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ARMY EDUCATIONAL OUTREACH PROGRAM

GEMS

2020 Annual Program Evaluation Report Findings

August 2021

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ARMY EDUCATIONAL OUTREACH PROGRAM

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3 | Introduction

The Army Educational Outreach Program (AEOP) vision is to offer a collaborative and cohesive portfolio of Army sponsored science, technology, engineering and mathematics (STEM) programs that effectively engage, inspire, and attract the next generation of STEM talent through K-college programs and expose participants to Department of Defense (DoD) STEM careers. The consortium, formed by the Army Educational Outreach Program Cooperative Agreement (AEOP CA), supports the AEOP in this mission by engaging non-profit, industry, and academic partners with aligned interests, as well as a management structure that collectively markets the portfolio among members, leverages available resources, and provides expertise to ensure the programs provide the greatest return on investment in achieving the Army's STEM goals and objectives.

AEOP Goals

Goal 1: STEM Literate Citizenry. Broaden, deepen, and diversify the pool of STEM talent in support of our defense industry base.

Goal 2: STEM Savvy Educators. Support and empower educators with unique Army research and technology resources.

Goal 3: Sustainable Infrastructure. Develop and implement a cohesive, coordinated, and sustainable STEM education outreach infrastructure across the Army.

This report documents the evaluation study of one of the AEOP elements, Gains in the Education of Mathematics and Science (GEMS). GEMS is administered on behalf of the Army by the National Science Teaching Association (NSTA). The evaluation study was performed by NC State University in cooperation with Battelle, the Lead Organization (LO) in the AEOP CA consortium.

Program Overview

GEMS, administered NSTA on behalf of the AEOP, is a non-residential summer STEM enrichment program for elementary, middle, and high school students (herein referred to as students). GEMS is hosted by Army laboratories and centers on site or in close coordination off site with the area Army laboratories and centers (herein referred to as GEMS sites). Due to the COVID-19 pandemic, all GEMS programs that continued forward (a total of nine) were held in virtual formats in 2020 and six program sites canceled activities.

The following overarching mission drives the GEMS program: to interest youth in STEM through a hands-on Army laboratory or center experience that utilizes inquiry-based learning and Near-Peer mentoring. GEMS is an entry point for a pipeline of AEOP opportunities affiliated with the U.S. Army research laboratories and centers. The various GEMS sites are run independently, with NSTA providing support and guidance in program execution to local lab coordinators. Although they operate under a shared mission, GEMS sites are free to include different topics in their curricula that highlight the mission of the laboratory or center, and sites may set, in addition to the overall program goals, individual laboratory or center goals. Instead of prescribing a specific program-wide model and curriculum, individual sites are able to design curricula (using the hands-on, inquiry-based model) and procedures that make sense considering the specialties of each facility and available resources.

The mentorship model also varies by GEMS site. Many of the GEMS sites use Army scientists and engineers (Army S&Es) to lead GEMS educational activities while other sites use Near-Peer Mentors (NPMs) as a key element in their instructional model. NPMs are developing scientists and engineers (college and high school students) who translate and communicate complex STEM content and their own STEM experiences to the younger GEMS participants. Many sites also leverage the expertise of in-service Resource Teachers (RTs). RTs assist Army S&Es and NPMs in translating STEM research, STEM concepts, and STEM practices into educational curricula as well as provide coaching and instructional supervision to NPMs. RTs also provide adaptive support to individual student participants to ensure maximal engagement and learning. Herein, Army S&Es, NPMs, and RTs are referred together as GEMS mentors except where it is appropriate to differentiate their roles and experiences.

All GEMS programs are designed to meet the following objectives:

1. To nurture interest and excitement in STEM for elementary, middle, and high school participants;
2. To nurture interest and excitement in STEM for mentor participants;
3. To implement STEM enrichment experiences using hands-on, inquiry-based, educational modules that enhance in-school learning;
4. To increase participant knowledge in targeted STEM areas and laboratory skills;
5. To increase the number of outreach participants inclusive of youth from groups historically underrepresented and underserved in STEM;
6. To encourage participants to pursue secondary and post-secondary education in STEM;
7. To educate participants about careers in STEM fields with a particular focus on STEM careers in Army laboratories and centers; and
8. To provide information to participants about opportunities for STEM enrichment through advancing levels of GEMS as well as other AEOP initiatives.

GEMS sites included 18 Army research centers and laboratories operating at 15 program sites in ten states in 2020 (see Table 1). Because of the COVID-19 pandemic, only nine of the 15 program sites held programs. GEMS enrolled 2,203 students at nine sites, a 35% decrease in enrollment compared to 2019 when 2,985 students were enrolled at 14 sites and a 52% decrease in enrollment compared to 2018 when 3,341 students were enrolled at 15 sites. This decrease in participation is attributable due to cancellations of six GEMS programs resulting from the COVID-19 pandemic.

GEMS sites continued to receive applications from more qualified students than they could serve. Sites collectively received 4,533 participant applications in 2020, a 17% decrease compared to 2019 when 5,296 student applications were submitted, and an 21% decrease compared to the 2018 when 5,500 applications were received. Table 2 provides the application and participation data by GEMS site for 2019.

In addition to student participants, 214 adults or high school students acting as mentors worked with the program, including 106 NPMs, 38 RTs, 40 Army S&Es, and 30 other volunteers. This represents a 64% decrease in adult participation as compared to 2019 when 351 adults worked with the program, and a 178% decrease from the 595 adults who participated in 2018.

Table 1. 2020 GEMS Sites

Laboratory or Center	Command*	Location
U.S. Army DEVCOM - C5ISR Center U.S. Army DEVCOM - Army Research Lab – Aberdeen Proving Ground U.S. Army MRDC - Medical Research Institute of Chemical Defense	DEVCOM/ MRDC	Aberdeen, MD
U.S. Army DEVCOM - Army Research Lab – Adelphi	DEVCOM	Adelphi, MD
U.S. Army DEVCOM - Army Research Lab – South	DEVCOM	Austin, TX
U.S. Army Engineer Research Development Center - Construction Engineering Research Laboratory	ERDC	Champaign, IL
U.S. Army MRDC – Aeromedical Research Laboratory	MRDC	Fort Rucker, AL
U.S. Army Medical & Development Command	MRDC	Frederick, MD
U.S. Army DEVCOM - Aviation and Missile Center	DEVCOM	Huntsville, AL
U.S. Army MRDC - Research Institute of Environmental Medicine	MRDC	Natick, MA
U.S. Army DEVCOM - Soldier Center	DEVCOM	Orlando, FL
U.S. Army DEVCOM - Army Research Lab – West	DEVCOM	Playa Vista, CA
U.S. MRDC - Army Institute of Surgical Research	MRDC	San Antonio, TX
U.S. Army MRDC - Walter Reed Army Institute of Research	MRDC	Silver Spring, MD
U.S. Army Engineer Research Development Center	ERDC	Vicksburg, MS
U.S. Army DEVCOM - Data & Analysis Center - White Sands Missile Range U.S. Army ATEC - White Sands Missile Range	DEVCOM / ATEC	White Sands, NM
U.S. Army ATEC - Yuma Proving Ground	ATEC	Yuma, AZ

<table>
<tr><th colspan="5">Table 2. 2020 GEMS Site Applicant and Enrollment</th></tr>
<tr><th>Command</th><th>2020 GEMS Site</th><th>Location</th><th>Number of Applicants</th><th>Number of Enrolled Participants</th></tr>
<tr><td rowspan="2">ATEC</td><td>U.S. Army ATEC - Yuma Proving Ground[1]</td><td>Yuma, AZ</td><td>96</td><td>0</td></tr>
<tr><td>U.S. Army ATEC - White Sands Missile Range</td><td rowspan="2">WSMR, NM</td><td rowspan="2">148</td><td rowspan="2">0</td></tr>
<tr><td rowspan="8">DEVCOM</td><td>U.S. Army DEVCOM - Data & Analysis Center - White Sands Missile Range</td></tr>
<tr><td>U.S. Army DEVCOM - Army Research Lab</td><td>Adelphi, MD</td><td>313</td><td>124</td></tr>
<tr><td>U.S. Army DEVCOM - Army Research Lab – South</td><td>Austin, TX</td><td>87</td><td>21</td></tr>
<tr><td>U.S. Army DEVCOM - Aviation and Missile Center</td><td>Huntsville, AL</td><td>205</td><td>0</td></tr>
<tr><td>U.S. Army DEVCOM - Soldier Center</td><td>Orlando, FL</td><td>100</td><td>46</td></tr>
<tr><td>U.S. Army DEVCOM - Army Research Lab – West</td><td>Playa Vista, CA</td><td>83</td><td>57</td></tr>
<tr><td>U.S. Army DEVCOM - Army Research Lab - Aberdeen Proving Ground</td><td rowspan="3">Aberdeen, MD</td><td rowspan="3">599</td><td rowspan="3">18</td></tr>
<tr><td>U.S. Army DEVCOM - C5ISR Center</td></tr>
<tr><td rowspan="5">MRDC</td><td>U.S. Army MRDC - Medical Research Institute of Chemical Defense</td></tr>
<tr><td>U.S. Army MRDC – Aeromedical Research Laboratory</td><td>Fort Rucker, AL</td><td>534</td><td>372</td></tr>
<tr><td>U.S. Army Medical & Development Command</td><td>Frederick, MD</td><td>854</td><td>693</td></tr>
<tr><td>U.S. Army MRDC - Research Institute of Environmental Medicine</td><td>Natick, MA</td><td>349</td><td>195</td></tr>
<tr><td>U.S. Army MRDC - Walter Reed Army Institute of Research</td><td>Silver Spring, MD</td><td>859</td><td>677</td></tr>
</table>

[1]The YPG GEMS program is a joint effort lead by DEVCOM and executed by ATEC, YPG.

	U.S. MRDC - Army Institute of Surgical Research	San Antonio, TX	115	0
ERDC	U.S. Army Engineer Research Development Center	Vicksburg, MS	69	0
	U.S. Army Engineer Research Development Center - Construction Engineering Research Laboratory	Champaign, IL	122	0
TOTAL		**15**	**4,533**	**2,203**

Table 3 displays demographic information for the 2,087 GEMS student participants for whom demographic data were available. If participants participated in more than one GEMS program, those participants were counted only once in the student profile.

Overall student demographics for 2020 are similar to those of previous years. Half of GEMS students (50%) were female in 2020 (47% in 2019 and 2018). The proportion of students identifying as White decreased somewhat in 2020 as compared to previous years (36% in 2020, 44% in 2019, and 40% in 2018). The proportion of Asian students reversed the downward trend of recent years, with 29% of students identifying as Asian in 2020, compared to 14% in 2019 and 17% in 2018. The proportion of Black or African American students remained relatively constant, with 24% of students identifying themselves as Black or African American in 2020 as compared to 23% in 2019 and 24% in 2018. There was a slight decrease proportion of students identifying themselves as Hispanic or Latino/a (7% in 2020 and 9% in both 2019 and 2018). As in 2019, relatively few students reported being eligible for free-or reduced price school lunch (FARMS), a commonly used indicator of socioeconomic status (12% in 2020 and 13% in 2019), nearly all (97%) spoke English as their first language, and few (8%) would be first generation college attendees. The proportion of students who met the AEOP definition of underserved in 2020 (40%) was similar to 2019 (42%) but slightly higher than in 2018 (35%).

Table 3. 2020 GEMS Student Profile		
Demographic Category		
Gender (n=2,087)*		
Female	1,047	50.2%
Male	1,029	49.3%
Choose not to report or did not provide	11	<1%
Race/Ethnicity (n=2,087)		
Asian	395	18.9%
Black or African American	508	24.3%
Hispanic or Latino	138	6.6%
Native American or Alaska Native	4	<1%
Native Hawaiian or Other Pacific Islander	7	<1%
White	756	36.2%
More than one race	171	8.2%
Other race or ethnicity	22	1.1%
Choose not to report or did not provide	86	4.1%
Grade Level (n=2,087)		
3rd	1	<1%
4th	45	2.2%
5th	190	9.1%
6th	249	11.9%
7th	392	18.8%
8th	430	20.6%
9th	305	14.6%
10th	252	12.1%
11th	170	8.1%
12th	50	2.4%
College – Freshmen	0	0%
College – Sophomore	2	<1%
College – Junior	1	<1%
College – Senior	0	0%
Choose not to report or did not provide	0	0%
School Location (n=2,087)		
Urban (city)	425	20.4%
Suburban	1,080	51.7%
Rural (country)	149	7.1%
Frontier or tribal School	0	0%
DoDDS/DoDEA School	4	<1%
Home school	85	4.1%
Online school	2	<1%
Other	18	<1%
Choose not to report or did not provide	324	15.5%
Receives Free or Reduced-Price Lunch (FARMS) (n=2,087)		
Yes	239	11.5%
No	1,757	84.2%
Choose not to report or did not provide	91	4.4%

English is First Language (n=2,087)		
Yes	2,018	96.7%
No	56	2.7%
Choose not to report or did not provide	13	<1%
One or More Parent/Guardian Graduated from College (n=2,087)		
Yes	1,848	88.5%
No	162	7.8%
Choose not to report or did not provide	77	3.7%
Underserved Status (n=2,087)		
Yes	832	39.9%
No	1,023	49.0%
Insufficient data to make determination**	232	11.1%

*Note – demographic data were available for 2,188 participants. Of these, 101 had participated in more than one GEMS program, and duplicate data were removed, leaving data for 2,087 unique participants.

** Insufficient data is defined as participants who are missing/chose not to report two or more demographic fields OR are missing/chose not to report one demographic field and satisfies only one other condition for Underserved status.

Table 4 summarizes 2020 GEMS program costs. The total cost of the program was $1,253,707. The cost per student participant was $569. The reported travel costs for FY20 programs are from pre-pandemic travel (Oct 2019-Feb 2020) and from non-refundable travel expenses that were booked prior to shifting to virtual programming.

Table 4. 2020 GEMS Program Costs	
Total Cost	$1,253,707
Total Travel	$7,443
Participant Travel	$0
Total Awards	$801,049
Student Awards/Stipends	$282,864
Adult/Teacher/Mentor Awards	$518,185
Cost Per Student	$569

4 | Evaluation At-A-Glance

NC State University, in collaboration with NSTA, conducted a comprehensive evaluation of GEMS. The GEMS logic model below presents a summary of the expected outputs and outcomes for GEMS in relation to the AEOP and GEMS-specific priorities. This logic model provided guidance for the overall GEMS evaluation strategy.

Inputs	Activities	Outputs	Outcomes (Short term)	Impact (Long Term)
• Army sponsorship • NSTA providing oversight of site programming • Operations conducted by 16 Army research laboratories or centers operating in 10 states • 2,203 Students participating in GEMS programs • 214 adults including Army S&Es, Near Peer Mentors, and Resource Teachers participating in GEMS as mentors • Stipends for students • Centralized branding and comprehensive marketing • Centralized evaluation	• Students engage in hands-on and experiment-based STEM programs • Army S&Es, Near Peers, and Resource Teachers facilitate learning experiences for students • Program activities that expose students to AEOP programs and/or STEM careers in the Army or DoD	• Number and diversity of student participants engaged in GEMS • Number of Army S&Es serving as mentors in GEMS • Number of, Near Peers serving as mentors in GEMS • Number of Resource Teachers serving as mentors in GEMS • Number and Title 1 status of schools served through participant engagement • Students, mentors, site coordinators, and NSTA contributing to evaluation	• Increased participant STEM competencies (confidence, knowledge, skills, and/or abilities to do STEM) • Increased interest in future STEM engagement • Increased participant awareness of and interest in other AEOP opportunities • Increased participant awareness of and interest in STEM research and careers • Increased participant awareness of and interest in Army/DoD STEM research and careers • Implementation of evidence-based recommendations to improve GEMS programs	• Increased student participation in other AEOP opportunities and Army/DoD-sponsored scholarship/ fellowship programs • Increased student pursuit of STEM coursework in secondary and post-secondary schooling • Increased student pursuit of STEM degrees • Increased student pursuit of STEM careers • Increased student pursuit of Army/DoD STEM careers • Continuous improvement and sustainability of GEMS

The GEMS evaluation gathered information from multiple participant groups about GEMS processes, resources, activities, and their potential effects in order to address key evaluation questions related to program strengths and challenges, benefits to participants, and overall effectiveness in meeting AEOP and GEMS program objectives.

Key Evaluation Questions

- What aspects of GEMS motivate participation?
- What aspects of GEMS structure and processes are working well?
- What aspects of GEMS could be improved?
- Did participation in GEMS:
  - Increase apprentices' STEM competencies?
  - Increase apprentices' interest in future STEM engagement?
  - Increase apprentices' awareness of and interest in other AEOP opportunities?
  - Increase apprentices' awareness of and interest in Army/DoD STEM research and careers?

The assessment strategy for GEMS included student and mentor questionnaires, phone interviews with students and mentors, and d other program information prepared by NSTA using data from all GEMS sites. Tables 5-9 outline the information collected in student and mentor questionnaires and focus groups, as well as information from the APR that is relevant to this evaluation report.

Table 5. 2020 Student Questionnaires	
Category	**Description**
Profile	Demographics: Participant gender, age, grade level, race/ethnicity, and socioeconomic status indicators
	Education Intentions: Degree level, confidence to achieve educational goals
AEOP Goal 1	Capturing the Student Experience: In-school vs. In-GEMS experience (students)
	STEM Competencies: Gains in knowledge of STEM, science & engineering practices; contribution of GEMS to gains (impact)
	Transferrable Competencies: Gains in 21st Century skills
	STEM Identity: Gains in STEM identity, intentions to participate in STEM, and STEM-oriented education and career aspirations; contribution of GEMS to gains (impact)
	AEOP Opportunities: Past participation, awareness of, and interest in participating in other AEOP programs; contribution of GEMS, impact of AEOP resources
	Army/DoD STEM: Exposure to Army/DoD STEM jobs, attitudes toward Army/DoD STEM research and careers, change in interest for STEM and Army/DoD STEM jobs; contribution of GEMS, impact of AEOP resources
AEOP Goal 2 and 3	Mentor Capacity: Perceptions of mentor/teaching strategies (students respond to a subset)
	Comprehensive Marketing Strategy: How students learn about GEMS, motivating factors for participation, impact of AEOP resources on awareness of AEOP and Army/DoD STEM research and careers
Satisfaction & Suggestions	Benefits to participants, suggestions for improving programs, overall satisfaction

Table 6. 2020 Mentor Questionnaires	
Category	Description
Profile	Demographics: Participant gender, race/ethnicity, occupation, past participation
Satisfaction & Suggestions	Awareness of GEMS, motivating factors for participation, satisfaction with and suggestions for improving GEMS programs, benefits to participants
AEOP Goal 1	Capturing the Student Experience: In-program experiences for students
	STEM Competencies: Gains in knowledge of STEM, science & engineering practices; contribution of GEMS to gains (impact)
	Transferrable Competencies: Gains in 21st Century skills
	AEOP Opportunities: Past participation, awareness of other AEOP programs; efforts to expose students to AEOP, impact of AEOP resources on efforts; contribution of GEMS to gains (impact)
	Army/DoD STEM: Attitudes toward Army/DoD STEM research and careers, efforts to expose students to Army/DoD STEM research/careers, impact of AEOP resources on efforts; contribution of GEMS in changing student Army/DoD career metrics (impact)
AEOP Goal 2 and 3	Mentor Capacity: Perceptions of mentor/teaching strategies (mentors)
	Comprehensive Marketing Strategy: How mentors learn about GEMS, usefulness of AEOP resources on awareness of AEOP and Army/DoD STEM research and careers

Table 7. 2020 Student Interviews	
Category	Description
Profile	Gender, grade level, past participation in GEMS, past participation in other AEOP programs
Satisfaction & Suggestions	Awareness of AEOP, motivating factors for participation, involvement in other programs in addition to GEMS, satisfaction with and suggestions for improving GEMS programs, benefits to participants
AEOP Goal 1 and 2 Program Efforts	Army STEM: AEOP Opportunities – Extent to which students were exposed to other AEOP opportunities
	Army STEM: Army/DoD STEM Careers– Extent to which students were exposed to STEM and Army/DoD STEM jobs

Table 8. 2020 Mentor Interviews	
Category	Description
Profile	Gender, occupation, organization, role in GEMS, past participation in GEMS, past participation in other AEOP programs
Satisfaction & Suggestions	Perceived value of GEMS, benefits to participants, suggestions for improving GEMS programs
AEOP Goal 1 and 2 Program Efforts	Army STEM: AEOP Opportunities – Efforts to expose students to AEOP opportunities
	Army STEM: Army/DoD STEM Careers – Efforts to expose students to STEM and Army/DoD STEM jobs
	Mentor Capacity: Local Educators – Strategies used to increase diversity/support diversity in GEMS

Table 9. 2020 Program Information from NSTA	
Category	Description
Program	Description of course content, activities, and academic level
AEOP Goal 1 and 2 Program Efforts	Underserved Populations: mechanisms for marketing to and recruitment of students from underserved populations
	Army STEM: Army/DoD STEM Careers – Career day exposure to Army STEM research and careers; Participation of Army engineers and/or Army research facilities in career day activities
	Mentor Capacity: Local Educators - University faculty and student involvement, teacher involvement

The GEMS Evaluation included examination of participant outcomes and other areas that would inform continuous program improvement. A focus of the evaluation is on efforts toward the long-term goal of GEMS and all of the AEOP to increase and diversify the future pool of talent capable of contributing to the nation's scientific and technological progress. Thus, it is important to consider how GEMS is marketed and ultimately recruits student participants, the factors that motivate students to participate in GEMS, participants' perceptions of and satisfaction with activities, what value participants place on program activities, and what recommendations participants have for program improvement. The evaluation also collected data about participant perspectives on program processes, resources, and activities for the purpose of recommending improvements as the program moves forward.

Findings are presented in alignment with the three AEOP priorities. The findings presented herein include several components related to AEOP and program objectives, including impacts on students' STEM competencies (e.g., knowledge and skills), STEM identity and confidence, interest in and intent for future STEM engagement (e.g., further education, careers), attitudes toward research, and their knowledge of and interest in participating in additional AEOP opportunities.[2] STEM competencies are necessary for a

[2] The outcomes measured in the evaluation study were informed by the following documents:

Committee on STEM Education. (2013*). Federal Science, Technology, Engineering, and Mathematics (STEM) education 5-year strategic plan: A report from the Committee on STEM Education, National Science and Technology Council.* Washington, DC: The White House, Office of Science and Technology Policy.

National Research Council. (2009). Learning Science in Informal Environments: People, Places, and Pursuits. Committee on Learning Science in Informal Environments. Philip Bell, Bruce Lewenstein, Andrew W. Shouse, and Michael A. Feder, Editors. Board on Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

President's Council of Advisors on Science and Technology (P-CAST). (February 2012). *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.* Executive Office of the President.

STEM-literate citizenry and include foundational knowledge, skills, and abilities in STEM, as well as the confidence to apply them appropriately. STEM competencies are important not only for those engaging in STEM enterprises, but also for all members of society as critical consumers of information and effective decision makers in a world that is heavily reliant on STEM. The evaluation of GEMS measured students' self-reported gains in STEM competencies and engagement in opportunities intended to develop what are considered to be critical STEM skills in the 21st Century—collaboration and teamwork.

Detailed information about methods and instrumentation, sampling and data collection, and analysis are described in Appendix A, the evaluation plan. The reader is strongly encouraged to review Appendix A to clarify how data are summarized, analyzed, and reported in this document. Findings of statistical and/or practical significance are noted in the report narrative, with tables and footnotes providing results from tests for significance. The student and mentor interview protocols are provided in Appendix B (student) and Appendix C (mentor); and student and mentor questionnaire instruments are located in Appendix D (student) and Appendix E (mentor).

Study Sample

Student and mentor participation in GEMS surveys, response rates, and margins of error at the 95% confidence level (a measure of how representative the sample is of the population) are displayed in Table 10. While margin of error was acceptable for students (±2.43%), it was larger than generally acceptable for mentors (±18.89%) indicating the sample of mentors may not be representative of the population. Thus, caution is warranted when interpreting mentor data.

Table 10. 2020 GEMS Questionnaire Participation

Participant Group	Respondents (Sample)	Total Participants* (Population)	Participation Rate	Margin of Error @ 95% Confidence[3]
Students	913	2,087	44%	±2.43%
Mentors	24	214	11%	±18.89%

* Cvent participation data are used for statistical analyses of student data throughout this report

Report of the Academic Competitiveness Council (ACC). (2007). U.S. Department of Education. Available on the Department's Web site at: http://www.ed.gov/about/inits/ed/competitiveness/acc-mathscience/index.html.

[3] "Margin of error @ 95% confidence" means that 95% of the time, the true percentage of the population who would select an answer lies within the stated margin of error. For example, if 47% of the sample selects a response and the margin of error at 95% confidence is calculated to be 5%, if you had asked the question to the entire population, there is a 95% likelihood that between 42% and 52% would have selected that answer. A 2-5% margin of error is generally acceptable at the 95% confidence level.

Because of the pandemic, GEMS programs conducted virtual programs, and phone interviews were conducted with student participants and mentors in lieu of on-site focus groups. Interviews were conducted with 11 students and 15 mentors representing two program sites. Seven of the student participants were male and four were female. Student participants were all middle school or high school students (6^{th} to 12th grades). Fifteen mentors were interviewed also. Nine of the mentors interviewed were NPMs, three were RTs, and three were Army S&Es. Interviews are not intended to yield generalizable findings; rather provide additional evidence of, explanation for, or illustrations of questionnaire data. They add to the overall narrative of GEMS's efforts and impact and highlight areas for future exploration in programming and evaluation.

Respondent Profiles

Student Demographics

Student demographic data for GEMS participants who completed the evaluation survey are presented in Table 11. Nearly 60% of student demographic data were missing from the survey rendering reported student demographics much smaller proportions than normal and potentially not representative of the overall population of survey completers. Among the 371 students with reported demographics, more indicated they were male (57%) than female (43%). Nearly a third of students reported they were Asian (31%) followed by White (28%), and Black/African American (23%). A large proportion of reported demographic students (85%) indicated they were not eligible for free or reduced lunch. Approximately half of students indicated they attended a suburban school (52%). Nearly all students reported speaking English as a first language (97%) and having a parent who graduated from college (89%). Less than half of GEMS students (45%) who provided demographic data and completed the evaluation survey met the AEOP definition of Underserved. Because of the substantial amount of missing demographic data, it is not possible to draw conclusions regarding the similarity of student respondents to the overall enrolled population of GEMS students.

Table 11. 2020 GEMS Student Respondent Profile

Demographic Category	Questionnaire Respondents	
Gender (n=913)		
Female	212	23.2%
Male	159	17.4%
Choose not to report or did not provide	542	59.4%
Race/Ethnicity (n=913)		
Asian	115	12.6%
Black or African American	86	9.4%
Hispanic or Latino	19	2.1%
Native American or Alaska Native	0	0%
Native Hawaiian or Other Pacific Islander	2	<1%

White	105	11.5%
More than one race	30	3.3%
Other race or ethnicity	2	<1%
Choose not to report or did not provide	554	60.7%
Grade Level (n=913)		
3rd	0	0%
4th	3	<1%
5th	19	2.1%
6th	36	3.9%
7th	57	6.2%
8th	54	5.9%
9th	63	6.9%
10th	60	6.6%
11th	52	5.7%
12th	29	3.2%
College – Freshman	0	0%
Choose not to report or did not provide	540	59.1%
School Location (n=913)		
Urban (city)	87	9.5%
Suburban	192	21.0%
Rural (country)	25	2.7%
Frontier or tribal school	0	0%
DoDDS/DoDEA School	0	0%
Home school	21	2.3%
Online school	0	0%
Other	3	<1%
Choose not to report or did not provide	585	64.1%
Receives Free or Reduced-Price Lunch (FARMS) (n=913)		
Yes	43	4.7%
No	314	34.4%
Choose not to report or did not provide	556	60.9%
English is First Language (n=913)		
Yes	361	39.5%
No	12	1.3%
Choose not to report or did not provide	540	59.2%
One or More Parent/Guardian Graduated from College (n=913)		
Yes	330	36.1%
No	33	3.6%
Choose not to report or did not provide	550	60.3%
Underserved Status (n=913)		

Yes	167	18.3%
No	176	19.3%
Insufficient data to make determination*	570	62.4%

* Insufficient data is defined as participants who are missing/chose not to report two or more demographic fields OR are missing/chose not to report one demographic field and satisfies only one other condition for Underserved status.

Mentor Demographics

GEMS mentor demographics for those who responded to the evaluation survey are provided in Table 12. Approximately two-thirds or more of mentors indicated they were male (63%) and White (71%). A quarter of respondents were scientists, engineers, or mathematicians in training (25%). Most mentors reported serving as NPMs (54%) or Assistant NPMs (21%).

Table 12. 2020 GEMS Mentor Respondent Profile		
Demographic Category	Questionnaire Respondents	
Gender (n=24)		
Female	9	37.5%
Male	15	62.5%
Choose not to report	0	0%
Race/Ethnicity (n=24)		
Asian	4	16.7%
Black or African American	1	4.2%
Hispanic or Latino	1	4.2%
Native American or Alaska Native	0	0%
Native Hawaiian or Other Pacific Islander	0	0%
White	17	70.7%
More than one race	0	0%
Other race or ethnicity	1	4.2%
Choose not to report	0	0%
Occupation (n=24)		
Teacher	3	12.5%
Other school staff	0	0%
University educator	0	0%
Scientist, Engineer, or Mathematician in training (undergraduate or graduate student, etc.)	6	25.0%
Scientist, Engineer, or Mathematics professional	2	8.3%
Other	13	54.2%

Role in GEMS (n=24)		
Instructor (typically a University or Army Scientist or Engineer)	2	8.3%
Classroom Assistant	0	0%
Resource teacher (RT)	2	8.3%
Near peer mentor (NPM)	13	54.3%
Assistant Near peer mentor	5	20.8%
Other	2	8.3%

5 | Priority #1 Findings

Broaden, deepen, and diversify the pool of STEM talent in support of our Defense Industry Base

STEM Practices

In order to understand the nature of their STEM engagement during GEMS, the evaluation survey asked students how often they engaged in various STEM practices (see Table 13). Sixty percent or more of students (60%-94%) reported engaging in all STEM practices at least once during GEMS. Activities engaged with most often (most or every day) by approximately two-thirds of students or more were: Examining data to make a conclusion (75%); Using scientific tools and steps to do an experiment (71%); and Planning to do an experiment (68%).

Table 13. Student Engagement in STEM Practices in GEMS (n=913)

	Not at all	At least once	Most days	Every day	Response Total
Work with a person who works in a STEM job on their project	32.4%	23.8%	19.2%	24.6%	
	296	217	175	225	**913**
Work with a person who works in a STEM job on a project assigned by my teacher	32.7%	23.7%	22.3%	21.2%	
	299	216	204	194	**913**
Plan my own research based on my ideas	22.0%	30.3%	30.0%	17.6%	
	201	277	274	161	**913**
	40.4%	32.0%	15.6%	12.0%	

Present a project to a judge or someone from the community	369	292	142	110	**913**
Talk with people working in STEM careers	14.7%	26.8%	20.8%	37.7%	
	134	245	190	344	**913**
Use scientific tools and steps to do an experiment	9.4%	19.3%	35.4%	35.9%	
	86	176	323	328	**913**
Plan and do an experiment	8.9%	22.7%	30.1%	38.3%	
	81	207	275	350	**913**
Examine data or information to make a conclusion or decision	6.2%	18.8%	32.7%	42.2%	
	57	172	299	385	**913**
Work with others as part of a team or group	22.1%	19.6%	26.3%	32.0%	
	202	179	240	292	**913**
Solve real problems	11.1%	25.3%	27.8%	35.8%	
	101	231	254	327	**913**

A composite score[4] was calculated for this set of items entitled "Engaging in STEM Practices in GEMS"[5]. Response categories were converted to a scale of 1 = "Not at all" to 5 = "Every day" and the average across all items in the scale was calculated. This composite score was used to test whether there were differences in student experiences by overall Underserved Classification and all relevant demographics (i.e., gender, race/ethnicity, school location, ELL, 1st Generation Status, and FARMS). Differences in engagement in STEM practices were found by Underserved classification (Underserved students greater agreement; small effect size, d=0.283). Additionally, differences were found by first generation college status (first generation students greater engagement; small effect size, d=0.223) and FARMS (FARMS students greater engagement; small effect size, d=0.207).[6]

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[4] Using multiple statistical tests on related outcomes requires the use of a Type I error rate adjustment to reduce the likelihood of false positives (i.e., detecting a difference when one does not truly exist). However, Type I error rate adjustments lead to a reduction in statistical power (i.e., the ability to detect a difference if it does exist). The use of a composite score helps avoid both of these problems by reducing the total number of statistical tests used. In addition, composite scores are typically more reliable than individual questionnaire items.

[5] The Cronbach's alpha reliability for the Engaging in STEM Practices in GEMS 10 items was 0.841.

[6] Independent samples t-test for GEMS STEM Engagement: Underserved – t(341)=2.61, p=.010; First Generation – t(372)=2.15, p=.033; FARMS – t(372)=2.00, p=.046.

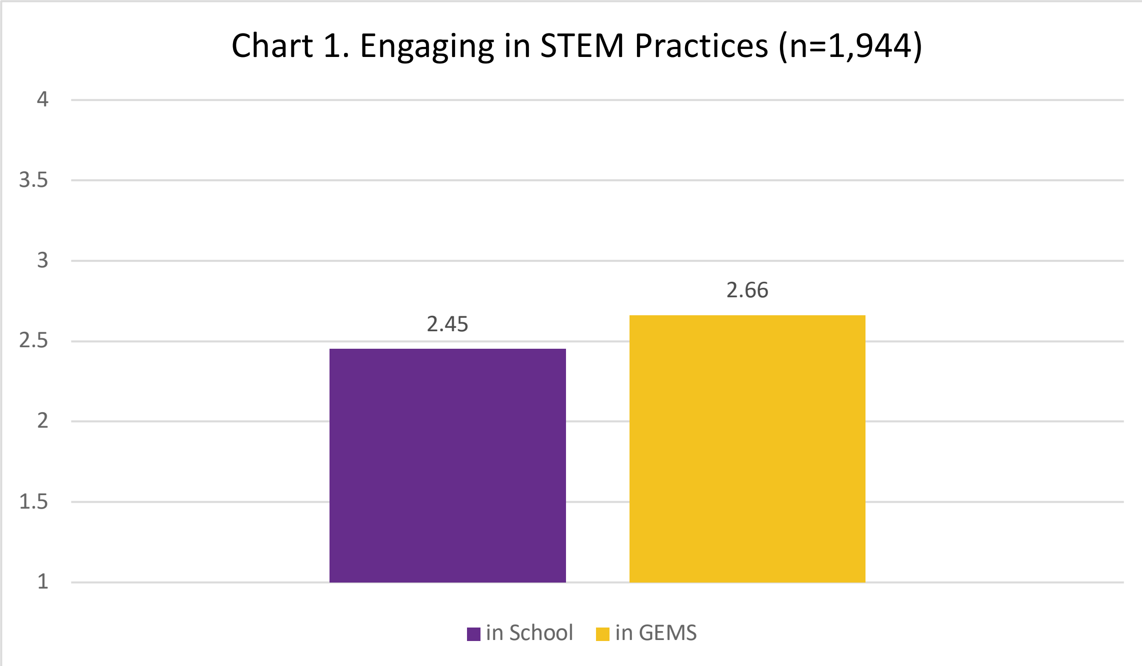
Table 14 presents the same STEM practice items but in reference to an in-school context in order to compare students' typical school experiences with those in GEMS. These responses were also combined into a composite variable "Engaging in STEM Practices in School"[7]. Chart 1 shows scores were significantly higher "in GEMS" compared to "in school" with a medium effect size (d = 0.697).[8]

[7] Cronbach's alpha reliability for the Engage in STEM Practices in School 10 items was 0.845.

[8] STEM Engagement dependent samples t-test: t(912)=10.52, p=.000.

Table 14. Student Engagement in STEM Practices in School (n=913)

	Not at all	At least once	Most days	Every day	Response Total
Work with a person who works in a STEM job on their project	39.8%	34.7%	14.6%	11.0%	
	363	317	133	100	**913**
Work with a person who works in a STEM job on a project assigned by my teacher	40.2%	36.5%	15.3%	8.0%	
	367	333	140	73	**913**
Plan my own research based on my ideas	15.3%	41.3%	34.3%	9.1%	
	140	377	313	83	**913**
Present a project to a judge or someone from the community	38.9%	44.5%	12.8%	3.8%	
	355	406	117	35	**913**
Talk with people working in STEM careers	17.7%	48.1%	21.0%	13.1%	
	162	439	192	120	**913**
Use scientific tools and steps to do an experiment	4.6%	31.3%	46.0%	18.1%	
	42	286	420	165	**913**
Plan and do an experiment	5.6%	35.8%	42.5%	16.1%	
	51	327	388	147	**913**
Examine data or information to make a decision	5.4%	25.8%	45.1%	23.7%	
	49	236	412	216	**913**
Work with others as part of a team or group	6.6%	16.2%	48.0%	29.2%	
	60	148	438	267	**913**
Solve real problems	8.0%	29.7%	37.0%	25.3%	
	73	271	338	231	**913**



Students also shared information about how their GEMS experiences compared with their typical in-school experiences in their responses to open-ended questionnaire items. Students cited differences in the type of learning they experienced in GEMS as compared to in school, and also noted that GEMS content helps them to understand school-based content or for distance learning. For example,

> *"[GEMS] is more fun than science in school."* (GEMS Student)
>
> *"[GEMS] prepared me for next school year's distance learning."* (GEMS Student)
>
> *"[A benefit of GEMS] is working on something outside the school syllabus."* (GEMS Student)

STEM Knowledge and Skills

Students reports of the impact of GEMS on their STEM knowledge is found in Table 15. Three-quarters or more of students (76%-87%) reported that they "learned more than a little" or "learned a lot" in each area. The impact of GEMS on students' new knowledge of a STEM topic (86%) was the most frequently reported area of impact.

Table 15. Student Report of Impacts on STEM Knowledge (n=913)

	No new learning	Learned a little	Learned more than a little	Learned a lot	Response Total
New knowledge of a STEM topic	1.4%	12.0%	33.6%	52.9%	
	13	110	307	483	**913**
How scientists and engineers work on real problems in STEM	4.1%	18.7%	34.8%	42.4%	
	37	171	318	387	**913**
What research work is like in STEM	5.1%	18.8%	32.1%	43.9%	
	47	172	293	401	**913**

These items were combined into a composite variable[9] to test for differential impacts for overall Underserved classification and across subgroups of students. Significant differences were found by Underserved classification (Underserved students learned more; small effect size d=0.387). Additionally, differences were found by gender (females learned more; small effect size; d=.0277), first generation status (first generation students learned more; small effect size, d=0.224), FARMS (FARMS students learned more; small effect size, d=0.265), ELL status (ELL students learned more; small effect size, d=0.212), and race/ethnicity (minority students learned more; small effect size, d=0.365).[10]

Students were also asked about how GEMS impacted their STEM competencies or skills (Table 16). Sixty percent or more of students (66%-89%) reported learning at least a little on all STEM competencies with the exception of two items: How to create charts/graphs to show data/find patterns (45%) and How to identify strengths/limitations of information in technical/scientific books (49%). Areas where students indicated they learned the most (more than a little or a lot) were: How to use knowledge and creativity to come up with a solution (74%); How to support my ideas with my STEM learning (69%); and How to make a model to show how something works (67%).

Composite scores were calculated for STEM competencies[11] to examine whether the GEMS program had differential impacts on student based on Underserved classification and by subgroups of students; no differences were found.

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[9] The Cronbach's alpha reliability for the 3 STEM Knowledge items was 0.795.

[10] Independent samples t-test for STEM Knowledge Impact: Underserved – t(341)=3.57, p=.000; Gender – t(372)=2.67, p=.008; First Generation – t(372)=2.16, p=.032; FARMS – t(372)=2.56, p=.011; ELL – t(372)=2.04, p=.043; Race/Ethnicity – t(372)=3.52, p=.000.

[11] The 13 STEM Competencies items composite had a Cronbach's alpha reliability of 0.945.

Table 16. Students Reporting Gains in their STEM Competencies – Science Practices (n=913)

	No new learning	Learned a little	Learned More than a little	Learned A lot	Response Total
How to explain a problem that can be solved by developing something new	7.1%	26.4%	38.6%	27.9%	
	65	241	352	255	**913**
How to ask a question that could be answered with experiments	12.3%	24.2%	33.7%	29.8%	
	112	221	308	272	**913**
How to use knowledge and creativity to come up with a solution to a problem	6.2%	19.9%	33.6%	40.2%	
	57	182	307	367	**913**
How to make a model to show how something works	10.3%	22.8%	30.6%	36.4%	
	94	208	279	332	**913**
How to design steps for an experiment that work	10.3%	24.6%	33.1%	32.0%	
	94	225	302	292	**913**
How to identify the limitations of steps and tools used for collecting data	11.4%	25.6%	35.3%	27.7%	
	104	234	322	253	**913**
How to do an experiment and record data correctly	13.6%	25.5%	29.7%	31.2%	
	124	233	271	285	**913**
How to create charts or graphs to show data and find patterns	28.0%	26.7%	25.1%	20.2%	
	256	244	229	184	**913**
How to consider different opinions to decide if something works as planned	11.3%	27.6%	33.2%	27.9%	
	103	252	303	255	**913**
How to support my ideas with my STEM learning	8.2%	23.1%	33.8%	34.8%	
	75	211	309	318	**913**
How to identify the strengths and limitations of information in technical or scientific books	25.1%	25.7%	27.2%	22.0%	
	229	235	248	201	**913**
How to present my thoughts that uses data and/or findings from an experiment	14.3%	26.0%	31.1%	28.6%	
	131	237	284	261	**913**
	12.4%	25.2%	29.7%	32.7%	

How to support my thoughts with real data	113	230	271	299	**913**

Students were asked to rate the impact of GEMS on their 21st Century skills, defined as skills such as collaboration, communication, perseverance, and problem-solving that are necessary across a wide variety of fields (Table 17). Overall, students reported high levels of impact on 21st century skills with 40% or more reporting having learned more than a little or a lot across items except for how to create videos, blogs, and social media posts (29%). Skills impacted the most were: How to solve problems (73%); How to use creative ideas to make something (71%); How to think about how systems work and how parts interact with each other (69%); and How to think creatively (67%).

Table 17. Student Report of Impacts on 21st Century Skills (n=913)

	No new learning	Learned a little	Learned More than a little	Learned A lot	Response Total
How to think creatively	8.8%	24.1%	30.9%	36.3%	
	80	220	282	331	**913**
How to work creatively with others	24.5%	22.6%	24.9%	28.0%	
	224	206	227	256	**913**
How to use my creative ideas to make something	8.0%	20.9%	31.1%	40.0%	
	73	191	284	365	**913**
How to think about how systems (big things) work and how parts interact with each other	7.7%	23.1%	30.1%	39.1%	
	70	211	275	357	**913**
How to judge other people's thoughts and beliefs	29.4%	27.8%	23.2%	19.6%	
	268	254	212	179	**913**
How to solve problems	6.5%	20.8%	36.0%	36.7%	
	59	190	329	335	**913**
How to communicate clearly in speaking and writing	21.6%	26.2%	26.8%	25.4%	
	197	239	245	232	**913**
How to work with others well	29.0%	21.0%	22.5%	27.5%	
	265	192	205	251	**913**
	21.7%	23.9%	25.3%	29.1%	

How to interact well with people in a respectful and professional manner	198	218	231	266	**913**
How to get and evaluate information and the sources of information in an acceptable time period	14.5%	28.3%	29.6%	27.7%	
	132	258	270	253	**913**
How to use and manage information or data accurately, creatively, and ethically	13.1%	25.0%	30.9%	31.0%	
	120	228	282	283	**913**
How to analyze media (the news) to understand the different points of view of people	33.6%	22.7%	23.4%	20.3%	
	307	207	214	185	**913**
How to create videos, blogs, and social media posts	52.5%	18.2%	14.6%	14.8%	
	479	166	133	135	**913**
How to use technology to do research, organize my ideas, evaluate things, and communicate information	16.9%	29.8%	25.4%	27.9%	
	154	272	232	255	**913**
How to adapt to change when things don't go as planned	10.5%	25.1%	28.7%	35.7%	
	96	229	262	326	**913**
How to use feedback on my work effectively	16.1%	26.0%	29.4%	28.6%	
	147	237	268	261	**913**
How to get started and do work without being told to	20.5%	23.8%	25.3%	30.4%	
	187	217	231	278	**913**
How to manage projects to complete them on time	17.5%	21.8%	26.8%	33.8%	
	160	199	245	309	**913**
How to stick with work until it is finished to produce results	14.8%	22.2%	27.6%	35.4%	
	135	203	252	323	**913**
How to lead and guide others in a team or group	35.9%	21.4%	21.8%	20.9%	
	328	195	199	191	**913**
How to be responsible to others - thinking about the larger community good	22.8%	23.5%	23.7%	30.0%	
	208	215	216	274	**913**

The 21st Century skills items were combined into a composite variable[12] to test for differential impacts by overall Underserved classification and across subgroups of students; significant differences were not found.

STEM Identity and Confidence

Since STEM identity, or seeing oneself as capable of succeeding in STEM, has been linked to future interest and participation in STEM as a field of study and career choice[13], GEMS and other programs in the AEOP portfolio emphasize supporting participants' STEM identities. Thus, the student survey included evaluation items intended to measure the impact of GEMS on students' STEM identities (Table 18). After participating in GEMS, extremely large proportions of students (82%-94%) either agreed or strongly agreed with each statement related to the impact of GEMs on their STEM identities. More than 90% of GEMS students reported positive impacts in the following areas: Feeling more prepared for more challenging STEM activities (94%) and Feeling like they accomplished something in STEM (93%). Comparing results on a composite created from these STEM Identity items,[14] there were no significant differences by overall Underserved status, and only one significant difference found by individual student demographics in terms of first generation status (first generation students reported higher agreement; small effect size, d=0.280).[15]

Table 18. Student Report of Impacts on STEM Identity (n=913)

	Strongly disagree	Disagree	Agree	Strongly Agree	Response Total
I am interested in a new STEM topic	1.6%	8.5%	50.5%	39.3%	
	15	78	461	359	**913**
I am thinking about pursuing a STEM career	2.8%	15.3%	35.5%	46.3%	
	26	140	324	423	**913**
I feel like I accomplished something in STEM	1.4%	5.6%	47.2%	45.8%	
	13	51	431	418	**913**
I feel more prepared for more challenging STEM activities	1.5%	4.9%	49.1%	44.5%	
	14	45	448	406	**913**

[12] The 21st Century Skills composite (21 items) has a Cronbach's alpha reliability of 0.964.

[13] Chang, M. J., Sharkness, J., Hurtado, S. and Newman, C. B. (2014), What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups. J. Res. Sci. Teach., 51: 555–580.

[14] The Cronbach's alpha reliability for these 6 Identity items was 0.851.

[15] Independent samples t-test results for Identity and First Generation Status: t(372)=2.70, p=.007.

I am confident to try out new ideas or procedures on my own in a STEM project	1.8%	8.7%	46.2%	43.4%	
	16	79	422	396	**913**
I am interested in working with mentors who work in STEM	2.7%	8.7%	44.2%	44.4%	
	25	79	404	405	**913**

6

6 | Priority #2 Findings

Support and empower educators with unique Army research and technology resources.

Mentor Strategies and Support

Mentors, including NPMs, RTs, and site directors, play a critical role in the GEMS program in terms of students' engagement in STEM, their sustained interest in STEM, and their inspiration to pursue STEM careers in the future. The nature and quality of the various supports provided by these individuals is a key component in students' GEMS experiences. Mentors were therefore asked whether they used a number of strategies when working with students. These strategies comprised five main areas of effective mentoring:[16]

1. Establishing the relevance of learning activities;
2. Supporting the diverse needs of students as learners;
3. Supporting students' development of collaboration and interpersonal skills;
4. Supporting students' engagement in "authentic" STEM activities; and
5. Supporting students' STEM educational and career pathways.

Tables 19-23 summarize mentors' reported use of strategies associated with each of the five areas of effective mentoring. A majority of mentors reported using most strategies in each area.

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[16] Mentoring strategies examined in the evaluation were best practices identified in various articles including:

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among US students. *Science Education*, *95*(5), 877-907.

Ornstein, A. (2006). The frequency of hands-on experimentation and student attitudes toward science: A statistically significant relation (2005-51-Ornstein). *Journal of Science Education and Technology*, *15*(3-4), 285-297.

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education*, *96*(3), 411-427.

Approximately 70% or more of mentors (71%-96%) reported using each strategy to help make the learning activities in GEMS relevant to students (Table 19) except for the strategy of selecting readings/activities that relate to students' backgrounds (42%). Strategies used most frequently (endorsed by 90% or more of mentors) were asking students to relate real-life events/activities to topics covered in GEMS (96%) and helping students become aware of the roles STEM plays in their everyday lives (96%).

Table 19. Mentors Using Strategies to Establish Relevance of Learning Activities (n=24)

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Become familiar with my student(s) background and interests at the beginning of the GEMS experience	83.3%	16.7%	
	20	4	**24**
Giving students real-life problems to investigate or solve	79.2%	20.8%	
	19	5	**24**
Selecting readings or activities that relate to students' backgrounds	41.7%	58.3%	
	10	14	**24**
Encouraging students to suggest new readings, activities, or projects	83.3%	16.7%	
	20	4	**24**
Helping students become aware of the role(s) that STEM plays in their everyday lives	95.8%	4.2%	
	23	1	**24**
Helping students understand how STEM can help them improve their own community	70.8%	29.2%	
	17	7	**24**
Asking students to relate real-life events or activities to topics covered in GEMS	95.8%	4.2%	
	23	1	**24**

Two-thirds or more of mentors (67%-100%) reported using all strategies to support the diverse needs of students as learners (Table 20) with the exception of two strategies: Highlighting under-representation of women and racial/ethnic minority populations in STEM (42%) and Integrating ideas from education literature to teach/mentor students from groups underrepresented in STEM (29%). All mentors, however, indicated they used a variety of teaching/mentor activities to meet the needs of all students (100%).

Table 20. Mentors Using Strategies to Support Diverse Needs of Students as Learners (n=24)

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Identify the different learning styles that my student (s) may have at the beginning of the GEMS experience	66.7%	33.3%	
	16	8	**24**
Interact with students and other personnel the same way regardless of their background	83.3%	16.7%	
	20	4	**24**
Use a variety of teaching and/or mentoring activities to meet the needs of all students	100.0%	0.0%	
	24	0	**24**
Integrating ideas from education literature to teach/mentor students from groups underrepresented in STEM	29.2%	70.8%	
	7	17	**24**
Providing extra readings, activities, or learning support for students who lack essential background knowledge or skills	70.8%	29.2%	
	17	7	**24**
Directing students to other individuals or programs for additional support as needed	83.3%	16.7%	
	20	4	**24**
Highlighting under-representation of women and racial and ethnic minority populations in STEM and/or their contributions in STEM	41.7%	58.3%	
	10	14	**24**

Half or more of mentors (50%-88%) reported using each strategy associated with supporting students' development of collaboration and interpersonal skills (see Table 21). More than three-quarters of mentors reported having students listen to ideas of others with an open mind (88%) and having students tell other people about their backgrounds and interests (79%).

Table 21. Mentors Using Strategies to Support Development of Collaboration and Interpersonal Skills (n=24)

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Having my student(s) tell other people about their backgrounds and interests	79.2%	20.8%	
	19	5	**24**
Having my student(s) explain difficult ideas to others	75.0%	25.0%	
	18	6	**24**
Having my student(s) listen to the ideas of others with an open mind	87.5%	12.5%	
	21	3	**24**
Having my student(s) exchange ideas with others whose backgrounds or viewpoints are different from their own	62.5%	37.5%	
	15	9	**24**
Having my student(s) give and receive constructive feedback with others	66.7%	33.3%	
	16	8	**24**
Having students work on collaborative activities or projects as a member of a team	58.3%	41.7%	
	14	10	**24**
Allowing my student(s) to resolve conflicts and reach agreement within their team	50.0%	50.0%	
	12	12	**24**

Half or more of mentors (50%-100%) reported using each strategy associated with supporting student engagement in "authentic" STEM activities (Table 22) except having students search for and review technical literature to support their work (17%). All mentors reported providing students with constructive feedback to improve their STEM competencies (100%) and allowing students to work independently to improve their self-management abilities (100%).

Table 22. Mentors Using Strategies to Support Student Engagement in "Authentic" STEM Activities (n=24)

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Teaching (or assigning readings) about specific STEM subject matter	79.2%	20.8%	
	19	5	**24**
Having my student(s) search for and review technical research to support their work	16.7%	83.3%	
	4	20	**24**
Demonstrating laboratory/field techniques, procedures, and tools for my student(s)	66.7%	33.3%	
	16	8	**24**
Supervising my student(s) while they practice STEM research skills	83.3%	16.7%	
	20	4	**24**
Providing my student(s) with constructive feedback to improve their STEM competencies	100.0%	0.0%	
	24	0	**24**
Allowing students to work independently to improve their self-management abilities	100.0%	0.0%	
	24	0	**24**
Encouraging students to learn collaboratively (team projects, team meetings, journal clubs, etc.)	50.0%	50.0%	
	12	12	**24**
Encouraging students to seek support from other team members	54.2%	45.8%	
	13	11	**24**

Half or more of mentors (50%-71%) indicated they used all strategies to support students' STEM educational and career pathways (see Table 23) with the exception of two items: Helping students with their resume, application, personal statement, and/or interview preparation (21%); and Helping students build a professional network in a STEM field (42%). Strategies with the greatest use by mentors were: Providing guidance about educational pathways that will prepare students for a STEM career (75%); Discussing STEM career opportunities in private industry or academia (71%); and Discussing the economic, political, ethical, and/or social context of a STEM career (71%).

Table 23. Mentors Using Strategies to Support Student STEM Educational and Career Pathways (n=24)

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Asking my student(s) about their educational and/or career goals	58.3%	41.7%	
	14	10	**24**
Recommending extracurricular programs that align with students' goals	58.3%	41.7%	
	14	10	**24**
Recommending Army Educational Outreach Programs that align with students' goals	58.3%	41.7%	
	14	10	**24**
Providing guidance about educational pathways that will prepare my student(s) for a STEM career	75.0%	25.0%	
	18	6	**24**
Discussing STEM career opportunities within the DoD or other government agencies	62.5%	37.5%	
	15	9	**24**
Discussing STEM career opportunities in private industry or academia	70.8%	29.2%	
	17	7	**24**
Discussing the economic, political, ethical, and/or social context of a STEM career	70.8%	29.2%	
	17	7	**24**
Recommending student and professional organizations in STEM to my student(s)	50.0%	50.0%	
	12	12	**24**
Helping students build a professional network in a STEM field	41.7%	58.3%	
	10	14	**24**
Helping my student(s) with their resume, application, personal statement, and/or interview preparations	20.8%	79.2%	
	5	19	**24**

Students were also asked about the use of teaching and mentoring strategies by their teacher during GEMS (Table 24). The most frequently reported strategies (85% or greater) include: Learning or practicing STEM skills (94%): Used more than one way to help students learn (89%); Giving extra help when needed (87%); and Helped me learn about STEM in my everyday life. Teachers were less likely to recommend AEOPS that align with students' interests (42%).

Table 24. GEMS Student Reports of Teaching and Mentoring Strategies used by Teachers (n=913)

	Yes – my teacher used this strategy	No – my teacher did not use this strategy	Response Total
Helped me learn about STEM in my everyday life	86.4%	13.6%	
	789	124	**913**
Helped me understand how I can use STEM to improve my community	78.3%	21.7%	
	715	198	**913**
Used more than one way to help me learn	89.3%	10.7%	
	815	98	**913**
Gave me extra help when I needed it	86.9%	13.1%	
	793	120	**913**
Encouraged me to share ideas with others	80.2%	19.8%	
	732	181	**913**
Allowed me to work on a team project or activity	68.9%	31.1%	
	629	284	**913**
Helped me learn or practice STEM skills	94.2%	5.8%	
	860	53	**913**
Gave me feedback to help me improve in STEM	80.8%	19.2%	
	738	175	**913**
Talked to me about the education I need for a STEM career	63.4%	36.6%	
	579	334	**913**
Recommended other Army programs that match my interests	41.8%	58.2%	
	382	531	**913**
	52.5%	47.5%	

Discussed STEM careers with the Army or Department of Defense	479	434	**913**

Program Features and Feedback/Satisfaction

Students and mentors were asked how satisfied they were with a number of features of the GEMS program. Responses to items can be classified into two main categories – largely satisfied with or did not experience. More than a third of GEMS students had not experienced features such as invited speakers (36% did not experience) and virtual field trips/laboratory tours (52% did not experience). Program features with which the most students reported satisfaction at the somewhat or very much satisfied levels were the teaching/mentoring provided during GEMS (70%) and STEM topics included in GEMS (70%).

Table 25. Student Satisfaction with GEMS Program Features (n=913)

	Did not experience	Not at all	Somewhat	Very much	Response Total
The virtual (online) GEMS program	0.4%	4.4%	39.5%	55.6%	
	4	40	361	508	**913**
The STEM topics included GEMS	0.3%	1.9%	27.9%	69.9%	
	3	17	255	638	**913**
Teaching or mentoring provided during GEMS activities	1.5%	1.9%	26.3%	70.3%	
	14	17	240	642	**913**
Educational materials (e.g., workbooks, online resources, etc.) used during program activities	4.1%	4.6%	33.6%	57.7%	
	37	42	307	527	**913**
Invited speakers events	35.6%	5.3%	24.8%	34.4%	
	325	48	226	314	**913**
Virtual field trips or laboratory tours	52.2%	8.5%	18.7%	20.5%	
	477	78	171	187	**913**

Students responded to an open-ended item on the questionnaire asking them about their overall satisfaction with their GEMS experiences. Of the 100 students whose responses were sampled, nearly all (97%) made positive comments and a large majority (87%) commented only on positive aspects of the program. Positive comments focused on the learning they experienced, the quality of mentors and students' connections with mentors, the career information they received, the flexibility programs displayed in transitioning to virtual formats, providing students with “something to do” over the summer, and appreciation for the stipend. Students said, for example:

> *“I loved it! I learned so much about how to do things on scratch. I probably wouldn't be so interested in computer programming without this class. If you posted a comment about a problem on your project, it gets answered almost immediately. It was fun, unlike some STEM camps, and that encouraged me to do the work. It was also fun to impress my parents with my work. Thank you for this awesome experience for me this summer!”* (GEMS Student)

> *“I felt like I learned a lot about various fields in STEM, and I was very satisfied with that. Before attending GEMS, I was primarily interested in Biomedical Sciences and Biology, but GEMS helped me feel more interested in engineering and astrobiology.*” (GEMS Student)

> *“I was satisfied with my GEMS experience. It was easy to talk to mentors if I had any questions and ask for clarification. They were very nice and taught us in ways which we would have fun learning including Kahoot.”* (GEMS Student)

> *“I had a great time in GEMS…I learned new things that school didn't teach us. I also learned more about STEM and STEM careers. I learned new skills that can help me in future STEM classes. I really enjoyed the labs that GEMS provided because it gave me something to do, and it kept me occupied.”* (GEMS Student)

Ten students made positive comments about their GEMS experience, but also included some caveats. These caveats included comments about the virtual format, not being challenged and/or being grouped with younger students, a desire for more activities using the virtual platform, a desire for more career information, being periodically bored, and having difficulty navigating the program content online. These students said, for example,

> *“I really enjoyed it and I thought it was well done considering it was virtual. I think it would've been more rewarding in person. I had fun, but I don't think I learned anything.”* (GEMS Student)

> *“I understand that the virtual nature of this year’s GEMS made it more challenging for the mentors. Overall, the experience was positive, and I know the mentors did the best they can under these circumstances. I would have preferred more virtual activities as opposed to hands-on activities at home using household objects.”* (GEMS Student)

> *“Most of the activities presented during my week in GEMS were far below my age level, and they were similar to things I had done in the past. Consequently, the activities were easy, and I found them to be boring. I know this is partially because the activities had to be feasible for a large range of ages and experiences. I think that, if possible, it would be beneficial towards more experienced*

students if they could be placed into a separate group that is given more complicated or advanced activities." (GEMS Student)

"It was pretty good, but I found myself kind of tuning it out sometimes because some of it was really boring. I enjoyed the hands on parts way more." (GEMS Student)

Three students made no positive comments, instead focusing on dissatisfaction with the virtual format, problems with technology, and a complaint that there was too much work assigned.

Another open-ended questionnaire item asked student to list three benefits of participating in GEMS. Of the 100 responses analyzed, the most frequently mentioned benefit, mentioned by half of respondents, was the STEM learning they experienced. Over a third (35%) mentioned the career information and guidance they received as a benefit of GEMS. Another 25% of respondents cited specific STEM skills or research skills as a benefit. About a fifth of respondents noted that participating in GEMS increased their motivation for or interest in STEM (22%) or that the hands-on nature of and real-world connections in GEMS (21%) was a benefit. Other benefits, mentioned by between 5% and 16% of respondents included having fun, increasing their confidence, teamwork, networking with professionals, problem solving skills improving communication skills, the mentors or teachers, the AEOP or DoD information they received, and giving them a focus for the summer.

Students participating in interviews were also asked to share their opinions about the benefits of the GEMS program. These students cited similar benefits as did questionnaire respondents, focusing on the opportunities for STEM learning, the career information they gained, and the NPMs. Students said, for example,

"I learned about… the way the military utilizes STEM and it's really intrigued me more into all the different jobs." (GEMS Student)

"[Having the NPMs] grounds the experience as not somebody who's had years' experience, [but] with somebody who's also learning and going through the steps of becoming an engineer, becoming a scientist, becoming mathematician…. [One of the NPMs] inspired me. I'm trying to follow in his footsteps as well as I can. And I believe that the fact that a mentor can do that is a great thing. "(GEMS Student)

Students were also asked in an open-ended questionnaire item to list three ways in which the program could be improved. A wide variety of improvements were suggested in the 100 responses sampled. The most frequently suggested improvements, mentioned by 40% of students, focused on activities, including requests for more hands-on activities, more or better speakers, virtual field trips, or more real-world demonstrations and examples. Over a third of students (36%) made suggestions related to the virtual platform for the program, including suggestions that the program be held in person, that more varied online tools be used (e.g., "not just kahoot"), and comments about technology problems. Nearly a quarter of students (24%) suggested improvements to the schedule or logistical elements of GEMS, including shorter presentations, providing more or longer breaks, and having longer days or a longer program. Improvements suggested by 15%-20% of students included improvements to organization and/or communication (e.g., providing daily schedules, communicating about program details, requests that the mentors speak more slowly), providing more or different topics, providing more interactions between students, and improving teamwork (more teamwork, smaller groups, or grouping students by experience level). Other improvements, mentioned by between 10% or less of students included the following:

- more in-depth or challenging content
- more career information
- more Army information
- expanding the age range for GEMS
- improvements to materials (e.g., students reported receiving incomplete materials "kits" and requested that more household materials be used for activities in the virtual format)
- Having a teacher chat function

Students participating in interviews were also asked for their opinions about ways that GEMS could be improved. These students made a variety of suggestions, most of which were similar to the suggestions made by questionnaire respondents and focused on having more hands-on activities available. These students also suggested having mentors create videos modeling activities.

Mentors were also asked to rate their satisfaction with GEMS program features (Table 26). Similar to student responses, mentor satisfaction can be classified in two categories – largely satisfied or did not experience. Half or more mentors indicated being at least somewhat satisfied with all program features (58%-100%) except for two which most did not experience: Communication with NSTA (67% did not experience) and Field trips/laboratory tours (63% did not experience). All or nearly all mentors indicated they were at least somewhat satisfied with Support for instruction or mentorship during program activities (100%) and Communication with GEMS organizers/site coordinators (96%).

Table 26. Mentor Satisfaction with GEMS Program Features (n=24)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Application or registration process	8.3%	0.0%	4.2%	41.7%	45.8%	
	2	0	1	10	11	**24**
Communicating with the National Science Teachers Association (NSTA)	66.7%	0.0%	12.5%	4.2%	16.7%	
	16	0	3	1	4	**24**
	0.0%	0.0%	4.2%	12.5%	83.3%	

Communicating with GEMS organizers/site coordinators	0	0	1	3	20	**24**
The physical location(s) of GEMS's activities	33.3%	4.2%	4.2%	29.2%	29.2%	
	8	1	1	7	7	**24**
Support for instruction or mentorship during program activities	0.0%	0.0%	0.0%	25.0%	75.0%	
	0	0	0	6	18	**24**
Stipends (payment)	8.3%	0.0%	12.5%	29.2%	50.0%	
	2	0	3	7	12	**24**
Invited speakers or "career" events	37.5%	0.0%	4.2%	12.5%	45.8%	
	9	0	1	3	11	**24**
Field trips or laboratory tours	62.5%	0.0%	0.0%	12.5%	25.0%	
	15	0	0	3	6	**24**

Like students, mentors were also asked to respond to open-ended questionnaire items asking for their opinions about GEMS and were asked to comment on their overall satisfaction with GEMS. Of the 20 mentors who responded, all but one made positive comments about GEMS. These mentors attributed their satisfaction to the engaging program content and activities, the career information students received, and the ability of the program to adapt. Mentors said, for example,

> *"Overall, I was pretty satisfied with GEMS this year. It was unfortunate that we had to run the program remotely rather than in person, but I think that everything actually went well and there were no major issues. I think everyone did a great job planning and communicating with one another to ensure that we could give the students as good of an experience as possible, even if we couldn't see them in real life. The labs and activities were all engaging for the kids and aligned with all different STEM aspects, giving the students lots of new and interesting information that hopefully inspires them to pursue STEM careers, or at least further their learning outside of the program and outside of school…. [I am] very impressed that we did such a great job with eGEMS this year and I am proud to have been a part of it. The mentors, coordinators, and students are all very caring, respectful and passionate."* (GEMS Mentor)

> *"I was very pleasantly surprised by how well virtual GEMS went this summer. I was apprehensive when I first learned that we'd be running GEMS online, but it ended up working out really well. Providing supplies went decently well and the kids were engaged and interested throughout the week. I know that eGEMS is certainly not the same as normal GEMS and I hope normal GEMS can happen again next year, but it's great to know that eGEMS is still a solid back-up plan. I was very satisfied with this summer - given the circumstances."* (GEMS Mentor)

"The [Army lab] team was amazing in their ability to adapt quickly to multiple problems that nobody could have anticipated. I've worked with multiple STEM-related camps/competitions with students from high-school through undergrad/grad and this was one of the most enjoyable camps of all of them. That's even more impressive given the virtual aspect of this one." (GEMS Mentor)

Three of the responding mentors made positive comments about their GEMS experience but added caveats. These caveats focused on issues with transitioning to the online format, the program schedule and program planning, and an observation that the NPMs are paid less than other mentors in spite of their sometimes heavier workload. Mentors said, for example,

"When [GEMS] went virtual, there were some forms that the army said were all good to go but when go time came, they changed their minds. Luckily, my contact, was excellent with helping figure out what I did need to do as I was [out of state] at the time. Once the camp had its orientation on the Friday before the camp started, we switched from Google Meet to Microsoft Teams, and it was a scramble to get the messages out because only one or two people were helping with getting invites out to all the kids. Once the camp got started and the team worked out connectivity issues the camp went smoothly. I would recommend having more structure to the final afternoon since even on Thursday evening the details of Friday afternoon were being changed and adjusted to fit additional items." (GEMS Mentor)

"Overall, I fairly enjoyed being a Near Peer Mentor for GEMS. Being able to interact and work with the students was both exhilarating and rewarding… Being able to smoothly lead a group allowed me to reflect on self-growth in leadership. The efforts of the students and mentors allowed for the successful commencement of GEMS…I wish that the near-peer mentors helped contribute to the organization of the program. I would have gladly accepted the responsibility to create spreadsheets of all the names along with their individual groups. In addition, instead of merely sending out the log-in information, the near-peer mentors could have been granted the task of reaching out to the students to confirm their ability to actually sign onto all the accounts for each activity." (GEMS NPM)

Only one responding mentor made no positive comments, noting technical issues the program had with using Microsoft Teams in the DoD context.

Mentors were also asked to identify the three most important strengths of GEMS. The 24 mentors who responded mentioned a wide variety of program strengths. The most frequently mentioned strengths, mentioned by eight mentors were the STEM learning students experience and the opportunity to acquire a range of 21st Century skills (e.g., problem solving, communication, work ethic, workplace skills, and the ability to work independently). Seven mentors cited the opportunity for hands-on learning as a strength, and five noted the NPMs were a strength of the program. Other strengths, noted by three or four mentors, included the real-world connections to students' learning, the speakers, the opportunity to network with professionals, increases in students' motivation for or interest in STEM, the program's organization and communication, and the adaptability of the program in transitioning to the virtual format.

Mentors participating in interviews were also asked to share their opinions about the value of GEMS, both to participating students and to themselves. Mentors cited a number of ways that students benefit from GEMS, focusing on students' increased in interest in STEM, the value of the hands-on experiences, the STEM learning students experience, the career information they gain, the opportunity to make real-world connections to their learning, and the relationships students form with the NPMs. Mentors said, for example,

> *"[In school, teachers] don't have a lot of time to implement science and social studies...with GEMS, the students are really experiencing science and math without the time constraint...it's opening, their minds to be critical thinkers, to be creative, to problem solve...it exposes them to science in a different way. They are able to participate in the hands-on experiments. They're able to learn science concepts and to learn about the different jobs that are available in the STEM world that they're not exposed to in their regular classrooms."* (GEMS RT)
>
> *"GEMS offers that fun part of science. [Students] can explore things from like robotics, all the way to forensic science...It really gives them an insight to what the STEM field really offers. It's also, targeted at people who may not have the resources to learn about the STEM field...And they get to really learn about what is really involved when it comes to this field in STEM."* (GEMS NPM)
>
> *"What GEMS is doing this summer is taking learning out of the classroom. And the value of that is that makes a lifelong learner...We [asked students] 'what's one thing you learned from GEMS or that surprised you from your GEMS experiments today?' And one student said really everything because I don't really like science, and this has been so interesting. And I thought 'that is a win.'"* (GEMS NPM)
>
> *"[GEMS is] immensely valuable to the students because it gives them an early exposure to real-life scientists and engineers doing real cutting-edge science. It gives them exposure to the many different career paths and how they all tie in. It gives them exposure to honestly a world that a lot of students don't know exists inside of the Department of Defense and the Army…It makes the military real to the students."* (GEMS RT)
>
> *"[Among the NPMs], we have some bio majors and then we also have younger near peer mentors who are just out of high school. So just having the demographic of the near peer mentors go over a lot of subject areas and also just experience levels is really helpful...I think the selection of the near peer mentors is a really important factor in how smooth the connection is with the students between the near peer mentors and the students."*(GEMS NPM)

Mentors participating in interviews also discussed the benefits they personally experience from participating in GEMS. RTs focused on the value of being able to take their experiences in STEM back to their classrooms. As one RT said,

> *"The benefit for me is the benefit for my students, because everything that I'm exposed to, I get to bring back to them on a yearly basis and let them know that that world exists. So, I get to reach a lot more students. I generally have a hundred and fifty plus students that I can reach out to tell about these programs, show them some different paths, all of the websites [and] the labs."* (GEMS RT)

Army S&E mentors noted that they benefit from the new perspective they gain on their work from presenting it to others, the satisfaction of working with participants and NPMs, and the incentive to keep abreast of information from private industry that mentoring provides them. One Army S&E mentor noted that a primary benefit to her of serving as a mentor is improving her communication skills. She said,

> *"The biggest benefit [to me] is my science communication skills. It's one thing to communicate science to your colleagues who are in the weeds of it, but it's an entirely different thing to communicate science and the science that you do and why you do it and why it's important to a rising fifth and sixth grader."* (GEMS S&E Mentor)

NPMs were especially vocal about the benefits they experience from acting as a GEMS mentor. NPMs noted a variety of benefits including developing leadership skills, and communication skills, and other workplace skills; the opportunity to learn science; improving their own teamwork skills; and the opportunity to network with Army S&Es. NPMs said, for example,

> *"Not only have I learned a lot more science through GEMS, but I've also become such a better person because of it...I used to be very, very shy and not a very strong leader or even a very strong team worker until I started GEMS. And now...I'm more vocal and outspoken. I can definitely lead and play as a team."* (GEMS NPM)

> *"[Working as a GEMS NPM] kind of instilled into me how to have a job, how to kind of perform in a work workplace environment with students who are looking up to you."* (GEMS NPM)

Another open-ended questionnaire item asked mentors to note three ways in which GEMS should be improved for future participants. The 22 mentors who responded suggested a wide variety of improvements. No single improvement was suggested by more than five mentors. The most frequently mentioned improvements (each mentioned by five mentors) were to provide more interaction between the students and the NPMs and S&Es, and to provide participants with more opportunities for collaboration or teamwork. Four mentors suggested that the program should be on-site rather than virtual. Improvements mentioned by three mentors each included providing more resources for materials for hands-on activities, selecting a greater diversity of participants, and improvements related to staff terms of employment (e.g., higher RT pay, higher NPM pay, and providing contracts for staff). Other improvements (none mentioned by more than two mentors), included the following:

- Providing more advanced material or differentiating materials for advanced students
- Improving communication from the program
- Providing a system so that mentors can access GEMS activities from sites nationwide
- Providing a larger variety of projects or more engaging activities
- Providing more AEOP information
- Providing more training time for NPMs

Mentors participating in interviews also suggested various improvements. These mentors suggested the following:

- More interaction between students and mentors
- Providing career videos for use in programs using a virtual platform
- Providing more publicity and/or outreach for the GEMS program
- Providing transportation to GEMS sites
- Adding more GEMS sites
- Providing more AEOP information
- Providing a “mobile GEMS” program
- Increasing funding
- Hiring more NPMs to help with highly technical activities
- Grouping participants in smaller groups
- Providing items for students to take home to continue engaging with the program topic
- Providing tips to presenters (e.g., suggest that presenters ask students questions during the presentation to keep their attention)
- Providing more activities in the virtual GEMS format,

7 | Priority #3 Findings

Develop and implement a cohesive, coordinated and sustainable STEM education outreach infrastructure across the Army.

How Participants Found out About AEOP

To understand more about recruitment method effectiveness, students were asked when they enrolled for GEMS to indicate all the ways that they had learned about AEOP (Table 27). After past participation in the program (42%), the most frequently reported sources of information about AEOP were personal connections, including friends (34%) and family members (30%). Other sources of information with more than 10% endorsement were the AEOP website (24%) and a school or university newsletter, email, or website (14%).

Table 27. How Students Learned about AEOP (n=385)

	Response Percent	Response Total
Army Educational Outreach Program (AEOP) Website	23.6%	91
AEOP on Facebook, Twitter, Instagram, or other social media	4.2%	16
School or university newsletter, email, or website	14.0%	54
Past participant of program	41.6%	160
Friend	34.0%	131
Family Member	29.6%	114
Someone who works at the school or university I attend	3.9%	15
Someone who works with the program	3.1%	12
Someone who works with the DoD (Army, Navy, Air Force, etc.)	9.1%	35
Community group or program	2.1%	8
Choose Not to Report	<1%	2

Mentors were also asked how they learned about AEOP (see Table 28). The most commonly reported sources of information, with a third or more mentors reporting, were past participation in GEMS (40%), a family member (33%), and someone who works with the program (33%). More than a quarter of mentors also indicated that they learned about AEOP through a friend (27%) and AEOP website (27%).

Table 28. How Mentors Learned About AEOP (n=15)

	Response Percent	Response Total
Army Educational Outreach Program (AEOP) Website	26.7%	4
AEOP on Facebook, Twitter, Instagram, or other social media	6.7%	1
School or university newsletter, email, or website	13.3%	2
Past participant of program	40.0%	6
Friend	26.7%	4
Family Member	33.3%	5
Someone who works at the school or university I attend	20.0%	3
Someone who works with the program	33.3%	5
Someone who works with the Department of Defense (Army, Navy, Air Force, etc.)	20.0%	3
Community group or program	0%	0
Choose Not to Report	0%	0

Students participating in interviews were also asked to share their reasons for choosing to participate in GEMS. These participants offered a variety of motivations for participating. Some noted that they had previously participated and had enjoyed the experience, and others reported being motivated by the opportunity to learn about STEM topics, to explore careers and interests, and to participate in a focused activity for the summer months. As one student said,

Students were asked both at enrollment and in interviews what motivated them to participate in GEMS. Student responses to a survey item asking them to select factors that motivated them to participate in GEMS (Table 29) show that a large majority of students (more than three-quarters) were motivated by their interest in STEM (90%) and desire to learn something new or interesting (87%) as motivators. More than two-thirds of students also reported that the opportunity to have fun (68%) and learning in ways not possible in school (70%).

Students who participated in phone interviews indicated that they had learned about STEM careers in the Army or DoD during GEMS. These students, who represented two GEMS sites, indicated that they learned about careers through connections made to program activities, speakers, and mentors. Some students who had participated in the past noted that the career information they received was not as robust as in previous years when they had been on-site, however several participants made comments indicating that the information they received about the DoD and STEM careers within the DoD was impactful. Students said, for example, *"I learned about…the way the military utilizes STEM and it's really intrigued me…I didn't want to be an engineer when I first started GEMS. I wanted to be a marine biologist. And when I first saw all the things that you could do with engineering, it made me think more about how the world works...and it inspired me to go into an engineering field, so that's what I'm aspiring to do right now."* (GEMS Student)

"I've learned more about the Army. I've learned like it's more than just fighting. It's helping involve our community… our nation to be exact, like more hands-on technology. It's not all about the... it's like they're teaching us what we can do to help make the world better." (GEMS Student)

Table 29. Factors Motivating Student Participation in GEMS (n=385)

	Response Percent	Response Total
Teacher or professor encouragement	13.8%	53
An academic requirement or school grade	2.1%	8
Desire to learn something new or interesting	86.5%	333
The mentor(s)	13.8%	53
Building college application or résumé	36.6%	141
Networking opportunities	22.9%	88
Interest in science, technology, engineering, or mathematics (STEM)	90.1%	347
Interest in STEM careers with the Army	38.7%	149
Having fun	68.1%	262
Earning stipends or awards for doing STEM	30.6%	118
Opportunity to do something with friends	31.7%	122
Opportunity to use advanced laboratory technology	63.4%	244
Desire to expand laboratory or research skills	60.0%	231
Learning in ways that are not possible in school	70.1%	270
Serving the community or country	36.6%	141
Exploring a unique work environment	49.6%	191
Figuring out education or career goals	56.4%	217
Seeing how school learning applies to real life	50.1%	193
Recommendations of past participants	23.6%	91
Choose Not to Report	0%	0

Previous Program Participation & Future Interest

Table 30 displays students' self-reported previous program participation. Half (50%) indicated being past GEMS participants. Smaller proportions reported having participated in Camp Invention (5%), eCM (1%), JSHS (<1%), JSS (<1%), and SEAP (<1%). Slightly less than a quarter (22%) indicated they had participated in other STEM programs in the past.

Table 30. Student Past Participation in AEOP Programs (n=385)

	Response Percent	Response Total
Camp Invention	4.9%	19
eCYBERMISSION	<1%	3
Junior Solar Sprint (JSS)	<1%	1
Gains in the Education of Mathematics and Science	49.9%	192
Unite	0%	0
Junior Science & Humanities Symposium (JSHS)	<1%	1
Science & Engineering Apprenticeship Program (SEAP)	<1%	1
Research & Engineering Apprenticeship Program (REAP)	0%	0
High School Apprenticeship Program (HSAP)	0%	0
College Qualified Leaders (CQL)	0%	0
Undergraduate Research Apprenticeship Program (URAP)	0%	0
Science Mathematics & Research for Transformation	0%	0
I've never participated in any AEOP programs	39.7%	153
Other STEM program	21.6%	83

Mentors were asked which of the AEOP they explicitly discussed with their students during GEMS (Table 31). Nearly all mentors reported discussing GEMS (88%) and almost three-quarters discussed GEMS NPMs (71%) with their students. Slightly less than half of mentors (46%) reported discussing AEOP generally with students but without reference to any specific program.

Table 31. Mentors Explicitly Discussing AEOP with Students (n=24)

	Yes - I discussed this program with my student(s)	No - I did not discuss this program with my student(s)	Response Total
Junior Solar Sprint (JSS)	20.8%	79.2%	
	5	19	**24**
eCYBERMISSION	29.2%	70.8%	
	7	17	**24**
Gains in the Education of Mathematics and Science (GEMS)	87.5%	12.5%	
	21	3	**24**
Unite	16.7%	83.3%	
	4	20	**24**
Junior Science & Humanities Symposium (JSHS)	16.7%	83.3%	
	4	20	**24**
Science & Engineering Apprenticeship Program (SEAP)	25.0%	75.0%	
	6	18	**24**
Research & Engineering Apprenticeship Program (REAP)	20.8%	79.2%	
	5	19	**24**
High School Apprenticeship Program (HSAP)	16.7%	83.3%	
	4	20	**24**
College Qualified Leaders (CQL)	16.7%	83.3%	
	4	20	**24**
GEMS Near Peer Mentor Program	70.8%	29.2%	
	17	7	**24**
Undergraduate Research Apprenticeship Program (URAP)	12.5%	87.5%	
	3	21	**24**
	12.5%	87.5%	

Science Mathematics, and Research for	3	21	**24**
National Defense Science & Engineering Graduate (NDSEG) Fellowship	12.5%	87.5%	
	3	21	**24**
I discussed AEOP with my student(s) but did not discuss any specific program	45.8%	54.2%	
	11	13	**24**

Table 32 displays responses to an item asking students how interested they are in participating in other AEOP in the future. With the exception of GEMS and GEMS NPM, approximately half or more of students reported having never heard of each AEOP about which they were asked (49%-68%). Most students were, however, at least a little interested in participating in GEMS again (82%) and in the GEMS NPM program (68%), and few (3%-7%) said they had no interest in participating in other AEOP.

Table 32. Student Interest in Future AEOP Programs (n=913)

	I've never heard of this program	Not at all	A little	Very much	Response Total
Camp Invention	54.3%	7.1%	19.1%	19.5%	
	496	65	174	178	**913**
eCYBERMISSION	60.8%	7.3%	16.0%	15.9%	
	555	67	146	145	**913**
Junior Solar Sprint (JSS)	61.7%	7.1%	16.8%	14.5%	
	563	65	153	132	**913**
Gains in the Education of Mathematics and Science (GEMS)	15.0%	3.2%	16.6%	65.2%	
	137	29	152	595	**913**
Unite	67.6%	5.1%	14.0%	13.3%	
	617	47	128	121	**913**
Junior Science & Humanities Symposium (JSHS)	62.0%	6.2%	16.0%	15.8%	
	566	57	146	144	**913**
Science & Engineering Apprenticeship Program (SEAP)	49.4%	4.4%	18.9%	27.3%	
	451	40	173	249	**913**
	52.1%	6.5%	17.6%	23.8%	

Research & Engineering Apprenticeship Program (REAP)	476	59	161	217	**913**
High School Apprenticeship Program (HSAP)	55.5%	6.0%	17.2%	21.2%	
	507	55	157	194	**913**
College Qualified Leaders (CQL)	59.0%	5.1%	16.9%	18.9%	
	539	47	154	173	**913**
GEMS Near Peer Mentor Program	26.5%	5.9%	31.8%	35.8%	
	242	54	290	327	**913**
Undergraduate Research Apprenticeship Program (URAP)	58.7%	6.2%	15.9%	19.2%	
	536	57	145	175	**913**
Science Mathematics, and Research for Transformation (SMART) College Scholarship	50.3%	4.3%	16.9%	28.6%	
	459	39	154	261	**913**
National Defense Science & Engineering Graduate (NDSEG) Fellowship	58.7%	4.9%	16.2%	20.2%	
	536	45	148	184	**913**

Awareness of STEM Careers & DoD STEM Careers & Research

Since exposing students to STEM careers in the Army and DoD is an objective of GEMS program, the student questionnaire asked how many jobs/careers in STEM in general, and how many STEM jobs/careers in the DoD more specifically, students learned about during their experience. Longitudinal trends of these data (2016 - 2020) are reported in Table 33. Similar to past years, in 2020 nearly all students (97%) reported learning about at least one STEM job/career, while slightly fewer students in this year compared to past indicated learning about five or more (43%). Fewer students (70%) reported learning about at least one DoD STEM job/career and only 16% reported learning about five or more DoD STEM careers.

Table 33. Number of STEM Jobs/Careers Students Learned About During GEMS

	STEM Jobs/Careers				**DoD STEM Jobs/Careers**			
	2017 (n=2,037)	**2018 (n=1,835)**	**2019 (n=1,802)**	**2020 (n=913)**	**2017 (n=2,029)**	**2018 (n=1,806)**	**2019 (n=1,789)**	**2020 (n=913)**
None	3%	4%	4%	5%	19%	11%	15%	30%
1	4%	4%	5%	5%	10%	9%	16%	12%
2	8%	11%	10%	11%	16%	16%	18%	18%
3	15%	16%	16%	18%	17%	18%	18%	15%

4	12%	13%	13%	18%	10%	12%	8%	9%
5 or more	58%	52%	52%	43%	28%	35%	25%	16%

Students who participated in phone interviews indicated that they had learned about STEM careers in the Army or DoD during GEMS. These students, who represented two GEMS sites, indicated that they learned about careers through connections made to program activities, speakers, and mentors. Some students who had participated in the past noted that the career information they received was not as robust as in previous years when they had been on-site, however several participants made comments indicating that the information they received about the DoD and STEM careers within the DoD was impactful. Students said, for example,

> *"I learned about…the way the military utilizes STEM and it's really intrigued me…I didn't want to be an engineer when I first started GEMS. I wanted to be a marine biologist. And when I first saw all the things that you could do with engineering, it made me think more about how the world works...and it inspired me to go into an engineering field, so that's what I'm aspiring to do right now."* (GEMS Student)

> *"I've learned more about the Army. I've learned like it's more than just fighting. It's helping involve our community… our nation to be exact, like more hands-on technology. It's not all about the... it's like they're teaching us what we can do to help make the world better."* (GEMS Student)

Student attitudes about the importance of DoD research are an important prerequisite to their continued interest in the field and potential involvement in the future. As such, students were asked to rate their level of agreement with DoD researchers and the value of DoD research statements (Table 34). Nearly all students (91%-97%) agreed or strongly agreed with each statement, implying they have positive opinions about DoD researchers and research after their GEMS experiences.

Table 34. Student Opinions about DoD Researchers and Research (n=913)

	Strongly Disagree	Disagree	Agree	Strongly Agree	Response Total
DoD researchers improve science and engineering jobs and work	1.8%	1.8%	55.1%	41.4%	
	16	16	503	378	**913**
DoD researchers create new and innovative technologies	1.4%	2.8%	47.6%	48.1%	
	13	26	435	439	**913**
DoD researchers solve real problems	1.5%	2.4%	41.9%	54.1%	
	14	22	383	494	**913**
DoD research is important to most people	1.5%	7.0%	53.1%	38.3%	
	14	64	485	350	**913**

Interest & Future Engagement in STEM

A key goal of the AEOP is to develop a STEM-literate citizenry. To achieve this goal, it is important that students be engaged in high-quality STEM activities both in and out of school. Table 35 shows student responses regarding changes in their likelihood of engaging in STEM outside of required school activities as a result of their GEMS experience. Very large proportions of students (79%-89%) reported being more likely or much more likely to engage in each activity after GEMS. Activities with the greatest reported likelihood after GEMS participation were: Participate in a STEM camp, club, or competition (89) and Play with a mechanical or electrical device (89%).

In an analysis of a composite created from these Likelihood to Engage in STEM Activities items[17] no significant differences by overall Underserved classification. The only significant difference found by individual demographics was for gender with females reporting higher likelihood than males (effect size small, d=0.334).[18]

Table 35. Change in Likelihood Students Will Engage in STEM Activities Outside of School (n=913)

	Much less likely	Less likely	More likely	Much more likely	Response Total
Watch or read non-fiction STEM	3.2%	13.9%	61.6%	21.4%	
	29	127	562	195	**913**
Play with a mechanical or electrical device (robot)	1.8%	9.4%	54.0%	34.8%	
	16	86	493	318	**913**
Work on solving math or scientific puzzles	2.4%	12.3%	54.1%	31.2%	
	22	112	494	285	**913**
Use a computer to design or program something	2.1%	12.4%	47.0%	38.6%	
	19	113	429	352	**913**
Talk with friends or family about STEM	2.8%	11.5%	51.3%	34.4%	
	26	105	468	314	**913**
Mentor or teach other students about STEM	4.5%	16.2%	47.1%	32.2%	
	41	148	430	294	**913**

[17] The Cronbach's alpha reliability for these 10 Likelihood to Engage items was 0.894.

[18] Independent samples t-test results for Gender: t(372)=3.22, p=.001.

Help with a community service project related to STEM	2.4%	14.1%	51.9%	31.5%	
	22	129	474	288	**913**
Participate in a STEM camp, club, or competition	2.0%	8.7%	44.4%	45.0%	
	18	79	405	411	**913**
Take an extra STEM class	2.5%	13.0%	44.9%	39.5%	
	23	119	410	361	**913**
Work on a STEM project or experiment in a university or professional setting	2.8%	12.3%	47.3%	37.6%	
	26	112	432	343	**913**

Students were also asked to report on their educational aspirations after participating in GEMS (Table 36). Nearly all students (95%) indicated wanting to at least finish college (get a Bachelor's degree), and over half (59%) reported a desire to continue their education after college.

Table 36. Student Education Aspirations After GEMS (n=913)

	Response Percent	Response Total
Graduate from high school	1.0%	9
Go to a trade or vocational school	1.0%	9
Go to college for a little while	3.2%	29
Finish college (get a Bachelor's degree)	36.1%	330
Get more education after college	58.7%	536

Resources

Since it is a goal of the AEOP for students to progress from GEMS into other AEOP, mentors were asked how useful various resources were in efforts to expose students to AEOP (see Table 37). A majority of mentors (54%-96%) reported each resource was at least somewhat useful for exposing students to AEOP with the exceptions of AEOP on social media (13%) and AEOP printed materials (21%). Nearly two-thirds of mentors (63%) reported not having experienced these two resources. Participation in GEMS was most frequently rated as at least somewhat useful (96%), followed by GEMS program administrators or site coordinators (75%).

Table 37. Usefulness of Resources for Exposing Students to AEOP (n=24)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Army Educational Outreach Program (AEOP) website	25.0%	0.0%	16.7%	29.2%	29.2%	
	6	0	4	7	7	**24**
AEOP on Facebook, Twitter, Pinterest or other social media	62.5%	4.2%	20.8%	4.2%	8.3%	
	15	1	5	1	2	**24**
AEOP printed materials	62.5%	4.2%	12.5%	8.3%	12.5%	
	15	1	3	2	3	**24**
GEMS Program administrator or site coordinator	8.3%	0.0%	16.7%	0.0%	75.0%	
	2	0	4	0	18	**24**
Invited speakers or "career" events	41.7%	4.2%	0.0%	16.7%	37.5%	
	10	1	0	4	9	**24**
Participation in GEMS	4.2%	0.0%	0.0%	20.8%	75.0%	
	1	0	0	5	18	**24**

Another goal of the AEOP and GEMS is to expose students to DoD STEM careers. Mentors were thus asked to rate the usefulness of resources for exposing students to DoD STEM careers (see Table 38). Again, mentors were most likely to rate participation in GEMS (83%) and the GEMS program administrator/site coordinator (75%) as at least somewhat useful for this purpose. Half of mentors (50%) also indicated that invited speakers were useful. Conversely, AEOP materials were reported as less useful with more than a third of mentors (38%-67%) noting having not experienced them.

Table 38. Usefulness of Resources for Exposing Student to DoD STEM Careers (n=24)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Army Educational Outreach Program (AEOP) website	37.5%	0.0%	25.0%	16.7%	20.8%	
	9	0	6	4	5	**24**
AEOP on Facebook, Twitter, Pinterest or other social media	66.7%	8.3%	12.5%	4.2%	8.3%	
	16	2	3	1	2	**24**
AEOP printed materials	62.5%	8.3%	8.3%	12.5%	8.3%	
	15	2	2	3	2	**24**
	8.3%	4.2%	12.5%	20.8%	54.2%	

GEMS Program administrator or site coordinator	2	1	3	5	13	**24**
Invited speakers or "career" events	41.7%	4.2%	4.2%	8.3%	41.7%	
	10	1	1	2	10	**24**
Participation in GEMS	8.3%	0.0%	8.3%	33.3%	50.0%	
	2	0	2	8	12	**24**

Mentors who participated in interviews (representing the same two sites as the student interview participants) indicated that their students were exposed to DoD STEM careers in GEMS from the hands-on activities, the speakers, and from the NPMs. One mentor, an Army S&E. said,

> *"We tell [GEMS participants] about our jobs. We show them videos about the different jobs in the military, because there are so many - it's over a hundred and fifty jobs in the military. And then we also show them the food that we eat when we're in the field and they get to ask us questions about our deployments, and how the Army impacted our lives."* (GEMS S&E Mentor)

Another mentor provided details more details about how the career information was presented to students, saying,

> *"We asked each scientist and engineer to give a brief overview of their job and what they do for the Army and the Department of Defense. And so that gives [GEMS] students insight on what they do. And we also ask them to discuss how they ended up in that job and discuss their career paths, so [students] can also get an understanding of what it took to get there."* (GEMS NPM)

Overall Impact

The final set of student evaluation survey items were related to overall impacts of participating in GEMS (Table 39). More than 60% of students (62%-93%) said GEMS contributed to each area of impact or was the primary reason for the impact. Areas in which students reported the greatest impact were related to: Confidence in personal STEM knowledge, skills, and abilities (92%); Interest in participating in STEM activities outside of school requirements (84%); and Appreciation of DoD STEM research (80%).

Overall Impact of GEMS items were combined into a composite variable[19] to test for overall Underserved classification differences and for differences among subgroups of students. No significant differences were found by Underserved classification. However, differences were found by first generation status (first generation students higher agreement; small effect size, d=0.293), FARMS (FARMS students higher

[19] The Cronbach's alpha reliability for the 7 Overall GEMS Impact items was 0.881.

agreement; small effect size, d=0.217), and ELL status (ELL students higher agreement; small effect size, d=0.232).[20]

Table 39. Student Opinions of GEMS Impacts (n=913)

	Disagree - This did not happen	Disagree - This happened but not because of GEMS	Agree - GEMS contributed	Agree - GEMS was primary reason	Response Total
I am more confident in my STEM knowledge, skills, and abilities	2.0%	6.6%	63.9%	27.6%	
	18	60	583	252	**913**
I am more interested in participating in STEM activities outside of school requirements	4.6%	11.9%	52.6%	30.9%	
	42	109	480	282	**913**
I am more interested in taking STEM classes in school	5.1%	15.9%	52.0%	26.9%	
	47	145	475	246	**913**
I am more interested in earning a STEM degree	8.9%	16.5%	51.2%	23.4%	
	81	151	467	214	**913**
I am more interested in pursuing a career in STEM	10.0%	17.7%	49.1%	23.2%	
	91	162	448	212	**913**
I have a greater appreciation of Army or DoD STEM research	10.7%	9.5%	44.0%	35.7%	
	98	87	402	326	**913**
I am more interested in pursuing a STEM career with the Army or DoD	23.8%	13.9%	40.9%	21.5%	
	217	127	373	196	**913**

Due to COVID-19 circumstances, students were asked to provide their overall opinion on the virtual nature of GEMS sessions (Table 40). Nearly all participants indicated virtual sessions were at least good (98%) and three-quarters of students reported these sessions were very good or excellent (75%).

[20] Independent samples t-test for Overall GEMS Impact: First Generation – t(372)=2.83, p=.005; FARMS – t(372)=2.09, p=.037; ELL – t(372)=2.24, p=.026.

Table 40. Student Opinion of Virtual Session (n=913)

	Response Percent	Response Total
Excellent	44.3%	404
Very Good	31.3%	286
Good	21.9%	200
Not So Good	2.5%	23

Because most GEMS programs used a virtual format for the 2020 program year, students were also asked to comment on their experiences with the virtual platform in an open-ended survey question, and many student interview participants also commented on the virtual format. Of the 100 questionnaire responses sampled, a large majority (95%) commented positively on the virtual format, although the overwhelming consensus in responses was that, although the virtual programs went well, students would have preferred to attend in person. The 78% of students who made only positive comments focused on the flexibility of the program, the availability of mentors, and the technology associated with program delivery. These students said, for example,

> *"The virtual experience was very organized and worked out perfectly. There weren't many issues, and it was just as educational."* (GEMS Student)

> *"My experience in using the virtual platform was good. I liked using the platform because I usually read the comments, and the comments helped my work with my code. I also liked how I could see questions I might've had that was asked and answered. I enjoyed how videos were posted about people and their STEM careers, and how every time there was a live session, the link was given again."* (GEMS Student)

> *"It was impressive that the GEMS program was still able to engage us, and we could still do our own at-home experiments with the supply kits with virtual mentors."* (GEMS Student)

> *"My experience on this virtual platform was great and very satisfying…I woke up every morning ready for class trying to learn something new about stem. And the mentors were amazing teachers."* (GEMS Student)

GEMS students who participated in interviews commented similarly upon the virtual format. While many expressed that they would prefer to complete the program in person, several students commented positively on the execution of the program, and one student noted that the on-line content delivery was better than what he had experienced from his school, commenting on the "amazing…professional looking videos," and felt that the quality of the GEMS program delivery exceeded that of his school, saying, *"Everyone recently in the school system had participated in at home online learning through the school systems...I believe that GEMS is definitely…the more advanced professional way of learning. I definitely saw different techniques used that kept you integrated with it. And also, the fact that they willing to support you the whole way throughout the program was definitely something I appreciated... I recommend their methods."* (GEMS Student)

In addition, even with the limitations imposed by distance, one student shared that GEMS was "still a hands-on experience…you're still learning about STEM" although another student noted that he missed the hands-on activities that would have been available in an in-person program, and others noted that it was more difficult to ask questions or for mentors to demonstrate activities. Several interview participants noted that one of the most significant omissions in the virtual format was the opportunity to connect with peers and make friends.

Seventeen students who responded to the open-ended questionnaire item about also made positive comments but added caveats related to the virtual platform. The most frequently noted caveats were that the online program was not as interactive or interesting as the online program and that instructions online were hard to understand or confusing. Other students expressed concerns about the choice of platform used (e.g., issues accessing Microsoft Teams) or noted technical issues (e.g., the technology was "glitchy"). Students said, for example,

"This virtual platform was very informative but wasn't as interactive as I would have liked. If it had been in person, it would have been more enjoyable, but it still helped further my interest in STEM." (GEMS Student)

"I believe for this program you needed physical interaction. It is sad we were not able to be there physically, and the technical difficult[ies] were the main bane of this virtual GEMS program. But besides that, it has been an absolute Joy! Even with all these problems I feel that it went well! I will definitely remember this program." (GEMS Student)

"The virtual platform was very good, and although there were a few glitches that involved the computer, and it was sometimes hard to understand what we were supposed to be doing because we weren't in person, the mentors and teachers were very clear with their explanations which helped make the labs easier to follow along with." (GEMS Student)

Five students responding to the open-ended questionnaire item made no positive comments about the virtual platform. These students noted technical issues and a preference for an in-person program.

While the mentor questionnaire did not include items specific to the virtual format, some mentors participating in interviews commented upon this topic. These mentors' comments were positive overall. Two mentors noted that although keeping students' attention is an extra challenge in the virtual format the program had done well in engaging students. One mentor's comments highlighted strategies that were included to engage students, including the provision of kits to students to facilitate hands-on learning and videos and question sessions to encourage collaboration and connections between students and mentors. She said,

> *"I am really proud of the online format. I was a little concerned because one of the benefits of GEMS is the face to face interaction, as is the relationships between the students and the mentors. But I feel that with us creating mentor moment videos, us creating introduction videos, making sure that they had everything that they needed in their kit so that parents didn't have to spend out any money…I feel like we were able to give them a quality online experience of GEMS…I've been loving seeing the interactions between the students and mentors through attendance questions and mentors responding back….[Participants] collaborated with other students through [Google] Stream and helped each other out. Their pictures of their experiment have been amazing. So, they're still getting high quality GEMS just in a digital format."* (GEMS RT)

Another mentor also commented upon the intentional use of community building strategies within the virtual GEMS program, saying,

> *"Our focus is to build a community among the students...One way we do that as invite them to post pictures and videos... I think it's building excitement for the experiments... because we're super quick to respond, the kids are interacting with us and interacting with each other."* (GEMS RT)

Mentors also noted that efforts were made to connect students with Army S&Es and provide career information by using videos and videoconferencing. One NPM said,

> *"I served as a near peer mentor the last two summers in-person, and I think that the online version is the best version that we could offer this summer due to the circumstances. The students are still able to hear from the scientists and engineers and they're still able to interact and learn."* (GEMS NPM)

Several mentors commented on the potential for virtual GEMS programs to expand the program's reach beyond communities where Army labs and centers are located. As one mentor said,

> *"One thing [the virtual format] does do is it may give the opportunity to reach more students because if you're not having to bring students on campus, then you don't have that logistical problem."* (GEMS RT)

8

8 | Findings and Recommendations

Summary of Findings

The 2020 evaluation of GEMS collected data about participants; participants' perceptions of program processes, resources, and activities; and indicators of achievement in outcomes related to AEOP and program objectives. A summary of findings is provided in the Table 41.

Table 41. 2020 GEMS Evaluation Findings	
Priority #1: *Broaden, deepen, and diversify the pool of STEM talent in support of our Defense Industry Base*	
GEMS continues to receive applications from more students than it can accommodate but served fewer students than in previous years.	GEMS sites collectively received 4,533 participant applications in 2020, a 17% decrease compared to 2019 when 5,296 student applications were submitted, and an 21% decrease compared to the 2018 when 5,500 applications were received.
	GEMS enrolled 2,203 students at nine program sites, a 35% decrease in enrollment compared to 2019 when 2,985 students were enrolled at 14 sites and a 52% decrease in enrollment compared to 2018 when 3,341 students were enrolled at 15 sites. Much of this decrease in enrollment is due to the cancellations of GEMS programs at six program sites due to the COVID-19 pandemic.
GEMS continued to reach students from populations historically underrepresented and underserved in STEM.	Overall student demographics for 2020 are similar to those of previous years. Half of GEMS students (50%) were female in 2020 (47% in 2019 and 2018). The proportion of students identifying as White decreased somewhat in 2020 as compared to previous years (36% in 2020, 44% in 2019, and 40% in 2018). The proportion of Asian students increased as compared to recent years, with 29% of students identifying as Asian in 2020, compared to 14% in 2019 and 17% in 2018. The proportion of Black or African American students remained relatively constant, with 24% of students identifying themselves as Black or African American in 2020 as compared to 23% in 2019 and 24% in 2018. There was a slight decrease proportion of students identifying themselves as Hispanic or Latino/a (7% in 2020 and 9% in both 2019 and 2018).

	As in 2019, relatively few students reported being eligible for free-or reduced-price school lunch (FARMS), a commonly used indicator of low socioeconomic status (12% in 2020 and 13% in 2019), nearly all (97%) spoke English as their first language; and few (8%) would-be first-generation college attenders. The proportion of students who met the AEOP definition of underserved in 2020 (40%) was similar to 2019 (42%) but slightly higher than in 2018 (35%).
Most students reported engaging in all STEM practices during GEMS and reported being more engaged in STEM practices in GEMS than in school; students meeting the AEOP definition of Underserved, students who would be first generation college attenders, and low-income students reported greater frequency of engagement than their peers.	Sixty percent or more of students (60%-94%) reported engaging in all STEM practices at least once during GEMS. Activities engaged with most often (most or every day) by approximately two-thirds of students or more were: Examining data to make a conclusion (75%); Using scientific tools and steps to do an experiment (71%); and Planning to do an experiment (68%).
	Differences in engagement in STEM practices were found by Underserved classification (Underserved students greater agreement; small effect size), by first generation college status (first generation students greater engagement; small effect size), and FARMS (FARMS students greater engagement; small effect size).
	Students reported significantly greater engagement in STEM practices in GEMS as compared to in school (medium effect size).
Students experienced gains in STEM knowledge during GEMS; students meeting the AEOP definition of Underserved, female students, students who would-be first-generation college attenders, and low-income students, ELL students, and minority students reported greater gains than their peers	Three-quarters or more of students (76%-87%) reported that they "learned more than a little" or "learned a lot" in each area. The impact of GEMS on students' new knowledge of a STEM topic (86%) was the most frequently reported area of impact.
	Significant differences in STEM knowledge gains were found by Underserved classification (Underserved students learned more; small effect size), by gender (females learned more; small effect size), first generation status (first generation students learned more; small effect size), FARMS status (FARMS students learned more; small effect size), ELL status (ELL students learned more; small effect size), and race/ethnicity (students from underserved minority groups learned more; small effect size).
Students experienced gains in their STEM competencies or skills during GEMS.	Sixty percent or more of students (66%-89%) reported learning at least a little in all STEM competencies with the exception of two items: How to create charts/graphs to show data/find patterns (45%) and How to identify strengths/limitations of information in technical/scientific books (49%). Areas where students indicated they learned the most (more than a little or a lot) were: How to use knowledge and creativity to come up with a solution (74%); How to support my ideas with my STEM learning (69%); and How to make a model to show how something works (67%).
	No significant differences in STEM competency gains were found by overall Underserved status or by any individual demographic component of Underserved status.

Students experienced gains in their 21st Century skills during GEMS.	Nearly half or more of students (40%-71%) reported that they learned more than a little or a lot in all 21st Century skills except for how to create videos, blogs, and social media posts (29%). Skills impacted the most were: How to solve problems (73%); How to use creative ideas to make something (71%); How to think about how systems work and how parts interact with each other (69%); and How to think creatively (67%).
	No significant differences in 21st Century skills gains were found by overall Underserved status or by any individual demographic component of Underserved status.
Students reported that participating in GEMS positively impacted their STEM identities - their interest in and feelings of capability about STEM; students who would be first generation college attenders reported greater impacts than their peers.	After participating in GEMS, extremely large proportions of students (82%-94%) either agreed or strongly agreed with each statement related to the impact of GEMs on their STEM identities. More than 90% of GEMS students reported positive impacts in the following areas: Feeling more prepared for more challenging STEM activities (94%) and Feeling like they accomplished something in STEM (93%).
	No significant differences in STEM identity gains were found by overall Underserved status. A difference was found by first generation college status (first generation students reported more gains; small effect size).
Priority #2: *Support and empower educators with unique Army research and technology resources.*	
Mentors reported using a range of mentoring strategies with students.	A majority of mentors reported using most strategies associated with each area of effective mentoring, including: • Strategies to help make the learning activities in GEMS relevant to students (71%-96%), with the exception of selecting readings/activities that relate to students' backgrounds (42%) • Strategies to support the diverse needs of students as learners (67%-100%) with the exception of highlighting under-representation of women and racial/ethnic minority populations in STEM (42%) and integrating ideas from education literature to teach/mentor students from groups underrepresented in STEM (29%). • Strategies to support students' development of collaboration and interpersonal skills (50%-88%) • Strategies to support student engagement in authentic STEM activities (50%-100%) with the exception of having students search for and review technical literature to support their work (17%) • Strategies to support students' STEM educational and career pathways (50%-71%) with the exception of helping students with their resume, application, personal statement, and/or interview preparation (21%); and helping students build a professional network in a STEM field (42%).

Most students expressed high levels of satisfaction with features of GEMS that they had experienced and cited various benefits of participating; students had a variety of suggestions for program improvement.	Very few students (2%-9%) reported dissatisfaction with any program feature. Program features with which the most students reported satisfaction at the somewhat or very much satisfied levels were the teaching/mentoring provided during GEMS (70%) and STEM topics included in GEMS (70%).
	More than a third of GEMS students had not experienced program features such as invited speakers (36% did not experience) and virtual field trips/laboratory tours (52% did not experience).
	Nearly all students (97%) made positive comments about GEMS in open-ended questionnaire items, and a large majority (87%) commented only on positive aspects of the program. Positive comments focused on the learning they experienced, the quality of mentors and students' connections with mentors, the career information they received, the flexibility programs displayed in transitioning to virtual formats, providing students with "something to do" over the summer, and appreciation for the stipend.
	Among the various benefits of GEMS mentioned by students in open-ended responses, the most frequently mentioned benefits were the STEM learning they experienced, the career information and guidance they received, the opportunity to acquire specific STEM skills or research skills, increases in their motivation for or interest in STEM, and the hands-on nature of and real-world connections in GEMS.
	Students made a wide variety of suggestions for program improvement. The most frequently suggested improvements focused on activities, (requests for more hands-on activities, more or better speakers, virtual field trips, or more real-world demonstrations and examples); the virtual platform for the program (suggestions that the program be held in person, that more varied online tools be used, and comments about technology problems); and the schedule or logistical elements of GEMS (shorter presentations, providing more or longer breaks, and having longer days or a longer program).
Mentors reported satisfaction with GEMS features and noted a number of strengths of GEMS. Mentors also made suggestions for program improvement.	Half or more mentors indicated being at least somewhat satisfied with all program features (58%-100%) except for two which most did not experience: Communication with NSTA (67% did not experience) and Field trips/laboratory tours (63% did not experience). All or nearly all mentors indicated they were at least somewhat satisfied with support for instruction or mentorship during program activities (100%) and communication with GEMS organizers/site coordinators (96%).
	All but one of the mentors responding to open-ended questions made positive comments about their satisfaction with GEMS, attributing their satisfaction to the engaging program content and activities, the career information students received, and the ability of the program to adapt.

	The program strengths most frequently cited by GEMS mentors regarding students were the STEM learning students experience and the opportunity to acquire a range of 21st Century skills (e.g., problem solving, communication, work ethic, workplace skills, the ability to work independently), the opportunity for hands-on learning, and the NPMs.
	Mentors noted benefits to themselves from serving as mentors, including the following: • GEMS RTs focused on the value of being able to take their experiences in STEM back to their classrooms • Army S&E mentors noted that they benefit from the new perspective they gain on their work from presenting it to others, the satisfaction of working with participants and NPMs, the incentive to keep abreast of information from private industry that mentoring provides them, and improvements in their communication skills • NPMs noted a variety of benefits including developing leadership skills, and communication skills, and other workplace skills; the opportunity to learn science; improving their own teamwork skills; and the opportunity to network with Army S&Es.
	Mentors suggested a range of program improvements. The most frequently mentioned improvements were to provide more interaction between the students and the NPMs and S&Es, to provide participants with more opportunities for collaboration or teamwork and holding the program on site rather than virtually.
GEMS students and mentors responded positively to the virtual format of GEMS program, although most noted that the online program was less impactful than face to face programs.	A large majority of GEMS students (76%) reported that they had an excellent (44%) or very good (31%) opinion of GEMS in the virtual format used in 2020. Only 3% reported that their opinion of virtual GEMS was "not so good."
	In an open-ended questionnaire item, nearly all students (95%) made positive comments about the virtual format of GEMS, although many also noted that they would have preferred to attend in person. Students participating in phone interviews were similarly positive about the virtual format but also regretted not being able to attend an in-person format, and several noted that a significant deficit of the virtual format is the more limited opportunities to connect with peers and make friends. Students noted several strengths of the virtual GEMS format, including flexibility of the program, the availability of mentors, and the technology associated with program delivery.
	Mentors participating in phone interviews made positive comments about the virtual format of GEMS. Mentors noted that programs had made efforts to forge connections between students, between students and mentors, and between students and invited guest speakers. Some mentors pointed to the potential for virtual GEMS programs to broaden the reach of GEMS nationally. Mentors also noted some challenges with the online

	format, including the difficulties in keeping students attention and engaging them in learning.
Priority #3: *Develop and implement a cohesive, coordinated and sustainable STEM education outreach infrastructure across the Army*	
Students who provided information about how they learned about AEOP primarily cited past participation and personal connections; mentors reported similar sources of information.	After past participation in the program (42%), students' most frequently reported sources of information about AEOP were personal connections, including friends (34%) and family members (30%). Other sources of information with more than 10% endorsement were the AEOP website (24%) and a school or university newsletter, email, or website (14%).
	The most commonly reported sources of information about AEOP for mentors were past participation in GEMS (40%), a family member (33%), and someone who works with the program (33%). More than a quarter of mentors also indicated that they learned about AEOP through a friend (27%) and AEOP website (27%).
Students reported being motivated to participate in GEMS primarily by their interest in STEM, the learning opportunities, and the opportunity to have fun.	A large majority (more than three-quarters of students) reported their interest in STEM (90%) and desire to learn something new or interesting (87%) as motivators. More than two-thirds of students also reported that the opportunity to have fun (68%) and learning in ways not possible in school (70%) motivated them to participate in GEMS.
Few students had participated in any AEOP other than GEMS and most had not heard of other AEOP; few mentors discussed specific AEOP other than GEMS and GEMS NPMs with students.	Half of students (50%) indicated being past GEMS participants. Smaller proportions reported having participated in Camp Invention (5%), eCM (1%), JSHS (<1%), JSS (<1%), and SEAP (<1%). Slightly less than a quarter (22%) indicated they had participated in other STEM programs in the past.
	With the exception of GEMS and GEMS NPMs, approximately half or more of students reported having never heard of each AEOP about which they were asked (49%-68%). Most students were, however, at least a little interested in participating in GEMS again (82%) and in the GEMS NPM program (68%), and few (3%-7%) said they had no interest in participating in other AEOP.
	Nearly all mentors reported discussing GEMS (88%) and almost three-quarters discussed GEMS NPMs (71%) with their students. Slightly less than half of mentors (46%) reported discussing AEOP generally with students but without reference to any specific program.
Mentors reported that GEMS participation and administrative staff were useful for exposing students to AEOP; many had not	Mentors rated participation in GEMS most frequently as at least somewhat useful resource for exposing students to AEOP (96%), followed by GEMS program administrators or site coordinators (75%).
	Nearly two-thirds of mentors (63%) reported not having experienced AEOP on social media and AEOP printed materials.

experienced other AEOP resources.	
Students reported learning about STEM careers generally during their GEMS experiences and, to a somewhat lesser extent, about STEM careers within the Army or DoD; students had learned about these careers through program activities, speakers, and their mentors.	Nearly all students (97%) reported learning about at least one STEM job/career, while slightly fewer students this year as compared to past years indicated learning about five or more (43%). Fewer students (70%) reported learning about at least one DoD STEM job/career and only 16% reported learning about five or more.
	Students participating in interviews, who represented two GEMS sites, indicated that they learned about careers through connections made in program activities, speakers, and mentors.
Mentors reported that GEMS participation, administrative staff, and speakers were useful for exposing students to DoD STEM careers; many had not experienced other AEOP resources.	Mentors were most likely to rate participation in GEMS (83%) and the GEMS program administrator/site coordinator (75%) as at least somewhat useful for exposing students to DoD STEM careers, and half of mentors (50%) also indicated that invited speakers were useful.
	AEOP materials were reported as less useful resources, with a third or more of mentors (38%-67%) reporting not having experienced resources such as AEOP on social media (67%), AEOP printed materials (63%), and the AEOP website (38%).
	Mentors participating in focus groups indicated that their students were exposed to DoD STEM careers in GEMS from the hands-on activities, the speakers, and from the NPMs.
Students had positive perceptions of DoD researchers and research after participating in GEMS.	Nearly all students (91%-97%) agreed or strongly agreed with statements about DoD researchers and research, implying they have positive opinions about DoD researchers and research after their GEMS experiences.
Students reported being more likely to engage in STEM activities after participating in GEMS; females reported higher likelihood of future engagement than males.	Very large proportions of students (79%-89%) reported being more likely or much more likely to engage in each activity after GEMS. Activities with the greatest reported likelihood after GEMS participation were: Participate in a STEM camp, club, or competition (89); and Play with a mechanical or electrical device (89%).
	No significant differences in likelihood of future STEM engagement were found by overall Underserved status. A difference was found by gender (female students reported higher likelihood; small effect size).
Students reported aspiring to at least finish college after participating in GEMS.	Nearly all students (95%) indicated wanting to at least finish college (get a Bachelor's degree), and over half (59%) reported a desire to continue their education after college.

GEMS had positive impacts on students in areas of their STEM learning and interest, their appreciation for STEM research, and their interest in STEM careers; students who would be first generation college attenders, low income students, and ELL students reported greater impacts than their peers.	More than 60% of students (62%-93%) said GEMS contributed to each area of impact or was the primary reason for the impact. Areas in which students reported the greatest impact were related to: Confidence in personal STEM knowledge, skills, and abilities (92%); Interest in participating in STEM activities outside of school requirements (84%); and Appreciation of DoD STEM research (80%).
	No significant differences in the impact of GEMS were found by overall Underserved status. Significant differences in impact were found by first generation status (first generation students higher agreement; small effect size), FARMS (FARMS students higher agreement; small effect size), and ELL status (ELL students higher agreement; small effect size).

Recommendations for FY21 Program Improvement/Growth

Evaluation findings indicate that FY20 was a successful year for the GEMS program despite a need to shift to virtual program delivery due to COVID-19. As in previous years, GEMS participants reported growth in their STEM knowledge, skills, and identity after participating in the program. While the successes for GEMS detailed above are commendable, there are some areas that remain with potential for growth and/or improvement. The evaluation team therefore offers the following recommendations for FY21 and beyond.

AEOP Priority: Broaden, deepen, and diversify the pool of STEM talent in support of our Defense Industry Base

Due to COVID-19, GEMS sites were presented with the need to decide between virtual program delivery or cancelling summer programs. As a result, nine program sites moved forward with a virtual GEMS program for FY20, which is a sizable drop from 15 sites in FY19. Therefore, there were fewer students who had the opportunity to participate in GEMS in FY20 (2,203) compared to FY19 (2,985). It is commendable that GEMS maintained the representation of underserved students in the program at 40%, which was only a 2% decrease from FY19 overall. Of the 2,203 who participated in GEMS this year, 50% reported being repeat participants in the program. The demand for GEMS remains high – as 4,533 applications were received in FY20 – making the placement rate at less than 50% for the program. It is recommended that GEMS take lessons learned from the virtual program delivery in FY20 and apply these best practices to FY21 to attempt to support more GEMS sites to go virtual with programming. Given the large demand for GEMS and the number of GEMS sites and face-to-face facility requirements as potential barriers, NSTA should consider working with Army stakeholders to potentially conceptualize a virtual aspect of GEMS for the future that may be able to engage not only more students, but also a greater geographic reach for engaging participants in GEMS.

AEOP Priority: Support and empower educators with unique Army research and technology resources

Though mentors reported using some of the effective strategies for mentoring students in FY20 (making learning relevant, supporting diverse student needs, and development of collaboration and interpersonal skills), there were some areas that were shared as less frequently used with GEMS participants. Those areas include connecting activities/readings to student backgrounds and highlighting underrepresented groups in STEM. These are strategies that are particularly important with underserved populations and NSTA should consider providing resources to GEMS program directors to help with integrating this into their programming.

The top area for improvement that mentors mentioned was to provide more interaction between the students and the Near Peer Mentors and S&E's. Additionally, more opportunities for collaboration and teamwork across the GEMS programs was also mentioned as an area for additional focus. Students noted the availability of mentors and flexibility of the program in FY20 were strengths, though many noted a face-to-face delivery format was more attractive.

AEOP Priority: Develop and implement a cohesive, coordinated, and sustainable STEM education outreach infrastructure across the Army

As in the previous three years, many students (49-68%) had not heard of other AEOP. Further, 46% of mentors reported discussing AEOP generally with reference to any specific program. This means that in FY20 more than half (54%) of mentors did not discuss other AEOP at all. It is recommended that NSTA work with GEMS sites to provide required guidance and activities for GEMS participants to learn about other appropriate AEOP.