A Longitudinal Study of the Effectiveness of a K-12 Engagement Program on Graduate Student Learning Outcomes

Faith Weeks[1], Ruiyang Gong[2] & Jon Harbor[3]

[1] Department of Biological Sciences, Towson University, Towson, Maryland, USA

[2] Department of Mathematics, Purdue University, West Lafayette, Indiana, USA

[3] Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, West Lafayette, Indiana, USA

Correspondence: Jon Harbor, Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, West Lafayette, Indiana 47907-1397 USA. E-mail: jharbor@purdue.edu

Received: June 27, 2015 Accepted: July 13, 2015 Online Published: August 17, 2015

doi:10.5430/ijhe.v4n3p188 URL: http://dx.doi.org/10.5430/ijhe.v4n3p188

Abstract

Programs that connect higher and K-12 education provide benefits to K-12 students, teachers, and higher education. The National Science Foundation (NSF) invested in programs connecting domestic STEM graduate students with K-12 education for over a decade (GK-12), intending that such engagement would help achieve graduate student learning outcomes and would be sustained after NSF funding. By comparing two cohorts of graduate and post-doctoral student participants in a sustained GK-12 we have begun longitudinal assessment of a program as it matures and diversifies by integrating non-STEM and international students. Qualitative analysis of participant journals shows that the sustained GK-12 has continuing impacts on graduate students' teaching, teamwork, and communication skills, and aids in shaping their future career plans. A new theme that emerged in the later cohort related to participants' changing perspectives on pedagogy and teaching as a part of faculty responsibilities. We encourage universities seeking to meet expanded graduate student learning outcomes to consider adopting/adapting the GK-12 model.

Keywords: Graduate student, Learning outcomes, K-12 engagement

1. Introduction and Literature Review

The core of most graduate programs, especially at the PhD level, is the development of an advanced level of scholarship, research, or artistic achievement that expands the frontiers of knowledge. In addition, given the range of career goals of graduate students, there has been increasing emphasis on the need to include additional learning outcomes. National accrediting bodies and professional organizations, such as the Council of Graduate Schools, promote a holistic approach to graduate education combining excellence in scholarship with other skills, such as communication, ethics, and engagement. This provides students with additional skills and knowledge of value in non-academic careers as well as for faculty and staff careers in colleges and universities. These experiences can also improve students' abilities to communicate their research and their methodological research skills (Trautmann & Krasny, 2006; Feldon et al., 2011; Weeks & Harbor, 2014). For example, the California College of the Arts lists 13 graduate outcomes, including written and verbal communication, understanding of cultural diversity, collaboration, ethics and interdisciplinarity (California College of the Arts, 2014), while the Graduate School at Cornell University includes in its learning proficiencies that graduate students should "effectively engage in one's broader community through various forms of outreach" and should be able to "understand and articulate the impact of research on society" (Cornell University Graduate School, 2014).

Considering the importance of meeting graduate student learning outcomes it is important to assess programs aimed at achieving one or more of these outcomes. For over a decade the National Science Foundation (NSF) funded graduate fellowship projects at over 140 US universities under a program called GK-12 (Graduate STEM Fellows in K-12 Education), which aimed to enhance graduate education for students in science, technology, engineering, and mathematics (STEM) fields while also providing curricular support for K-12 schools, teachers, and students (Stoll & Ortega, 2013). A range of assessments was conducted to determine the impact of GK-12 programs on graduate student learning outcomes, and these generally showed that the GK-12 experience had a very positive impact on communication skills, career and professional development, and teaching skills (Laursen, Thiry, & Liston, 2012;

Page, Wilhelm, & Regens, 2011).

One of the main goals of the NSF GK-12 program was "t*o improve future scientists' communication skills through engaging K-12 students in STEM activities*" (Hillman, Bloodsworth, Tilburg, Zeeman & List, 2014). Brownell, Price, and Steinman (2013) emphasized the importance of science communication, and went so far as to suggest that formal training in effective communication methods with non-scientists should be mandatory for undergraduate and graduate student education. The NSF GK-12 program aimed to improve this skill in its program, and several studies documented significant improvements in GK-12 graduate fellows' communication skills in a range of situations (Cormas & Barufaldi, 2011; George & Tankersley, 2013; Mitchell et al., 2003; Page et al., 2011). The GK-12 program also had impacts on fellows' careers, including confirming their chosen career paths, learning how to multitask effectively, and helping them secure their first academic appointment (Laursen et al., 2012; Ufnar, Kuner, & Shepherd, 2012).

One of the major additional impacts of the GK-12 program was in improving fellows' teaching skills. Hurst (2010) analyzed factors that influence the development of graduate student teaching skills, with the first factor being that of professional development or training provided by the graduate program. Previous research has found that teaching experiences during graduate study have a positive impact on students' confidence in teaching when pursuing academic positions (Thoron, Myers, Harder, Stedman & Roberts, 2012), but that unless these graduate students are provided with pedagogical instruction and the opportunity to practice their teaching, new teachers often just replicate the teaching models that they witnessed when a student (Hill, 2014). A study by Nyquist and colleagues (1999) found that graduate students reported a desire for more professional development as teachers, which suggests that programs such as the GK-12 program are essential in meeting this goal. This experience also produces a well-rounded graduate student, because teaching experiences have been found to improve students' methodological research skills (Feldon et al., 2011). These benefits demonstrate the impact of the NSF GK-12 program on graduate fellows and its ability to meet graduate learning outcomes.

GK-12 projects received NSF funding for 3 or 5 years, and this funding included an expectation that the recipient universities would, at the end of their program, create and implement a sustainable version of the program to continue meeting graduate student learning outcomes without additional funding from NSF. Although the research base has effectively assessed the impacts of NSF funded GK-12 programs, little work has been published on the effectiveness of the few GK-12 programs that have been sustained at US universities after the NSF grants ended (Weeks & Harbor, 2014). These programs differ from the NSF-funded programs in that they do not have the large external funding base supplied by the NSF grant, and are not constrained to the NSF requirement that the program be restricted to US citizens in STEM fields. Thus they can involve international students as well as domestic students, and the full range of fields that are included at the institutions.

The purpose of the qualitative research reported here is to address the gap in research on impacts of sustained GK-12 programs by providing a longitudinal comparison of the experience of graduate and post-doctoral students in a locally sustained GK-12 program at a large Midwestern university. We sought to assess whether the experiences of participants in the initial two years of the sustained program (Cohort 1; Weeks & Harbor (2014)) were maintained or changed as the program matured over the course of the following three years (Cohort 2) and with increasing involvement of international students and students from different disciplinary backgrounds. The experiences we examined focus on the goals of the original GK-12 program, including community engagement, understanding of pedagogy, and communicating with diverse audiences (Weeks & Harbor, 2014). Thus our main objective was to investigate if participant experiences and perceptions of the main impacts of the program continue to meet key graduate student learning outcomes as the program matures and diversifies.

In brief, the locally sustained GK-12 program at a large Midwestern university has goals to enhance graduate students' pedagogical knowledge, enhance their communication skills with diverse audiences, and to provide a foundation for students' future K-12 engagement activities. This is a voluntary program that can be taken for graduate credit, and is open to graduate and Post-Doctoral students. The program starts with a training session focused on communication, pedagogy, and the realities of K-12 classrooms, and also includes a series of group sessions focused on inquiry-based learning, developing a lesson plan, grant writing, state education standards, and career issues. After observing and co-teaching in a middle school classroom, participants develop then implement an inquiry-based lesson to bring their graduate research topic in to the classroom they have worked with. Additional details are provided in Weeks and Harbor (2014).

2. Methods

2.1 Framework

The theoretical framework that guided our research is phenomenology, which seeks to understand the lived and shared experiences of the graduate and post-doctoral students in this locally sustained GK-12 program. Phenomenology attempts to identify what the participants experience by being in the program, as well as how they experienced it, which can inform how individuals and groups make sense of these events (Patton, 2002). By examining students' written narratives, this study seeks to examine how the lived and shared experiences of participants in this GK-12 program match the program's intended learning outcomes, and compares these experiences to those from a similar analysis of the program in the first two years of the sustained model.

2.2 Participants and Data Sources

Participants in this study were graduate and post-doctoral students who volunteered to be a part of the GK-12 program for one semester, either in the Fall or Spring semesters, over the course of three years. These participants included men and women, international and domestic students, and specializations in both STEM and non-STEM fields (Table 1). Over time the program has attracted students from a wider range of disciplinary backgrounds (for example the addition of students from the colleges of Education and Health and Human Sciences in Cohort 2) and increasing numbers of international students (Cohort 1 is 63% domestic and Cohort 2 is 44% domestic; Table 1). To join the program, participants submit a written statement about their background and interest in teaching, and then completed weekly journal responses over the 10 weeks of the program. Writing prompts were created to help participants reflect on their experience, make observations about the students and teachers in the classroom, and to guide the development of the participants' lesson plans, including design and implementation (Table 2). These journal entries also allowed the staff to provide essential feedback and guidance, and to tailor training meetings to the needs of the participants. Data sources for this study are the written narratives provided by the participants in the journal entries that were a required component of the program, and the study complies with the human subjects research requirements of the home university.

Table 1. Characteristics of the Participants in this Study, Compared by Cohort

	Cohort 1	Cohort 2
SEX		
Female	12	12
Male	7	15
ORIGIN		
National	12	12
International	7	15
DEGREE		
Master's	3	7
Doctorate	15	17
Post Doctorate	1	3
COLLEGE		
Agriculture	2	5
Education	0	4
Engineering	6	7
Health and Human Sciences	0	2
Liberal Arts	3	2
Pharmacy	1	0
Science	6	5
Technology	0	2
Vet Medicine	1	0

Table 2. GK-12 Program Stages and Writing Prompts for Participant Journals

Stage of the program	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?

2.3 Data Analysis

Analysis of the data was an inductive process using open coding as well as the coding scheme from the data analysis of Cohort 1 (Weeks & Harbor, 2014). Any new themes were added to the coding scheme and applied to all the documents for comparison. Authors read the participant narratives separately and identified common themes between Cohort 1 and Cohort 2 in each sentence or grouping of sentences. While there were no pre-decided themes for the analysis of Cohort 2 narratives, comparisons were made between the themes of the two participant groups to determine differences amongst them. Any emerging themes from Cohort 2 were discussed, revised, and consolidated into assertions and sub assertions, then compared to the assertions and sub assertions of Cohort 1 for similarities. If Cohort 2 data results were found to overlap with those of Cohort 1, the wording and structure of the assertions and sub assertions of the previous work were repeated for ease of comparison. To illustrate the major themes found in this cohort, descriptive quotes from cohort 2 participant narratives were selected for each assertion and sub assertion.

3. Results and Discussion

From the analysis of the journal entries of the graduate students and post-doctoral students in Cohort 2, as well as the comparison to Cohort 1's coding results, the four main assertions were maintained. Three of these assertions have sub-assertions, with all but one sub-assertion retained from the data analysis for Cohort 1. One major difference was found between Cohort 1 and Cohort 2, and it is discussed at the end of assertion 1.

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

This study found that numerous participants responded to our journal prompts with comments about the role this program had in their career plans, including confirming their career goals and providing them with some skills

necessary to succeed in those professions. The majority of the participants in both Cohort 1 and Cohort 2 discussed how the GK-12 experience provided them with the skills necessary to communicate with diverse audiences and assist them with understanding the major elements of their future careers, especially for those interested in pursuing faculty positions.

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

Improving communication skills with diverse audiences was an important goal in the NSF-funded GK-12 program, and it continued to play an essential role in this locally sustained program. According to Guion & Diehl (2010), 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". In their narratives, participants in this program repeatedly shared how their experience in the classroom has assisted them in strengthening their communication skills with teachers and students. They also highlight that communicating with these broader audiences required them to learn how to interact with audiences outside of their field and outside of academia, and the role of this skill in their future careers. One participant wrote "*I also learned about communicating to people outside of my field and with different intellectual capabilities and learning styles, which are essential skills for both teaching and conducting research at the university level*." [Participant A] Other participants touched upon the need to change their language choices when discussing research with laypeople, for example Participant B stated that "*the experience in GK-12 helped me better understand how to make things simple, talk to someone who has no idea about your field, and make them easily understand the contents*." Many of these skills came from participant experience with creating and implementing a lesson plan for middle school students, and frequently participants discussed the importance of knowing and meeting the needs of their audience. Almost all participants wrote about their need to modify their lesson to better suit the students, such as needing to "*really think about the lesson plan from the middle school students' perspective*." [Participant C] One participant shared her advice for other graduates going into teaching, which she based on her experience with writing her lesson and reflections after teaching her lesson.

> *Be sure to teach at their level. Know what they already know and what they can be expected to learn. Build on their prior knowledge and experiences; assume they have some prior understanding that can be used as a foundation for almost anything you want to teach them and use that as the basis for your lesson. Make sure you have one main point and you keep referring to that point as you go along, helping the students to make connections to other subjects and experiences along the way*. [Participant D]

This GK-12 opportunity also increased participant communication skills when talking with experts in their field, sharing about their increased comfort with understanding how to start a conversation with experts. For example one participant who led us to this conclusion said: "*This experience has reminded me that you can never assume what another person knows, no matter how educated. Whenever starting a new collaboration or just a conversation about science, it's important to lay a groundwork based on shared knowledge.*" [Participant E] Through this experience, the communication skills gained by the participants also assisted in their comfort with discussing their research with all types of audiences. For example, one participant said: "*I am more comfortable talking about my area in front of others, and I know how to answer lots of different questions I didn't think about before.*" [Participant F] Overall, participants shared their belief that this program has increased their communication skills, including comfort discussing their research and their ability to teach to diverse audiences.

> *Sub-Assertion: The GK-12 program provides experiences that support major elements of future faculty responsibilities.*

The analysis of the data also revealed numerous entries about the way in which this engagement experience provided the participants with new teaching styles, a passion for service learning, and a fresh perspective on education to take with them in future careers in academia. Participants noted that the GK-12 program gave them a better understanding of how teaching and service fit into a faculty position, as well as enhance their research. A participant was discussing his future career goals, and stated that "*it seems like middle school and high school outreach will be an important component to an individual's research program. In that respect, [the program] supports and prepares you greatly*." [Participant G] The GK-12 program also inspires a passion for engagement with the community, and many future faculty shared in their journals their plans for incorporating such experiences into their career paths. One participant noted "*I gained a lot of inspiration to share more of my knowledge and skills with other people*" [Participant H] and went on to discuss possible venues for this engagement when she obtains her anticipated career as a faculty member.

Numerous participants were grateful to have learned new teaching styles and strategies, including lesson planning, classroom management, and communicating new concepts with students. Many shared in their narratives how this

program challenged them to become a better, more effective teacher for future careers. For example Participant I said:

> *This program has definitely helped me develop skills that will be required for teaching in the future. I got a lot of practice at developing lesson plans to teach individual concepts and gained a new appreciation for the depth of attention required for keeping groups focused and the need to understand group dynamics. I also had the change to practice explaining concepts to those who don't have a lot of background in the field*.

Participant J echoes this sentiment in his journal narrative, writing:

> *This program has supported me by teaching me how to effectively construct a lesson plan, manage a classroom, and share my research expertise with students. I received support throughout the semester in developing my lesson plan and I learned how to raise funds to support classroom activities. I feel like I am now much more comfortable teaching students and I believe I have become a more effective teacher*.

Overall, this GK-12 program provides participants with the opportunity to enhance their teaching styles and strategies to be prepared for their future careers as faculty or other teaching responsibilities. One major difference between Cohort 1 and Cohort 2 was the increased discussion in Cohort 2 of how this program changed the participants' perspective on the role of teaching in faculty responsibilities. Many students in both cohorts shared their prior misconceptions of the reality of teaching in a middle school classroom, but Cohort 2 also wrote about how these misconceptions applied to their view of their own teaching. One participant wrote:

> *At a high level, it completely changed my personal understanding about teaching; before this program, I merely thought teaching is just a course of delivering knowledge to students. Now, I believe that teaching is a course of nurturing students' thought process, developing students' true interests and talents, and making them ready to explore their lives in the world. I realized that teaching was one of the most rewarding works that I have ever done*. [Participant K]

This sustainable GK-12 program supplies participants with an experience that enhances the skills necessary for their future careers, especially for those entering academia, and providing them with an opportunity to find passion in engagement experiences.

3.2 Assertion 2: The GK-12 program helps participants realize the importance of teacher interactions with students.

Analysis of participant journals also revealed the importance participants placed on their interaction with their paired teacher, as well as the interaction between the teacher and the students. Numerous participants noted the different ways in which their teacher engaged the students, their teaching style, and classroom management skills. Participant L wrote "*I personally liked [my teacher]'s teaching style. She is very knowledgeable and has a specific approach for each class hour*." Other participants shared their reflections of these interactions, writing about their overall experience with their teacher. For example, Participant I wrote "*Interaction with teachers also helped give me a much better look at what goes into the development of teaching materials and planning lessons*." This interaction gave many participants a better understanding of the role of teaching and how this experience changed their outlook of teaching. Participant M wrote about her gratitude towards her paired teacher over the course of the semester, sharing that "*collaborating with a veteran teacher really helped me understand the issues teachers and students face every day as well as some of the ways curriculum and instruction can be shaped for young adolescents*."

A strong theme was the importance of communication with the teacher as the best avenue to engaging the students and learning the skills necessary to be an effective teacher. This program allowed participants to shadow a middle school teacher, not only to work closely with them but to also observe how they handle teaching and working with the students. One participant shared his advice for future participants, including the tip to "*have good communication with your teacher. It is important that she or he engages in your activity. She knows her students. She has the tools to control them.*" [Participant N] This advice is also found in other participant narratives, with another participant writing "*use the teacher as a resource – they know their students and can help find ways to keep them focused*." [Participant I] An important part of this program is how our participants are instructed to observe their teacher working with the students to note teaching styles, techniques, and the intricate ways in which teachers interact with their students. Observations in the classroom take place for one day a week over a one-month period, which is a major time commitment over the course of a single semester, yet the participants consistently remark on the importance of this period of time in shaping their interactions with teachers and students.

3.3 Assertion 3: The GK-12 program helps participants identify the elements of an effective lesson.

Throughout their journals, participants in the GK-12 program reflected on the elements of an effective lesson, identifying those that they believe are essential to such as lesson when observing their teacher, co-teaching with them, and after teaching their own lesson. This research determined that the GK-12 program aided participants to distinguish those fundamentals needed to develop and implement a successful lesson that meets classroom curriculum and state standards, as well as being engaging to the students.

Sub-Assertion: GK-12 participants display an understanding of how to organize & structure a lesson that fits the needs of the students, classroom, & school curriculum.

Many participants cite the need for teaching experience as a reason for joining this sustainable GK-12 program, providing them with an opportunity to create a lesson that best conveys their research to the student audience, but also meets to the needs of the teacher and school curriculum. Most participants remarked in their journals about the importance of being organized, not just to keep the students engaged in the material but also to create an environment that is conducive for learning. After her first week in the classroom, Participant O wrote:

> *I have learned that as a teacher you spend a lot of time on preparing the materials in advance to make class go smoothly. Many slides and assignment sheets are designed and prepared to make the constraint 53-min to be an efficient period of time.*

Besides the challenge of being organized and keeping to the time frame, numerous participants shared their feelings about where their lesson would fit into the classroom curriculum so as to be beneficial to the teacher and provide enrichment to the subject. Many participants have concerns about how to transform their research into an appropriate lesson for middle school students and to fit into the current subject. For instance, Participant P was at first concerned about how his work would be understandable to younger students, but he worked with his paired teacher to find how the basic elements of his research could be found in their current curriculum. He wrote "*they will be doing chemistry by the time I teach, so I am trying to thinking of things I do that will fit and still be fun for them*". [Participant P]

After becoming a part of the classroom, participants know the pressure placed on teachers to meet standards and prepare for high stakes testing, and they work diligently to find innovative ways to incorporate their research into the curriculum rather than stop the classroom flow to teach a new topic. Other participants shared their lesson planning process, including their ideas, concerns, making connections to the classroom subject, and working to fit the needs of the students. For example, Participant J wrote:

> *I am thinking of trying to turn the students into rocket scientists for the day. I should be able to review some of the material they will have had by the time I teach like states of matter, atomic structure, and elements from the periodic table. Through the past weeks I'm seeing more and more the classes definitely behave less than others and I need to think carefully about how to keep all the students interested and also keep things orderly*.

Participant narratives also contained numerous references to the elements of an effective lesson, especially the different ways of teaching and structuring lessons to best engage the students and teach the necessary material. Most of this information comes from their observations and interactions with their paired teacher, and the way their teacher handles the classroom and subject. For example, Participant L wrote:

> *[My teacher] was very prepared, as usual, for the lecture…she prepared some handouts with gaps for students to fill in the important concepts. She used a combination of verbal and visual teaching methods which made it very effective for almost every student in the class.*

Another participant noted that "*you need to be able to adapt to the students. [My teacher] plans several activities no more than 20 minutes each so that students' attention doesn't drift.*" [Participant E] These writings demonstrate that participants in this program are able to identify the essential elements of an effective lesson by learning, especially from their teacher, how to structure a lesson that engages the students, meets their individual needs, but also meets school and state curricular requirements.

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

Almost all participants wrote in their journals about the key elements of an effective lesson, including as the importance of real world application, chosen vocabulary, and engaging the students in the topic. Participants shared the different tactics that their teachers utilized to teach an effective lesson to all the students, every day, and keep it interesting to their students. One participant noted "*[My teacher] shows enthusiasm for the material she is teaching. That brings enthusiasm to her students too. A teacher must like what he/she is doing to convince the students that*

what they are learning is interesting." [Participant Q] One important tactic that most participants observed was the way in which the teacher conveyed the information to the students through carefully selected language and vocabulary. Participants identified this tactic, and reflected that lessons need to simple and given in a language that is appropriate for the student to effective teach their lesson. A participant wrote "*I have to use simple language to explain complex concepts. Less information has better results. In other words, it is not effective to overwhelm the students with too much information*." [Participant N] Other participants also shared their belief that an effective lesson needs to be simple, especially for those not in their field of research. One participant wrote about her need to change her language choices when in the classroom, and her mistake of using technical vocabulary when first in the school. She writes that "*one important part of sharing research with non-experts, like middle school students, is accepting the fact that you may need to simplify complex structures and language*." [Participant M] This sentiment is echoed in many other narratives, as the graduate and post-doctoral students identify the need to choose their language carefully when in the classroom. For instance, Participant A wrote "*this experience has taught me how important it is to avoid jargon and use examples to explain my research*", and another noted that "*avoiding unnecessary jargons or technical terms is an important step when explaining things to non-expert groups*." [Participant K] This sustainable program aided participants in identifying the role of language and simplicity in effective lessons, as well as different ways to engage students.

Another key element that participants identified as an important part of a lesson is to relate the classroom material to real life situations. Many participants work on very complex, detailed research, and they needed to find a way to connect the students to their specific area. Connecting their work to real world applications allowed the students to understand the importance of the research as well as demonstrating to the students how their classroom learning connects to the real world. One participant wrote about his desire to connect his research on burned organic matter remnants (biochar) to the real world, stating "*I see my biochar research fitting in very well to the upcoming section on chemistry. [My teacher] and I talked about how it would be a great chance for me to show application of chemistry to address real-world issues.*" [Participant R] Making the lesson relatable for the students also keeps the students engaged in the topic, and many participants utilized this technique to teach an effective lesson. A participant wrote about his choice to connect the students to his research through real world application, writing that "*students have prior knowledge that can be activated and connected to your topic. How interested they become is based on whether you can convey the relevancy of the information to their everyday lives*." [Participant S] Another participant noted "*it is vital that people have a hook, something that is important to them that relates to whatever you're talking about*." [Participant I] This sustainable GK-12 program helped participants identify these important elements for teaching an effective lesson, which they can use to improve their teaching, both in the remainder of their time as a graduate or post-doctoral student and in their future careers.

3.4 Assertion 4: The GK-12 experience helps participants understand the realities of teaching in a middle school.

Analysis of GK-12 participant narratives found that being a part of this program exposed them to the reality of teaching in the classroom, especially the differences between teachers and students in middle schools and those in higher education. Participants also discussed how the GK-12 program helped them understand what is needed to be an effective teacher, primarily based on their observations of and working closely with their classroom teacher.

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

A recurring theme in participant narratives was how this experience changed the conceptions graduate and post-doctoral students have about what really happens in a middle school classroom. Many narratives included observations about the school as a whole, and how it differed from their own experiences, especially for international participants. One participant originally from South America wrote about the comparisons between the small, private school she experienced growing up and the large public school she visited, noting "*I learned that the middle school is a relatively large public school and has a diverse population. Most students were active and participated in classroom activities well.*" [Participant T] Another misconception that GK-12 participants noted was the behavior of the students as compared to undergraduate students, and the need to keep students engaged in the material. One participant wrote about how surprised she was at the students' learning levels, noting "*I honestly found that middle school students are autonomous and relatively mature; however, I also realized that they are just children who can get excited over treats and rewards from the teacher.*" [Participant S] Participants who recognized their initial misconceptions about middle school students used their observations and interactions to enhance their lessons and to meet the needs to the students. One participant noted "*the students were great for the most part and seemed really excited to learn. They did seem to get restless if one activity was too long so it seems important to change things up*

to keep them interested." [Participant P] Meeting the needs of the students also included structuring and running a lesson that was designed for the different behaviors of each class, rather than trying to apply one way of teaching to all classes they taught during the course of a day in the school. For example, one participant commented that "*each class is widely different and affects how the class is taught. And each individual is also different and they all have their own needs*." [Participant J] Another participant wrote about these differences, writing "*I observed a huge difference between the two classes I attended – they differ significantly in their appearance, discipline, and the way they ask questions*." [Participant U] These data show that this GK-12 program helps students identify their misconceptions about the behavior of students and schools which allows them to better recognize and meet the needs of the students when teaching.

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

Through their observations and interactions, many participants in the GK-12 program start to identify what skills are necessary to be an effective teacher in any classroom, including time management, classroom organization, flexibility, and sensing the needs of the students. Working with their paired teacher and creating their own lesson gave participants the experience they needed to better understand what constitutes an effective teacher. Numerous observations were on how busy their teacher was, and how important it was for the teachers to manage their time and tasks to meet multiple deadlines. One participant wrote that she saw that "*teachers were very busy with diverse work. They not only teach mathematics, but also do paperwork and have to discuss topics that are not related to teaching mathematics. It is important for them to plan ahead of time*." [Participant T] Classroom management is also very important for effective teachers to handle different student behaviors and keep the class focused on the lesson. One participant wrote:

> *I learned that it is important to be proactive rather than reactive in regard to managing behavior during teaching. Students feed off of the behavior of other students. If you do not control inappropriate behavior by one student, other students will begin to exhibit the same inappropriate behavior.* [Participant S]

Many students wrote about their concerns with handling classroom management during their own lesson, writing "*When interacting with students, it's difficult to judge who to call on and how to keep the class relatively calm, with only one or two students speaking at once*." [Participant E] This sustainable program shows participants what classroom teachers really do throughout the school day, and what techniques are needed to teach effectively.

Another theme connected to effective teaching focused on the need for teachers to sense the needs of their students during the lesson to best convey the topic and ensure understanding. This involves ongoing assessment of student understanding during a lesson, and making just-in-time adjustments to meet the learning needs that are identified. One participant wrote "*Things happen in the classroom. You'll have to go with the flow and change things up a bit…Be prepared to define concepts and words that you thought they would understand but don't.*" [Participant I] Another participant noticed this technique with her classroom teacher as well, writing about how the teacher changed the entire week to ensure that the students understood the basic concepts of the topic. She wrote "*I learned that sometimes you have to go with the flow of the lesson or even make last minute adjustments based on student understanding. You can't plow through a lesson if remediation is necessary.*" [Participant S] Being flexible is also very important for effective teaching, as a teacher cannot be entirely certain how the students will respond to the lesson. Numerous participants wrote about the need to be flexible when designing and teaching a lesson, with one participant noting "*It is often necessary to remain flexible regarding your schedule and lessons, because you never know how a given class will react to what you have planned*" [Participant V], and another participant wrote "*Each class will respond differently to your lesson so it's helpful to build in some flexibility or at least be prepared to adjust your lesson slightly to be better for certain classes.*" [Participant J] The GK-12 participants learned through this experience the importance of being flexible and prepared, as the class may not react or comprehend the class in the way that the teacher expected, and that an effective teacher needs to be ready to adjust to meet the needs of their students. Overall, this sustainable program helped participants identify the skills necessary to be an effective teacher in any classroom, and how to use these skills to create lessons and manage their own classrooms in the future.

4. Conclusions

By comparing two cohorts of participants in a sustained GK-12 outreach program we have the first step of a longitudinal assessment of the effectiveness of the program in meeting graduate student learning outcomes. The data presented here and in Weeks et al. (2014) indicate that the locally sustained GK-12 program continues to support graduate student education by providing graduate and postdoctoral students with an experience that enhances their communication skills, expands upon their understanding of what it takes to be an effective teacher and create a successful lesson, and aids in shaping their future careers. Journal entries reveal that this program contributes to

several graduate student learning outcomes, including developing pedagogical knowledge, enhancing communication skills with diverse audiences, and getting involved in engagement activities outside of academia. One new theme that emerged in Cohort 2 compared to Cohort 1 was more discussion of how this program changed the participants' perspective on the role of teaching in faculty responsibilities, and how participants' learning about teaching in a middle school could be applied to their future teaching at the university level. This theme is likely to be the result of explicit discussion that occurred during regular participant and staff check-up meetings in Cohort 2. These discussions included a focus on the implications for college level teaching of the things that the participants had observed in the middle school.

The overall results are also consistent with previously observed learning outcomes from NSF-funded GK-12 programs, including impacts on graduate students' teaching, teamwork, and communication skills (George & Tankersley, 2013). In addition to its value to graduate programs, the GK-12 approach is beneficial to local teachers, K-12 students, and college-community relationships. The success of this type of program leads us to encourage other universities seeking to enhance their graduate education and meet expanded graduate student learning outcomes to consider implementing this model for a low budget yet high impact program. In 2014 a pilot version of a program called "Doktorander I Skolan" was launched at Stockholm University, Sweden, based on the GK-12 model that was the subject of the research described in this paper, and this program demonstrates that the GK-12 model can also be adapted to international contexts.

Although these results provide valuable perspectives on a maturing and diversifying GK-12 program, the expansion of GK-12 beyond the restrictions imposed by the original NSF funding provide the opportunity for more focused future research that specifically examines differences between how domestic and international students are impacted by this type of program, and the extent to which a program that was originally designed for STEM students is also meeting the needs of non-STEM graduate and post graduate students.

Acknowledgements

Funding for the sustained GK-12 program is provided by the Graduate School at Purdue University, and Gong's participation in this research was supported by an internship from the Discovery Learning Research Center at Purdue University. We thank the teachers and administration at Tecumseh Middle School in Lafayette, Indiana, for their sustained enthusiasm for participating in this project. The authors thank the journal editor and two anonymous reviewers who provided constructive suggestions that improved this paper.

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