded GK-12 project to a broader, locally sustained GK-12 program that places graduate students from STEM as well as any other discipline in middle school classrooms one day a week. The stated goals of the program are to enhance the graduate students' communication skills with diverse audiences, to develop pedagogical knowledge, and to provide a foundation for effective future K-12 engagement as professionals. This is a voluntary program that

can be taken for graduate credit, and is offered in conjunction with separate Preparing Future Faculty and Preparing Future Professionals programs offered by the graduate school to PhD and Post-Doctoral students. After observing and co-teaching in the middle school classroom, participants develop and implement a standards- and inquiry-based lesson that brings their graduate research theme in to the middle school classroom. The program includes an initial training session focused on pedagogy, communication, and the realities of middle school classrooms, as well as a series of group sessions for the graduate students focused on inquiry-based learning, state education standards, developing a lesson plan, grant writing, and career issues.

The locally sustained GK-12 program replicates many of the elements of the NSF-funded GK-12 program that is was based on, but has some important differences. The NSF-funded version provided graduate participants with full NSF fellowships ($30,000 per year fellowship payment, plus tuition and other benefits) that allowed them to focus a significant amount of time on both their research and the educational activities connected to the program. The NSF-funded project also provided generous resources for classroom materials, teacher support, and staff to administer and assess the program. Graduate students spent at least one year in the program and typically attended several weeks of summer training and were in middle school classrooms about two days per week during the academic year. The NSF-funded program was also restricted to domestic students in STEM graduate programs. In contrast, using very modest resources, the locally sustained program provides no funding for the graduate student participants, places participants in schools for one semester, and is supported by a single graduate fellowship to fund staff support combined with campus service-learning grants to provide classroom supplies. In fact there is no additional cost to the university to have this program because the single graduate fellowship and the service learning grants are part of existing programs – they have just been redirected to support this particular use. The locally sustained program is also open to international as well as domestic students (Figure 1),

Figure 1: Participants in the GK-12 program include domestic majority and traditionally underrepresented minority students, international students, and came from a wide spectrum of liberal arts, science, engineering, technology, agriculture and professional graduate programs.

and to students in all of the university's graduate programs. Given the low cost of the program and its potential benefit to graduate students as well as local K-12 schools and teachers, other universities have expressed strong interest in adopting or adapting the program, and thus it is important to assess the impact that it is having on diverse graduate participants.

Purpose of the Research

The purpose of this qualitative study is to explore the experience of graduate and post-doctoral students in a locally sustained GK-12 program at a large midwestern university, relative to the goals of the program, including communication to diverse audiences, pedagogy, and community engagement. Thus, our main research objectives are to investigate: a) what the participants perceive are the main experiences and impacts of the program on them, and b) participants' perceptions of the ways in which the program may be of use to them in their current and future careers.

Methods

Framework
Because the research question is seeking to understand the lived experience of the graduate students in this program, the theoretical framework that underlies our research is phenomenology. Phenomenology can incorporate a myriad of meanings, according to Patton (2002), and at its core it is useful to understand how people and groups make sense of their experiences. This study seeks to examine how the lived experience of the students in the GK-12 program, as revealed by their written narratives, matches the programs' intended learning outcomes.

Participants and Data Sources
The participants in this study were 19 graduate and post–doctoral students who voluntarily joined the GK-12 program for

a period of one semester. The GK-12 program was open to PhD and post-doctoral students from any area of study, and information on the availability and goals of the program was disseminated widely by email (via department heads or graduate program contacts). In addition, targeted GK-12 recruitment presentations were made as part of "Preparing Future Faculty" and "Preparing Future Professionals" courses offered by the graduate school. Given that only ~0.1% of the university's graduate students participate in the program each semester, there is strong self-selection in the participants in the GK-12 program.

Participants in this study were from several semesters of the program, and included STEM and non-STEM students, men and women, and international and domestic students (Table 1). Participants were required to complete initial written assignments to apply to join the program, as well as weekly responses to writing prompts (Table 2). These prompts were designed to help the participants process their experiences, make observations about the classroom teacher and students, and to develop their ideas for a lesson they would design and implement in the classroom. These written responses also allowed the staff to provide guidance or intervention, if necessary, and to tailor training sessions to the issues emerging in the participants' narratives. The participants' written materials are the data used in this study, including 76 Observer journals and 18 End of Program journal responses.

Data Analysis
Data analysis was addressed as an inductive process using open coding with both authors participating. Each author read the participant narratives and identified a theme or several themes in every sentence or group of sentences. Preliminary coding of the data was conducted separately then all emergent themes were brought together for discussion, revision, and consolidation into main codes. All themes were discussed between the two authors until complete agreement was achieved. These codes were grouped by their similarities, then assertions and sub-

Table 1: Characteristics of the Participants in this study

	SEMESTER 1	SEMESTER 2	SEMESTER 3	TOTAL
GENDER				
Female	3	5	4	12
Male	2	1	4	7
DEGREE				
Master's	0	1	2	3
Doctorate	4	5	6	15
Post Doc	1	0	0	1
COLLEGE				
Agriculture	1	0	1	2
Engineering	2	1	3	6
Liberal Arts	0	1	2	3
Pharmacy	0	0	1	1
Science	2	3	1	6
Veterinary Medicine	0	1	0	1

Table 2: GK-12 Program Stages and Writing Prompts

Program Stage	Example Writing Prompts
Observer	What did you learn about being a teacher this week?
	Reflect on the style of interaction the teacher has with the students.
	What have you learned from the teacher about how to structure lessons effectively?
Co-teacher	How did co-teaching this week change your ideas about what it takes to be an effective teacher?
	Reflect on the style of interaction you have with the students.
	How has co-teaching changed you thinking about how you will bring your research into your teacher's curriculum?
Teacher	Briefly describe how your lesson went and how it was received by the students and your teacher.
	If you teach your lesson again, how will you modify it to make it even more effective?

	How did teaching this week change your ideas about what it takes to be an effective teacher?
End of Program	Given this experience, what advice would you give a fellow graduate student who has agreed to develop and teach a lesson for a middle school classroom?
	How has this program supported you as a potential future faculty member?
	What has this experience taught you about communicating about your field to non-experts?

assertions were created to describe that particular group. There were no pre-decided themes; rather, the themes emerged from the participant narratives and were then consolidated to provide insight into the major points that participants stressed in their thoughts as expressed in their written work. Descriptive quotes for each assertion and sub assertion were chosen to illustrate the themes found.

Results and Discussion

From the analysis of the journal entries of the graduate students four assertions emerged, three of which have sub-assertions.

Assertion 1: GK-12 participants gain important skills and experiences related to their future careers.

In this study, it was found that the majority of participants wrote in their journals about how this experience assisted in confirming their future career plans, as well as providing training in skills that would be useful for those careers. Participants included graduate students who intended to pursue an academic career as well as graduate students intending to pursue a career in business, industry, or research laboratories. Numerous participants discussed how this experience increased their communication skills with diverse audiences, and helped them to evaluate and support their career plans, and many noted that it assisted them in learning about major elements of future faculty responsibilities.

Sub-Assertion: GK-12 participants have increased communications skills with diverse audiences.

Diversity can be defined as "a mosaic of people who bring a variety of ethnic and cultural backgrounds, styles, perspectives, values, and beliefs as assets to the groups and organizations with which they interact" (Guion & Diehl, 2010). Our data reveals that participants in the GK-12 program frequently discuss how this program has given them the opportunity to strengthen their communication skills to those outside their fields, and that they now understand what is necessary to share very specific/detailed research with all types of audiences. One participant wrote:

> "*I think I learned how to explain for others, not for myself, and that's the most critical.*"

Other participants noted how this opportunity made them more able to discuss their research with diverse audiences, stating:

> "*The exercise of communicating my research to non-experts greatly improved my teaching abilities, and made me much more comfortable with discussing my research.*"

Many participants also discussed the importance of understanding the needs of the audiences and to adjust their teaching to meet those needs. One participant wrote about how this experience has helped her obtain a different view of her research because of needing to break down her research to be understood by middle school students.

> "*In designing my lesson, I really had to break my research down to the basics. Since I had never done this, it was good to acquire this skill. Additionally, it gave me a broader view of my research, which will greatly help me as I come up with ideas to implement as a professor and begin my own research program.*"

Almost all participants noted in their journals that they modified their lessons to meet the needs of the students, including knowledge, background, and activity level. Journal entries included quotes such as:

> "*It is absolutely essential to know your audience and have a clear idea about what the students already know*"

and,

> *"Make sure to bring it down to the middle school level and relate it to things that they already know about, but don't dumb it down too much that you insult their intelligence…They will not know as deep or wide as you do, so design a lesson at a level they can easily understand and remember."*

Overall, participants found that this program has increased their comfort and ability to teach and discuss their research with all types of audiences.

Sub-Assertion: **The GK-12 experience helps participants evaluate and support their career plans.**
In their journals, many participants discussed the role that the GK-12 program played in confirming their future careers, especially supporting their desire to continue teaching. One participant wrote:

> *"I think that this program has further confirmed that I want to be a faculty member in the future."*

Other participants believe that this program has given them the opportunity to teach others, an experience that they have been lacking during the course of their graduate studies:

> *"I really did not have any teaching experience before this program. In my CV, it is an obvious drawback. I have indeed built a strong experience and concept of teaching. I will definitely apply what I have learned from this program to my future career as faculty member."*

GK-12 participants have found that this experience aids them in evaluating what they want in their future careers (including level and relative emphasis on teaching for those intending to become faculty), as well as providing them with the necessary skills to support those plans.

Sub-Assertion: **The GK-12 program provides experiences that support major elements of future faculty responsibilities.**
Participants in this program also frequently wrote in their journals about learning effective teaching styles and strategies while in the middle school classroom. Many noted that they found observing their paired teacher as an important step to understanding their own teaching style in a middle school

classroom and for their future teaching roles and careers. One participant wrote that he found the observation phase of this program as the most important influence on his own teaching, stating:

> *"Observing a veteran teacher and paying close attention to her teaching style helped me develop my own ideas about what to do and what not to do in a classroom. This was an excellent opportunity to really think about what kind of teacher I want to be as a professor."*

Another participant, who had little teaching experience prior to this program, wrote that she now felt more comfortable teaching as she had learned different ways to teach many audiences:

> *"I now feel more confident in my ability to address a diverse classroom and prepare a lesson that will involve and excite the students…It has given me insights into the challenges faced by teachers at the middle school level and teaching strategies to incorporate into my future classroom."*

Another major element of future faculty responsibility that is offered as part of the GK-12 program is engagement. Participants discussed their experience with engagement, and how this exposure has changed their future role as faculty. A participant wrote of her experience, stating:

> *"I also think that have a little bit of experience with engagement will help me as a professor, since this is one of the three key areas of scholarship. After going through this program, I have a greater passion for K-12 outreach, and I plan to continue in this area as a professor."*

Another participant echoes this sentiment in his journal, writing:

> *"I think that it made me realized that when I do become a faculty member it will be important to continue outreach in the community so that future generations of scientists and engineers can be inspired and continue thinking that science is interesting and fun."*

Overall, this sustainable GK-12 program provides opportunities for participants to gain important skills that they will later use to meet the requirements of faculty.

<u>Assertion 2:</u> The GK-12 program helps participants realize the importance of teacher interactions with students.

Analysis of the data found that all participants discussed in their journals about the different ways and methods that the middle school teachers interacted with their students, and how this relationship evolved to include the participants themselves. This relationship was slow to start for many participants, especially due to the relatively small amount of time spent with each class per week. One participant wrote about her experience with the students, and how she transitioned from feeling like an out of place outcast to an essential part of the classroom:

> "*The students seem to be warming up to me now, calling me if they need help, and joking with me. It is nice not to just sit in the back of the room, but to feel needed.*"

Many participants noted that one-on-one teacher interactions with students appeared to benefit the students more, but that with numerous classes per day and more than 20 students per class, it was difficult for the teacher to provide that type of attention and consideration to all. All of the participants wrote of their experience as the second instructor in the classroom, and their feeling of usefulness when providing much needed individual attention to students in need. One participant wrote:

> "*one of the most surprising students was the one who was sent out 2 weeks ago because of his bad behavior, and I helped him. When we started, he had nothing done, empty paper. I explained the basic concept and he caught up very quickly. We did several questions together, and he finished the rest by himself. Guess what? He got 20 out of 20 correct. He was happy, I was happy, and [the teacher] was happy.*"

An important part of this program is to have participants focus on how their paired teacher interacts with the students as a way to allow the participant's own teaching style and interactions to emerge before they taught in the classroom. The importance of this interaction between the teacher and students was discussed numerous times in participant journals, noting that the key to becoming a better teacher is to understand this interaction. One participant noted:

> *"I believe that graduate students who are interested in participating in this program should stay in close communication with their classroom teacher – because they can gain a great deal of knowledge about teaching pedagogies from them that can be used at the university level."*

This program aids participants in recognizing the importance of these interactions between teachers and students and to use these experiences in their future relationships with students.

Assertion 3: The GK-12 program helps participants identify the elements of an effective lesson.
This research determined that all participants in the GK-12 program identified what they believe constitutes an effective lesson, especially due to observing their paired teacher, becoming a co-teacher with them, and after conducting their own lesson. These experiences helped participants recognize what is needed to create and teach a lesson that meets classroom curriculum and is welcomed by the students.

Sub-Assertion: GK-12 participants display an understanding of how to organize and structure a lesson that fits the needs of the students, classroom, and school curriculum.
To structure a good lesson, GK-12 participants found it important to be organized and prepared to teach, which allowed them not only the ability for the lesson to go smoothly, but also to maximize the amount of time the students spent with the material. Many participants wrote of instances while observing or co-teaching where an experiment or lesson did not go as planned, and how they found it valuable in their own lesson planning:

> *"I have learned the importance of having everything ready ahead of time so that it does not disrupt class and that there is enough time to complete the project. Our experiments could not be discussed because [the teacher] was running around at the beginning looking for lost materials. I will ensure that when I teach the students I will be as ready as I can be, so that we aren't scrambling to be ready and the students can enjoy the lesson."*

Other participants worked with the middle school teachers to understand how to be prepared to teach, which was especially important for one participant that had no prior teaching experience. She wrote that she:

> *"learned that being a teacher requires advance planning and coordination. [The teacher] and I communicated by email to organize the class time we had available and figure out how we were going to structure each class."*

With the pressure on schools now to meet high standards of teaching, many GK-12 participants wrote about their need to fit their lesson to the current school curriculum rather than interrupt the flow of knowledge. Many participants, at first, are apprehensive about applying their research to a specific curriculum, writing in their journals about their discomfort in not knowing what to focus on:

> *"At this point, I am not sure where my research will fit into the curriculum."*

All participants indicated in their writings that they worked diligently to incorporate state standards into their lesson plan and complement the teacher's curriculum. One participant wrote:

> *"I will then try to have the students analyze the energy use and operational cost of the different equipment options with a focus on using percents and ratios, which is the scheduled curriculum."*

Often GK-12 participants recognized the teacher's need to stress state standards in each lesson that they made their own lessons meet more standards for future use. One participant wrote of his experience to make his lesson good enough to be used the following year, rather than just a onetime event. He wrote:

> *"I am planning to incorporate a lot of the standards for 8th grade so that my lesson will be as beneficial as possible, even if it doesn't perfectly fit in with the unit covered at this time."*

GK-12 participants recognize that meeting the needs of the teacher and the classroom by being a part of the school curriculum is an important part of creating a lesson.

Sub-Assertion: *The GK-12 program helps participants identify key elements for teaching an effective lesson.*

Analysis of GK-12 participant narratives found numerous references to the key elements of an effective lesson, including engaging students, real world application, and keeping things simple for student comprehension. Many participants noted the different tactics that classroom teachers employ to engage the students with the topic and to keep their attention through the class. One participant noted his teacher's relaxed method to keep the students focused, stating:

> *"I really feel like the teacher knows how to engage the students and keep them interested, even if it involved getting a little bit off task sometimes."*

Observing this interaction allowed the participants to understand what is needed to create and sustain an effective lesson, and to keep the students interested in the topic. Another participant found that watching her teacher gave her tips for how to keep the students engaged throughout the lesson:

> *"I learned that it is essential to keep the students involved for the duration of the lesson. If they know they might have to put their answer on the board or answer a question, they seem to be more likely to stay on task."*

The same participant noted that she would employ some of the same tactics when it was her time to teach the students.

Real world application was also identified as a key element for an effective lesson, with an emphasis on connecting the lesson objectives to actual situations outside the classroom. Because many of the participants work on very detailed, in depth research, some found it important to connect their lessons to real world situations for student understanding. One participant wrote that she felt it was important to connect her research to the real world to allow the students to see what it is like to be a scientist and how science can help other people. She wrote:

> *"I believe this project will be useful for the students because they will have some practical laboratory experiences and get some ideas what is scientific research."*

Another participant wrote:

"I have a new approach to talking about my research, focusing on its motivation and implications instead of trying to describe exactly what it is that I do."

Finally, participants also identified keeping the lesson simple and not trying to teach their exact research as an essential part of a successful lesson. Working with the teacher allowed for some students to get an idea of how their research would be understood in the classroom, and many wrote of their surprise at how little most people understand their work. One participant wrote that, after discussing her research with the classroom teacher,

"I came to understand that I need to simplify a lot and not provide any detail. I found out that providing a big picture is enough to let others understand why my research area is important and why I am doing this…I have to prepare for the audience, simplify complicated concepts, and try to avoid jargons."

Many other participants noted a similar experience, and recognizing that it is important to simplify for students to understand the basic concepts and to expand from there. Identifying these key elements for teaching an effective lesson allowed the participants to improve their lessons and better teach their research to the students, as well as help them understand what is needed for future lesson planning and creation.

<u>Assertion 4:</u> The GK–12 experience helps participants understand the realities of teaching in a middle school.

Data analysis revealed that GK-12 participants identified this program as helping them to understand what really occurs in the middle school classroom, and how teachers and students behave outside of college academia. Two themes emerged that demonstrated that this program helped participants understand the needs of middle school classrooms: the true conceptions of how middle schools are run and react, and what it takes to be an effective teacher in such an environment.

Sub-Assertion: *The GK-12 program helps participants develop a conception of the realities of how students, classrooms, and schools are organized and behave.*

Most GK-12 participants wrote in their journals regarding how mistaken they were at their perceptions of what occurs in a middle school classroom prior to entering the program. Many were surprised by the differences, and often discussed their observations in their narratives:

> *"I didn't realize that middle school students asked so many questions. As a TA [teacher's assistant] at [the university], I felt like trying to get undergraduates to answer questions, let alone ask them, was like pulling teeth. It was very refreshing to encounter the high level of curiosity in the middle school students."*

Another issue that GK-12 participants found different from their previous conceptions were what the teachers and students worried about when in school, and how they differed. One participant wrote that he was amazed at how much the teachers stress over state standards testing, stating:

> *"I learned that middles schools are very concerned about the [state] test. The students, on the other hand, don't care about the test or what their results mean – they goof off, don't spell correctly, and finish as soon as possible so that they can talk to each other."*

Another participant wrote that she:

> *"found that being a teacher in a middle school is less about what you want the students to know or want to share with them, and more about the tests. Tests, tests, tests."*

The conditions of the school are also another misconception on the part of the participants. They see the lack of supplies, the old or used materials, and the need for updated items and are amazed the difference between university and public teaching. One participant, prior to writing a grant for lesson materials, wrote:

> *"This week I was shocked to see the poor quality of supplies in the science classroom."*

They also noticed the amount of work that their classroom teacher invested in their students' education. GK-12 participants

wrote numerous entries were they were amazed at what the teachers really contributed to the classroom, and what they had to go through to successfully teach the students. One participant noted:

> *"I now have a much greater appreciation for middle school teachers – it is way harder than I thought!"*

This program helps the participants recognize their misconceptions about what the realities of teaching and learning at the middle school level, and works to show them how these schools really work.

Sub-Assertion: *The GK-12 experience helps participants understand what it takes to be an effective teacher.*

GK-12 participants observed their classroom teachers and, throughout the 10 week program, came to identify what is required to be an effective teacher in any classroom, including task/time management, patience, sensing the needs of the students, flexibility, and classroom management. The participants learned what it takes to be a good teacher, as well as seeing firsthand what teachers endure everyday to be successful in their role. Many participants noted that teachers always seem very busy, and how they learned how to better balance their time and responsibilities while in that role for a short time. One entry discussed the many things that teachers do beyond just teaching, stating:

> *"I learned that being a teacher requires juggling a lot of different tasks from classroom management to being creative while developing lesson plans to grading and doing bookwork."*

Another participant wrote:

> *"teachers are often overworked and underpaid for the services that they provide to young people throughout the year. While sitting in the classroom, and at their team meetings, I remembered how much work was put into one lesson for the day, and how much time they have to be dedicated grading, lecturing, and teaching simultaneously."*

This program shows participants what teachers really do during the school day, and how to manage all their duties in addition to their classes.

Another emergent theme for effective teaching was for teachers to have patience. All the participants noted situations where their classroom teacher showed patience with students, other teachers, and with them. A participant wrote about one of her observations, stating:

> *"This week showed the great patience required to be a teacher. At one point, while students were checking their homework solutions, three students asked the same question one after another. Instead of reprimanding the students, [the teacher] recognized that they were focused on studying their answers and had missed her comments. Her patience encourages them to continue asking questions."*

In this situation, the participant wrote of how annoying it was to answer the same questions over and over, yet commended the teacher for her patience in recognizing what the real problem was with the students. This is also an example of how teachers sense the needs of their students to effectively teach their lesson. Other participants wrote of situations where the classroom teacher changed their plans because of the students, not because of behavior but to better teach a particular concept:

> *"Susie started to cover surface areas of three-dimensional objects. However, after one class period she realized that the students did not have a strong enough understanding of volume, and that she needed to spend more time on those calculations before moving on to surface area. She copied new worksheets between classes and adjusted her lesson plan on the fly to meet the needs of the students."*

Numerous participants found similar situations, noting how effective teachers do not just follow a curriculum, but alter their lessons to ensure that their students understand the materials. This situation also shows that effective teachers are very flexible, working around challenges and opportunities that arise during the day. One participant noted that:

> *"the teacher should be flexible and be able to adjust the lecture and other class activities to the unexpected changes in the schedule"*

and another found that good teachers:

> *"have to be flexible with their plans – all of my classes didn't do well on a test they took last week, so instead of moving on to the next topic, [the teacher] has been reviewing concepts with them so that they can re-take the test and hopefully improve their scores."*

All GK-12 participants wrote of their teacher's flexibility, especially with the addition of the participant's lesson into the curriculum, and that the students responded very well when the teacher adjusted to meet their needs.

Finally, participants noted that effective teachers need to have good classroom management, and how it does not always need to be very strict or relaxed, but that each teacher has their own devices to keep control over their classes. One participant observed that:

> *"being a teacher is acquiring the knowledge about each and every student in the group. The teacher seems to be aware of the moves of each student individually and was keeping her eye on the students who are likely to do something inappropriate. This understanding may help the teacher to gain the control over the group as well as to think about the teaching methods for each student."*

This statement shows that effective teachers are those that have found the best way for them to remain in charge of the students but to also understand the best way to teach them. Overall, the GK-12 program helps participants to see what elements create and sustain an effective teacher, and how they can use these attributes to be better teachers themselves.

Implications

This sustainable GK-12 program was found to provide participating graduate students with outcomes that included enhanced communication skills, increased understanding of effective lesson planning and what it takes to be an effective teacher, and also led them to reflect on their career goals and plans. The results show that the graduate students in this program gained important skills for communicating with diverse

audiences, as well as increased confidence in explaining their research to individuals both in and out of their field.

Many evaluations of the NSF-funded GK-12 program have noted graduate students' improved ability to communicate with others (Busch & Tanner, 2006; Gamse et al., 2010; McBride et al., 2011; Page et al., 2011). These results presented here suggest that a sustainable version of the GK-12 program can also attain this outcome despite the change to becoming a low-cost, volunteer program, and with an expansion in scope to include non-STEM and international graduate students who were not eligible for the NSF-funded program. After the 10-week program, participants shared about their newfound ability to identify essential elements of effective lessons, and their increased understanding of how to organize and structure material to meet the needs of their audience. Improved teaching skills have been at the core of NSF-funded GK-12 program outcomes (Busch & Tanner, 2006; Ferreira, 2007; Trautmann & Krasny, 2006), and this analysis demonstrates that graduate students are also more aware of how to teach based on student learning styles and classroom needs. Graduate students are also gaining insight into the realities of teaching, including the challenges of teaching in a middle school classroom.

Previous evaluations of NSF-funded GK-12 programs have also found that participants achieved greater awareness of what it takes to be an effective teacher (Busch & Tanner, 2006; Trautmann & Krasny, 2006), and the research presented here builds on this to show that a sustainable GK-12 program also provides this outcome. Although teaching in a middle school is not identical to university teaching, this paper presents strong evidence that there are connections and similarities between university and middle school teaching. Thus the middle school setting is a valuable learning environment for graduate students whose future teaching will most likely be at the university level.

These findings demonstrate that a low-cost, sustainable, GK-12 program open to all graduate students is beneficial in meeting important outcomes in graduate education. However, more in-

depth evaluation is needed to determine if this program is meeting its full potential. Significant changes from the NSF-funded GK-12 program that it was based on were made to make this program sustainable, including the inclusion of international and non-STEM participants. Differences between groups (domestic/international and STEM/non-STEM) were not specifically investigated in this study, and more research is needed to ensure that the specific needs of these groups are also being met. At the university where this program is being implemented, approximately 0.1% of graduate students participate in the GK-12 program each semester. Given the desirable outcomes of the program, future work is needed to examine why students self-select to participate or not in the program, the barriers that prevent students from participating who would like to take part but don't, and to assess the challenges and limitations of increasing the scale of such a program.

Conclusions

Participant narratives from a program that places graduate students in middle school classrooms show that the participants develop important skills and understandings that contribute to common goals in graduate education, including enhancing graduate students' communication skills with diverse audiences, developing pedagogical knowledge, and engagement outside academia. This particular program is moderately intensive, as it involves graduate students committing approximately one day a week over a ten week period to learn about the realities of middle school and effective pedagogy, observe teaching in a classroom, co-teach with an experienced teacher, and develop and implement a standards- and inquiry-based lesson that brings their graduate research theme into the classroom.

Beyond confirming that major learning outcomes previously observed in NSF GK-12 programs were achieved in a more inclusive, sustainable version, the themes that emerged from the graduate student participant narratives included awareness of

challenges in effective teaching for diverse audiences, insight into effective strategies for communicating research to teachers and students, and experiences that support future professional responsibilities. We suggest that this evidence, combined with prior research on the effectiveness of NSF GK-12 programs (George and Tankersley, 2013) demonstrates that such engagement is an effective component of graduate education, in addition to its value for teachers, K-12 students and college-community relationships. We thus encourage other universities to consider adapting this model to their contexts, and note that in 2014 a pilot version of a program called "Doktorander I Skolan" was launched at Stockholm University, Sweden, based on the GK-12 model described in this paper. This pilot program demonstrated that the GK-12 model can also be adapted to international contexts.

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