High School Students' Experience with Near-Peer Mentorship and Laboratory-Based Learning: In Their Own Words

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Introduction

The United States government has demonstrated a commitment to science, technology, engineering, and math (STEM) education with support spanning both the public and private sectors (100Kin10, 2011; Gonzalez, & Kuenzi, 2012). Presidents and lawmakers have developed policies and programs, created committees, spearheaded initiatives, and appropriated funding to foster growth in STEM education (STEM Master Teacher Corps, 2012; Educate to Innovate Initiative, 2009). These efforts are driven, in large part, by the nearly 50% pay gap between STEM and non-STEM associated median incomes, as well as economic forecasts that project a 16% increase in STEM-associated employment from 2012 to 2024 (Change the Equation, 2016).

Despite these enhanced STEM education efforts, the average performance of 15-year-old students in the U.S. on the Program for International Student Assessment (PISA) Science Literacy exam has remained relatively unchanged since 2006. In scientific literacy, the U.S. student performance, when compared to other nations, continues to be lower than students from 18 other educational systems and not measurably different than 12 educational systems (Kastberg, Chan, & Murray, 2016). Furthermore, of those students who register in a post-high school course of study in the STEM disciplines, 48% of baccalaureate students and 69% of associate or certificate students will either change majors from STEM disciplines or leave school. While the characteristics of these 'STEM leavers' are complex, two factors account for more than 50% of those exiting STEM: minimal math skills and/or belonging to a group currently underrepresented in the sciences (Chen, 2013). This attrition rate perpetuates the cycle of historical underrepresentation of ethnic/racial minorities and first-generation college students in STEM disciplines. This underrepresentation is consistent at every degree level, and in every STEM occupation, relative to the U.S. college-age population and workforce (Ross et al., 2012; National Science Board, 2015; National Science Foundation, 2015).

In recognition of these challenges, the Walter Reed Army Institute of Research established the Gains in the Education of Mathematics and Science (GEMS) program to serve communities in the National Capitol Area (Anderson, Tenenbaum, Ramadorai, & Yourick, 2015). The GEMS program was founded on four key elements to provide opportunities to primarily middle and high school students from under-resourced schools. Those four elements include: (1) leadership through undergraduate near-peer mentors, (2) innovative, experiential learning in a laboratory, (3) accessibility for diverse populations, and (4) continuity of programming. The current study examines the experiences of GEMS students through their own words. Using an open-ended survey, researchers asked 11th and 12th grade participants to reflect on their time within the program. The research questions focused on: 1) how relationships with near-peer mentors impacted them; 2) their involvement with the inquiry-based approaches; and 3) any increased and/or continued interest in pursuing STEM as an extension of their experience.

Background

Mentoring and research experience are both essential components of educating scientists, as indicated by numerous studies throughout the decades. (Barondess, 1995; Gallup-Purdue Index, 2015; Thiry, Laursen, & Hunter, 2011). For those students seeking to be the first scientist in their families, mentoring and research experiences have been shown to have significant educational benefits, including increased interest in pursuing the sciences, improved self-efficacy and technical skills, and higher retention rates in their fields of study (Fuchs, Kouyate, Kroboth, & McFarland, 2016; Patel, Rodriguez, & Gonzalez, 2015; Salto, Riggs, De Leon, Casiano, & De Leon, 2014). Research has demonstrated that pioneering students frequently face unique challenges in their pursuit of STEM careers, including limited knowledge about professional development, lack of technical skills, diminished self-confidence in their abilities, limited educational and personal resources, and absence of knowledgeable and renowned role models (Freeman, Landry, Trevino, Grande, & Shea, 2016; Holden, Rumala, Carson, & Seigel, 2014). Mentorship addresses many of these challenges by providing students with role models, subject matter experts, authentic experiences, and ongoing support for goal completion (Freeman et al., 2016; Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013). It can be particularly important for women and students of color to have role models who share the experience of being a minority in their field (Blake-Beard, Bayne, Crosby, & Muller, 2011; Weber, 2011).

Successful scientists have reported that a mentor or exposure to research in middle and high school helped launch their careers (DiLisi, McMillan, & Virostek, 2011; Holden et al., 2014). In the high school science classroom, students usually begin by participating in a peer mentorship model (Wilson et al., 2012), in which students of the same age or academic level are paired together to provide mutual support (Ghee, Keels, Collins, Neal-Spence, & Baker, 2016). Also common is the expert-novice model of mentoring (e.g., Balster, Pfund, Rediske, & Branchaw, 2010), in which a less experienced learner works with an experienced instructor. Through individualized interactions, the novice learns professional dynamics, academic knowledge, and becomes integrated into the community (Adedokun et al., 2012; Thiry et al., 2011). Mentoring relationships are usually successful for the individuals involved, but frequently restrict the number of students who can participate because experienced mentors have limited time.

An expanded model of mentorship, called *near-peer mentorship,* has been established in the Walter Reed Army Institute of Research GEMS program and incorporates established principals of mentoring. Vygotsky's influential theory of socially-mediated learning and instruction that combine to shape the psychological development of adolescents further elucidates our instructional approach of undergraduates facilitating learning in slightly younger students (Clarà, 2017). Near-peer mentorship brings together high school students and college level STEM majors. Near-peer mentoring encourages the growth and development of undergraduate and pre-college scientists by bridging the gap between senior level internships and the undergraduates' quest for beginning internships (Tenenbaum, Anderson, Jett, & Yourick, 2014). The NPMs are slightly older than their students and thus offer a unique perspective with regard to their experiences pursuing the sciences, while also offering personal and academic guidance. NPMs selection is competitive and requires an online application, interviews, and team discussions. Usually NPMs originate from the National Capitol Area and frequently mirror the population they serve (Table 1). Representing a range of majors, the NPMs introduce students into the numerous opportunities available within STEM, from museum amphibian archivist to mosquito barcoding for Zika virus (actual examples). This allows the middle and high school students an opportunity to explore a wide range of science disciplines while providing the undergraduate the opportunity to more deeply explore their own interests and knowledge.

The NPMs gain significant benefits arising from a combined research and teaching internship, particularly in terms of translating concepts to protocols, communications skills, general laboratory practices, and cross-disciplinary collaborations (Anderson et al., 2015). At the beginning of their three-week training, the NPMs are assigned to more experienced interns who in turn work with senior research scientists. In the mornings, the interns are taught by subject matter experts about topics such as educational research and evaluation, behavior management and expectations, laboratory safety, media and minors, time management, and what it means to be a mentor. The afternoons are devoted to bench work with researchers in the NPM's field of expertise. When the high school students arrive, the NPMs are prepared to implement the assigned investigations. In addition, the NPMs have identified an advanced student investigation (grades 11 and 12) that they will create, develop, implement, and evaluate as their personal project. As a team, the NPMs teach and mentor students in the laboratory with each NPM leading at least two investigations, creating one investigation, and helping with other protocols. The NPMs are supervised by a licensed teacher who offers guidance and they continue to have access to research and educational mentors. The annual abstract book and poster session allows interns and researchers to present their findings.

The current study seeks to further explore how near-peer mentorship can support youth as they begin their journey into the STEM world. Previous studies have shown that hands-on learning, authentic activities outside of school, or role models are effective in engaging and retaining pre-college students in the sciences. Early experiences in science that incorporate engaging and active learning positively impact a young student's interest in pursuing STEM-related careers and promoting science literacy (Clark et al., 2016; Goldsmith, Tran, & Tran, 2014; Miele, et al., 2011). Providing primarily underrepresented middle and high school students with exposure to a variety of scientific fields through hands-on investigations can unite education with the real world in a way that traditional instruction often does not. A study by Van Meter-Adams, Frankenfeld, Bases, Espina, and Liotta (2014) investigated early STEM experiences and found that extracurricular activities outside the classroom rank highest in engaging students. Over time, it was found that involvement in laboratory work helped to maintain initial interest in STEM. Complimenting laboratory work are numerous studies showing that active learning methods improved comprehension of scientific concepts (Goldsmith et al., 2014; Silla et al., 2014; VanMeter-Adams et al., 2014). The GEMS summer program seeks to foster student engagement in science by implementing an outside-the-classroom curriculum focused on unique laboratory investigations developed and led by undergraduate NPMs who serve as role models.

The GEMS summer program provides one week, 40-hour, internships to community students who express an interest in the sciences. Diversity is encouraged by accepting students who self-identify with any of the following: free or reduced-price lunch, racial or ethnic minorities historically underrepresented in STEM, English language learners, and potential first-generation college students. These students need awareness and opportunities to overcome discrepancies in access to experiences and resources (Holden et al., 2014). The GEMS program aims to address these discrepancies (National Academies of Sciences, 2011) by providing the experience free of charge, providing a stipend, and using postal codes and expressed interest more than grade point average for selection. Applicant selection also includes academically advanced students who seek additional opportunities in research. With an approximately 50% acceptance rate, the GEMS program seeks to balance excellence with access through a growing number of participants each year. The program promotes access by partnering with community organizations, participating in local school events, judging science fairs, and providing NPMs as guest assistants in local classrooms.

Through incorporating the elements of hands-on laboratory-based learning, near-peer mentorship, and increased accessibility, the GEMS program offers the opportunity for community students to improve their STEM literacy. In addition, GEMS offers students a continuum of opportunities (Adedokun et al., 2014; Ghee et al., 2016; Grossman & Rhodes, 2002) that increase the effectiveness of summer enrichments. Students may enter or continue through four levels: beginning for rising 7th and 8th graders, intermediate for rising 9th and 10th graders, advanced for rising 11th and 12th graders, and NPM assistant for the summer between senior year and college. The program provides students with continued mentoring, guidance in course selection, and opportunities that match the students maturing knowledge (Winkleby, Ned, & Crump, 2015). The senior GEMS students have opportunities to attend other programs, plan more advanced activities, and to become NPMs during their first undergraduate year.

The current study seeks to gain more information about the experiences of advanced GEMS students in their own words. Using a brief, open-ended survey, researchers asked 11th and 12th grade participants to reflect on their time within the program and discuss how certain aspects of the program impacted them. The students responded to questions grouped in three themes: (1) how did relationships with near-peer mentors impact you; (2) what did you think about the experiment-based approach to learning; and (3) did your interest in pursuing STEM increase and/or continue as an outgrowth of your GEMS experience?

Methods

The Program

This three-year study was conducted from 2013 to 2015 and involved 334 11th and 12th grade students in the Advanced GEMS program. During the one-week program, students completed a self-selected investigation related to current Walter Reed Army Institute of Research investigations. The independent project was facilitated by the NPMs who acted as the subject matter experts and guided the advanced students through the instruments available in the teaching laboratory (the complete program is detailed in Tenebaum, et. al., 2014; Army Educational Outreach Programs, 2016). The interconnected elements of being mentored by NPMs, who are themselves learning research, created a challenging and engaging environment for the advanced students. The students spent a week in morning classes, researching their topics and conducting experiments in the afternoon, and before 'graduating' they presented their findings to peers and scientific professionals.

Participants

The students ranged in age from 16-18 years (M = 16.33). Of the total 334 advanced program participants, 222 chose to participate in the current study by completing a brief survey. During the three summers, 39 NPMs guided the students in advanced projects. Approximately 33% of the advanced students were previous GEMS participants, and 100% completed the 40-hour program (Table 1). Each student selected an NPM with whom to work, based on the NPM's research project. Examples of project topics were malaria, risk assessment, water purification, forensics, biochemistry, designing a cardiac stent, medical entomology, and public health.

The Walter Reed Army Institute of Research Scientific Review Committee determined that because the current research involved population-based assessment only, as individual subject data were not collected, the protocol was not human subjects' research.

Measures

Survey questions and sentence completions were open-ended to allow students to share their perceptions in their own words (Table 2).

Comparison of Race/Ethnicity Reporting by Advanced GEMS Students and Near-Peer Mentors, 2013 - 2015

Self- identified Race/Ethnicity	Advanced Students (n=222)	Near-Peer Mentors (n=39)
African-American	40.42%	35.90%
Asian & Pacific Islander	18.56%	15.38%
Hispanic	5.69%	17.95%
White	12.87%	30.77%
Not Stated/Other	22.46%	0.00%
Total:	100.00%	100.00%

Table 1. Students and Near-peer Mentors are selected from the National Capital Community

Topic	Question(s)
Lessons	• My favorite module was ____ because ____. • I learned the most from ____ because ____.
Near-Peer Mentors	• Having a near peer mentor was____ because ____. • One thing I learned from a near-peer mentor other than science was ____.
Program Evaluation	• If I could change something about the program, I would: ____.
STEM Career Interest	• I would consider a career in STEM: Yes/No.

Table 2. Survey Question Examples

Data Analysis

Surveys were transcribed into digital format and entered into the Atlas.ti qualitative data analysis and research software (http://www.atlasti.com) in order to develop a coding scheme, establish inter-rater reliability, and interpret the responses (Varjas et al., 2006). Both deductive and inductive approaches to survey response data analysis were used. Combining a literature review on the topics of mentorship and STEM education and the review of three independent coders, carefully identified themes emerged from participant responses. This combined deductive and inductive approach is consistent with established qualitative data analysis methods supported by Grounded Theory (Nastasi & Schensul, 2005; Miles, Huberman, & Saldana, 2013). Inter-rater reliability was conducted between the three independent coders until a 90% agreement was established. Once a 90% coding agreement was obtained, survey responses were coded independently, with 10% of each survey coded and compared to ensure coder drift did not occur. Overall inter-rater reliability and coder drift was maintained at 90%.

Results

Data analysis revealed a coding hierarchy that contained three primary codes: *Near-Peer Mentors, Program Feedback, and STEM Career Aspirations*. Each primary code contained level two and three codes further explaining participants' relationships with near-peer mentors, their learning experience within the GEMS program, and their self-reported interest in a potential STEM career in their future (Table 3).

Near-peer mentors

The primary code, *near-peer mentors*, described GEMS student responses that focused on their experiences and relationships with near-peer mentors. This primary code contained two subcodes: *rapport* and *guidance.*

Rapport. The secondary code, *rapport*, described the unique relationship that developed between students and near-peer mentors. Sixty-four percent of the students discussed how much they enjoyed working with near-peer mentors and how their closeness in age made them relatable and able to teach concepts in a way that was fun and understandable. Students shared their thoughts by completing the sentence stem, *having a near-peer mentor was fun because*, "they understand what we want to learn and how we want to learn it," "they were fun to talk to and easy to learn from," "it was easier to learn from them since they are closer to our age." Other students shared, "Having a near-peer mentor was very helpful and nice because I'm not used to someone almost my age helping me and being so cool and fun;" "The best part about being in the GEMS program was having the opportunity to work alongside the near-peer mentors and see their mentality, work ethic, and have them share their ideas and knowledge."

Guidance. This secondary code described the ways in which near-peer mentors served as teachers to the student participants. It contained three subcodes: *STEM learning, educational planning*, and *life lessons*.

STEM learning. This code included student discussion of near-peer mentors as STEM instructors. GEMS students talked about novel concepts learned and how near-peer mentors supported their learning process. The students primarily shared their thoughts on STEM learning by elaborating on the sentence completion prompt, *the most important thing I learned from a near-peer mentor was*. Some examples of student responses included: "how to present experimental findings because I will need this in the future," "not contaminating supplies because it could skew our results," "following our instructions and carrying out experiments accurately," "more background information on malaria because I didn't know that malaria was mostly caused by female mosquitos," "proper dissection techniques." Participants reported a range of scientific information that the near-peer mentors helped them learn and understand in 68% of their responses.

Educational planning. This code described the ongoing discussions about education, college, career development, and course planning that occurred between students and NPMs. Forty percent of the students included this topic in response to the prompt: the most important thing I learned from a near-peer mentor was. For example, they wrote how the NPMs helped them to learn "how to choose a good college because they have experienced the decision making process and were able to give me some tips." Students also discussed learning more

Level 1 Codes	Level 2 Codes	Level 3 Codes
Near-Peer Mentors	Rapport	
	Guidance	STEM Learning Educational Planning Life Lessons
Program Feedback	Benefits	Engaging Learning Independence Camaraderie Self-Efficacy
	Challenges	Challenging Lessons Not Engaging Difficulty Understanding Time Limitations Comfort Zone
STEM Career Aspirations	Interest/Disinterest in STEM	

Table 3. Coding Hierarchy

about the potential for STEM careers, "*The most important thing I learned from a near-peer mentor was* that you can do multiple things with science because I wasn't sure before;" "The most important thing I learned in the GEMS program was how to go into a science career because all of the near-peer mentors are going into science careers." Participants noted that not only did near-peer mentors provide them with helpful advice, but they also trusted them as caring advisors, "The best part about having a near-peer mentor was them being in college because they were able to answer questions I had and I could relate to them. Their age also makes me more comfortable talking to them;" "Having a near-peer mentor was great because they really do care about you and are interested in your career plans and your interests."

Life lessons. In addition to educational guidance, GEMS students reported receiving mentorship in the areas of personal development and maturation. This code was termed *life lessons*. These life lessons often did not focus on scientific content, but rather on words to live by in order to achieve success as an individual. Students discussed the importance of pursuing a passion in their education and careers, which they felt the NPMs emphasized. Using the sentence starter, *the most important thing I learned from a near-peer mentor was,* students wrote that they learned "to pursue my passion because I would be doing it for the rest of my life," "how to learn and have fun because it's important to do what you love." The students discussed the important lesson of persistence in the face of challenges, "The most important thing I learned was to never let failure discourage you because it will always happen;" and "It's ok to be wrong." Students also discussed lessons of teamwork, "The most important thing I learned from a near-peer mentor was that cooperation is important because you can get things done easier."

Students wrote of lessons that ranged from encouragement, to expanding their horizons, to practice sessions in public speaking. Using the sentence stem, *one thing I learned from a near-peer mentor other than science was,* students stated, "to be ok with stepping out of your comfort zone because you could end up making amazing new friends," "how to be confident in what I know," "about speaking in front of people and how to overcome a fear of it." Students shared other life lessons from near-peer mentors such as, "to be nice to the people around me" and "to relax," and "not everything should be worried about your speed through. Take your time." Students commented that near-peer mentors taught them "that you can be young and be a successful scientist, which is inspiring," "to develop independence in research because people won't mentor you all the time," and "to keep exploring because that's how you advance in science." In total, 40% of the students wrote about life lessons. Students shared that they learned about respect, patience, and perseverance through their relationships with NPMs.

Program Feedback

The primary code, *Program Feedback*, included student opinions about their experiences in a hands-on, laboratory-based program. Student discussion of the program centered around two themes: *benefits and challenges*. Participants expanded upon the benefits and challenges of the program by highlighting ten level three codes that further described their experiences.

Benefits. This level two code encompassed all student feedback about the benefits associated with the hands-on learning approach of the GEMS program. The *benefits* code included five subcodes: *engaging, learning, independence, camaraderie, self-efficacy*.

Engaging. The code, *engaging,* included responses that described program lessons and projects as interesting, exciting, surprising, and/or increasing interest in STEM. Students talked about learning new branches of science that piqued their interest, with one student stating, "I learned how the brain works and how to use an EEG . . . I thought it was fascinating and sparked my interest in neuroscience." It was important for 100% of the GEMS students to actively choose and explore topics of their interest, which helped them maintain engagement and excitement about learning. "I was able to spend time working with something I really enjoyed and thinking with an active mentality;" "Project-based learning was beneficial because I got to work doing something that I love and I learned a lot!" "My favorite part of the GEMS program was projects because we worked in groups and the multiple trial and errors were very interesting." Having the opportunity to learn through projects and experiments resonated with students as they commented on the active nature of the program, "I loved going to depth in our projects and doing hands-on lab work;" "The best part about being in the GEMS program was learning and doing hands-on experiments, being able to present our projects, and work with each near-peer mentor."

Learning. The level three code, *learning*, included responses from 80% of the students on the experiences of learning something new within the GEMS program. Students discussed novel learning topics, having the opportunity to learn something they would not have otherwise, and how the things they learned would help them in the future. One student shared, "The most important thing I learned in the GEMS program was how to plate bacteria because I will need to know that when conducting bacterial experiments," discussing a skill that would be useful in the future. Another student reported, "I learned the most from my dissection project because I had the opportunity to research a very in-depth topic that I probably never would have known about," highlighting the unique opportunity to study a topic in detail. Other students talked about simply learning something new and how it impacted them, "My unexpected moment was during the malaria activity when I found out there's four different types of malaria;" "I learned most from the lesson on electrophysiology because not only did I learn a lot about the heart and how it works, but actually monitoring my heart was cool too."

Independence. Another program benefit reported by students was termed *independence,* a term used by 49% of the respondents. It describes responses which discussed the advantages of being able to select and pursue topics of personal interest. Participants primarily discussed projects, which were team experiments guided by a near-peer mentor that allowed students to select a broad topic and study it in depth. Students overwhelmingly shared how important it was to be able to choose a topic that they wanted to study, "Project-based learning was so much fun. Getting to choose what YOU thought would interest you most;" "My favorite thing about the GEMS program was projects because we could make up our own experiment. The experiment was driven by our interests;" "Project-based learning was enjoyable because you had a lot of freedom;" "My favorite activity was individual projects because I got to really pick a topic I thought was interesting and take it in any direction I wanted." Participants reported on how the independence of projects allowed them to practice and learn skills with more proficiency, "Project-based learning was less guided, which improved my skills to do research on my own;" "The best part about being in the GEMS program was the project. I enjoyed the chance to explore and do something on my own with little help;" "The most important thing I learned from the GEMS program was to be independent with lab work and to be curious because that's how you learn more." Several participants also mentioned that the opportunity to learn while working in a group was something that they enjoyed, "My favorite was projects because it was fun and independent. I also liked working in groups."

Camaraderie. This code incorporates responses about the positive experience of learning and working with other like-minded students. While many GEMS participants discussed the benefits of scientific learning, for 37% of the students the ability to meet new people and make friends resonated as a programmatic benefit. These students primarily reported on their camaraderie by using the sentence prompt, *the best part of being in the program was.* Student responses included, "making life-long friends," "meeting other interesting people," and "meeting new people." Students also reported that they appreciated the opportunity to not only meet new people, but work with people who share similar interests, stating that the best part about being in the program was "getting to work with like-minded people," "getting to interact with people my age that enjoy science," "meeting other people with similar interests to my own and having the opportunity to work with the variety of materials and instruments available here," and "meeting and interacting with other people who also have interest in STEM."

Self-Efficacy. This level three code describes responses about students' increased belief in their ability to pursue STEM goals. This theme was discussed infrequently, with only nine participants reporting on this theme, but those who did make mention of it talked about potentially seeing themselves as scientists through their participation in GEMS, "The most important thing I learned in the GEMS program was that I have a passion biomedical engineering and I could see myself studying it;" "The most important thing I learned from a near-peer mentor was that you can be young and be a successful scientist because it's inspiring." A further indication of a student's increased belief in an ability to pursue STEM is evident by the 23% of students who return to be a near-peer mentor at the Walter Reed Army Institute of Research site, the 53% who return to be a mentor at other US Army GEMS sites (Anderson et.al., 2015), and the 33% of students in 11th and 12th grade who have attended the program in previous years.

Challenges. In addition to benefits, students also discussed the challenges. This level two code contained five subcodes: *challenging lessons, not engaging, difficulty understanding, time limitations, and comfort zone.*

Challenging Lessons. This code includes student responses that discuss lessons and modules as difficult, but often still a positive learning experience. Students used the sentence completion prompt, f*or me the most challenging was*, to report on lesson challenges. Responses included within this code described difficulty with a particular subject because it was hard or had not yet been studied in school (29% and 2% respectively). For example, "chemistry and periodic law because I really never have worked with chemistry since I haven't taken the class yet," "buffer titration because it had to be very precise," "projects because it was all new to me and I had to do research and figure out things on my own." Other students noted times when things did not go as expected, "My unexpected moment was during projects when we found that the original hypothesis about the evolution of hearts was surprisingly mistaken."

Not Engaging. The code, *not engaging*, included the 34% of responses that described lessons as uninteresting or boring. Within this theme, students discussed the topic itself being uninteresting to them, "My least favorite was microevolution and tetrahymena because I was not really interested in it," or because they had learned the material previously, "My least favorite was chemistry and periodic law because I mostly knew about the topic." Students also had trouble engaging in lessons that were longer and required patience, "My least favorite was buffer titration because it took so long for the colors to change." Students also reported disliking lessons that included too much lecture and not enough hands-on activities, "My least favorite was chromatography because it was kind of basic and not very interactive leaving me uninterested."

Difficulty Understanding. This code included responses that described a lesson as confusing or hard to understand, "For me the most challenging was chromatography because I did not understand it;" and, "For me the most challenging was polymerase chain reactions because the concepts were new and confusing to me."

Time Limitations. For 6% of the students, the *time limitations* were a challenge. They talked about the difficulty of completing an original project with limited time. For example, one student shared, "Project-based learning was fun but we needed more time with some of the things that we were doing." Another student stated, "If I could change something about the GEMS program, I would increase the time length for projects."

Comfort Zone. Some students (7%) described how projects challenged them by pushing them out of their comfort zone. Students talked about projects being difficult to accomplish due to increased demands, "Project-based learning was definitely more difficult than previous years, but it made me more productive;" as well as having to complete a presentation, which was novel and uncomfortable for some students, "for me the most challenging was projects because I do not like presenting in groups."

STEM Career Aspirations

This primary code encompassed students' interest in pursuing a future career in STEM. Of all participants, 95% indicated that they would be interested in a STEM career. Students demonstrated interest in a broad range of science related careers, such as forensics, chemistry, biology, microbiology, medicine, dental health, engineering, genetics, psychiatry, psychology, pharmacy, cardiology, and physical therapy, among many others. Many of the career topics listed were ones included in GEMS lessons and projects throughout the week. Five percent of participants indicated that they would not consider a career in the sciences in their future. Interestingly, several of this small group of disinterested participants then listed STEM related careers as their first choice. (e.g., pediatrician, anesthesiologist, physical therapist). This suggests a gap in their understanding of how science is involved in a broad range of professions.

Discussion

This study examined the experiences of high school students participating in a hands-on summer science program guided by the teaching and mentorship of college-aged students studying STEM. Using qualitative research methods to gather information from students in their own words, the researchers sought to discover more about the relationships developed between high school students and NPMs, the participants' perception of the hands-on STEM learning experiences, and whether or not participants would consider STEM as a part of their future educational or professional careers. The present study revealed several unique findings that demonstrate how programs offering a STEM experience can encourage youth interest and engagement. These findings included the impact and range of the near-peer mentor/student relationship, the importance of both hands-on learning and autonomy in STEM education outreach programs, and the benefits of NPM led lessons with a career emphasis.

The current study revealed that the connections between the NPMs and the students consisted of equal parts instructor and mentor. Students discussed how much they enjoyed simply interacting with their NPMs and how this relationship was special due to their closeness in age and recently shared experiences. This type of relationship is unique to near-peer mentoring and cannot be replicated through classroom-teacher interactions or mentorship from a senior scientist. This mentoring relationship was also distinct from peer mentorship in that the NPMs were slightly older and could therefore offer guidance and experiences that a peer could not. The NPMs recognize that youth seek meaning and connection through what they do and in their relationships with role models (Noddings, 2017). As undergraduates, they share similar experiences and communities with their slightly younger students. They are encouraged to communicate about science, dreams, and achievement in the research setting. Therefore, the GEMS students reported receiving advice from NPMs on a range of topics, from science, to career and educational planning, to general life lessons. Their comments revealed that they learned lessons of kindness and compassion, pursuing passions, overcoming challenges, and college advice, in addition to scientific knowledge. Students reported that NPMs served as models of success in the sciences and encouraged them to see the possibilities of science in their lives and futures.

Given that the GEMS program supports a diversity of students from populations historically underrepresented in the STEM, our study shows that students explicitly express their appreciation and recognition of role models who are examples of who they could become (Blake-Beard et al., 2011; Weber, 2011). Previous research examining near-peer mentorship from the perspective of the mentor (Anderson et al., 2015; Tenenbaum et al., 2014) had shown that NPMs feel responsible for 'their' students learning and that they continue being active in mentoring (ten-year study, in preparation). The near-peer mentorship multiplies the number of students who have access to STEM experiences since one near-peer mentor is usually responsible for six or seven students. In addition, a greater number of undergraduates are placed in a paid internship to mentor the students. Finally, students return to a program that offers a continuum of opportunities. Of the NPMs, 23% had experience in previous GEMS programs, while 33% of the advanced students were previous participants. Combining the student perspectives from the current study with the gains and opportunities reported by the NPMs emphasizes that near-peer mentorship is yet another tool to incorporate into STEM experiences.

Participants also reported on the benefits of the hands-on, interactive teaching methods that are central to the program. Students shared that they preferred to learn through doing because it was more engaging and allowed them to understand the concepts more fully, which is supported by the literature (e.g., Clark et al., 2016; Sillah et al., 2014). One theme that emerged through this research was the importance of independence and autonomy in learning. When students were given the opportunity to explore a topic of their interest with support but without scripted instructions, they reported enjoying the experience more, learning more, and being challenged to grow and reach outside of their comfort zones. While researchers expected that students would report increased enjoyment and learning through hands-on methods, students' specific focus on the importance of their autonomy in learning and how much the opportunity to choose their own path resonated with them was an important finding supported in the literature. Autonomy research in student learning and motivation (Chirkov, 2009), and the words of our students, illustrate the effectiveness of independent learning. Findings from this research validated the benefits of interactive, self-selected investigative strategies when creating a STEM education program to foster student engagement and learning.

At the conclusion of the summer program, participants overwhelmingly reported they would consider a future career in STEM. Even many of the 5% who stated that they were not interested in STEM careers mentioned professions that involved the sciences. Although it is unknown whether or not these students were considering careers prior to their participation in GEMS, it is encouraging to know that they have an interest in the possibilities of the STEM field at the end of their time in the program. Also of note is that many of the students listed potential career ideas that correlated with projects or lessons during the week. Students discussed specific interests in forensics, epidemiology, public health, and biomedical engineering, for example, all of which were central to modules and projects that occurred during the week. When compared with the list of lessons learned, there is a correlation between lessons learned and the scientific fields introduced by the NPMs. This indicated to researchers that not only are students interested in STEM careers at the conclusion of the program, but they were also obtaining information about new careers they are eager to explore. Additionally, this supported the importance of incorporating NPM ideas into lesson planning because their interests and perspectives resonated most with students.

Limitations and Future Directions

Although this study provides invaluable information about the perspectives of young STEM learners and demonstrates consistency in the learning experiences of students over a three-year period, it is only a snapshot of their thoughts and experiences as the students only share their views at one specific point in time. This study focuses on efficacy of near-peer mentoring, laboratory learning, and continuity for a highly diverse population who have limited resources for STEM education. It is fully recognized that a summer program is but one step along the pathway to scientific literacy. Implementing similar strategies in a variety of settings will help to determine if these components can contribute to STEM education on a broader scale. Following this recommendation, researchers are currently in the process of developing and implementing a similar program in a public school classroom environment during the academic year. Findings will be examined and reported to the educational community as the research continues.

Conclusions

Findings from this study suggest the near-peer mentor model, active laboratory learning, community outreach, and access to a continuity of programs were beneficial to high school students with limited access to STEM enrichment opportunities. The students took the time to report personal and educational guidance from their mentors and growth by reaching outside their comfort zones and exploring their own autonomy and scientific interests. In addition to discussing the support received from near-peer mentors, students also reported on the benefits of the camaraderie they developed with fellow students who shared an interest in science. The combination of hands-on techniques and the positive relationships fostered within a program that offers access to a broad range of participants makes the near-peer mentorship model both unique and beneficial to young science learners.

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