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ARMY EDUCATIONAL OUTREACH PROGRAM

eCYBERMISSION

2019 Annual Program Evaluation Report

Evaluation Findings

July 2020

aeop ARMY EDUCATIONAL OUTREACH PROGRAM

eCYBERMISSION ACCEPT THE CHALLENGE U.S. ARMY

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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.

This report documents the evaluation of one of the AEOP elements, the eCYBERMISSION program (eCM), which is administered on behalf of the Army by the National Science Teaching Association (NSTA). The evaluation study was performed by North Carolina State University in cooperation with Battelle, the Lead Organization (LO) in the AEOP CA consortium.

AEOP Priorities

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.

Program Overview

eCM is sponsored by the U.S. Army and managed by NSTA. Since the program's inception in 2002, over 200,000 students from across the United States, U.S. territories, and Department of Defense Educational Activities (DoDEA) schools worldwide have participated in eCM. The program is a web-based STEM competition designed to engage sixth- to ninth-grade students in real-world problem solving through Mission Challenges that address local community needs through the use of either scientific practices or the engineering design process. eCM teams work collaboratively to research and implement their projects, which are documented and judged via the submission of Mission Folders hosted on the eCM

website. Regional winners receive an expense-paid trip to the National Judging & Educational Event (NJ&EE) held in the Washington, D.C. metropolitan area.

In FY19, the five eCM regional sites registered 17,944 students, a decrease of 11% compared to the 20,004 students registered in FY18 and 19% compared to FY17 (21,277). (Table 1). There were 33 Army/DoD Laboratories and Centers that collaborated with eCM in FY19.

Table 2 summarizes demographic information for students who competed at regional competitions and for those who competed at the NJ&EE. As in previous years, regional participants were about half (49%) female and nearly half (48%) male (in both FY18 and FY17, 51% were female and 49% were male); 3% of participants chose not to report their gender. Less than half (40%) of regional students identified themselves as White (45% in FY18; 48% in FY17) with another 22% identifying themselves as Hispanic or Latino/a (18% in FY18; 19% in FY17). While 9% of students chose not to report their race/ethnicity, 13% identified themselves as Black or African American (13% in FY18; 10% in FY17) and 9% as Asian (9% in FY18; 10% in FY17). As in FY17, Native American students comprised about 1% of the students reporting their race/ethnicity, and less than 1% were Native Hawaiian or Pacific Islanders. Over half of students (59%) met the AEOP definition of underserved (U2), compared to 53% in FY18.[1]

Over half of the 72 national finalists for whom data are available (60%) were female (63% in FY18). Less than half of NJ&EE participants (40%) were White (30% in FY18; 47% in FY17), and slightly fewer – just over a third (38%) - were Asian (52% in FY18; 30% in FY17). While White and Asian students composed the majority of the NJ&EE population, 7% were Hispanic or Latino/a (7% in FY18; 5% in FY17), and 3% were Black or African American (3% in FY18; 4% in FY17). Less than half (40%) of NJ&EE participants met the AEOP definition of underserved in FY19. Data for eCM Team Advisors by type of school location are included in Table 3.

[1] AEOP's definition of underserved (U2) includes **at least two** of the following: Underserved populations include low-income students (FARMS); students belonging to race and ethnic minorities that are historically underrepresented in STEM (HUR) (i.e., Alaska Natives, Native Americans, Blacks or African Americans, Hispanics, Native Hawaiians and other Pacific Islanders); students with disabilities (ADA); students with English as a second language (ELLs); first-generation college students (1stGEN); students in rural, frontier, or other federal targeted outreach schools (GEO); and females in certain STEM fields (Gender) (e.g., physical science, computer science, mathematics, or engineering).

Table 1. 2019 eCM State-Level Participation

State/DoDEA/ Territories[2]	No. of Participants	State/DoDEA/ Territories	No. of Participants
AE-E	73	**NC**	127
AK	24	**ND**	130
AL	150	**NE**	4
AP	242	**NH**	4
AR	27	**NJ**	566
AZ	477	**NM**	88
CA	1588	**NV**	375
CO	189	**NY**	510
CT	121	**OH**	640
DC	102	**OK**	207
DE	12	**OR**	33
FL	5127	**PA**	1448
GA	540	**PR**	26
GU	54	**RI**	0
HI	252	**SC**	119
IA	176	**SD**	6
ID	73	**TN**	279
IL	245	**TX**	617
IN	119	**UT**	270
KS	55	**VA**	458
KY	50	**VT**	186
LA	66	**WA**	205
MA	172	**WI**	108
MD	153	**WV**	247
ME	3	**WY**	4
MI	675	**INTER**	8
MN	71	**MP**	8
MO	244	**Total Participation**	**17944**
MS	178		
MT	13		

[2] AE-E – Armed Forces Europe; INTER – International (locations outside of DoDEA); MP – Northern Mariana Islands

Table 2. 2019 eCM Student Profile				
Demographic Category	**Overall Participants (n=17,944)**		**eCM-NJ&EE Participants (n=72)**	
Participant Gender (n=17,944)				
Female	8,888	49.5%	43	60%
Male	8,549	47.7%	27	37%
Choose not to report	507	2.8%	2	3%
Participant Race/Ethnicity (n=17,944)				
Asian	1,607	9.0%	27	37.5%
Black or African American	2,288	12.8%	2	2.8%
Hispanic or Latino	4,034	22.5%	5	6.9%
Native American or Alaska Native	220	1.2%	0	0%
Native Hawaiian or Other Pacific Islander	136	<1%	0	0%
White	7,249	40.4%	29	40.3%
Other race or ethnicity (self-reported, some more than 1 race)	911	5.1%	4	5.6%
Choose not to report	1,499	8.4%	5	6.9%
Participant Grade Level (n=17,944)				
6th	5,072	28.3%	16	22.2%
7th	5,497	30.6%	18	25.0%
8th	5,441	30.3%	19	26.4%
9th	1,934	10.8%	19	26.4%
Participant Eligible for Free/Reduced-Price (n=17,944)				
Yes	5,830	32.5%	7	9.7%
No	8,505	47.4%	60	83.4%
Choose not to report	3,609	20.1%	5	6.9%
English is a first language (n=17,944)				
Yes	13,939	77.7%	63	87.5%
No	2,898	16.2%	8	11.1%
Choose not to report	1,107	6.1%	1	1.4%
One parent/guardian graduated from college (n=17,944)				
Yes	12,869	71.7%	70	97.2%
No	2,604	14.5%	1	1.4%
Choose not to report	2,471	13.8%	1	1.4%
School Location (n=17,944)				
Urban	6,729	37.5%	18	25.0%
Suburban	7,916	44.1%	39	54.1%
Rural	1,048	5.8%	5	6.9%
DoDEA	375	2.1%	2	2.8%
Frontier/Tribal School	85	<1%	0	0.0%

Home School	64	<1%	0	0.0%
Online School	40	<1%	4	5.6%
Choose not to report	1,687	9.4%	4	5.6%
Underserved/Underrepresented Status (n=17,944)				
Yes	10,511	58.6%	29	40.3%
No	7,433	41.4%	43	59.7%

Table 3. 2019 eCM Team Advisor Participation by School Location	
School Location Type	**No. of total Participants**
Team Advisors from DoDEA	10
Team Advisors from Home School	2
Team Advisors from Online School	2
Team Advisors Rural	57
Team Advisors Suburban	216
Team Advisors Urban	187
Team Advisors Frontier or Tribal School	1
Choose not to report	14
No responses	0
Total	**489**

The total cost of the 2019 eCM program was $2,954,682. The average cost per student participant for 2019 eCM was $165 (Table 4).

Table 4. 2019 eCM Program Costs	
Total Cost	$2,954,682
Total Travel	$499,940
Participant Travel	$390,597
Total Awards	$700,297
Student Awards/Stipends	$694,897
Adult/Teacher/Mentor Awards	$5,400
Cost Per Student	$165

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4 | Evaluation At-A-Glance

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

Inputs	Activities	Outputs	Outcomes (Short term)	Impact (Long Term)
• NSTA providing oversight for all aspects of the competition • Students participating in state, regional and national levels competitions • STEM professionals and educators serving as Team Advisors, judges, CyberGuides, and Ambassadors • Awards for student competitors and teams. All students who submit a mission folder also receive recognition. • Centralized branding and comprehensive marketing • Centralized evaluation	• Students conduct "authentic" STEM and humanities research, often with Team Advisors • Students recognize the real-life applications of STEM • Teams of three or four students ask questions or define problems and then construct explanations or design solutions based on identified problems in their community • Team Advisors oversee the student led projects • STEM professionals judge the top 60 teams during the regional judging • Regional winners advance to the NJ&EE • Program activities that expose students to AEOPs and/or STEM careers in the Army or DoD	• Number and diversity of student participants engaged in programs • Number and diversity of STEM professionals and educators serving as Team Advisors, CyberGuides, and Ambassadors • Number and diversity of DoD scientists and engineers and other military personnel engaged in programs • Number and Title 1 status of schools served through participant engagement • Students, Team Advisors, and NSTA contributing to evaluation	• Increased participant knowledge, skills and abilities, and confidence in STEM • Increased student interest in future STEM engagement • Increased participant awareness of and interest in other AEOP opportunities • Increased participant awareness of and interest in DoD STEM research and careers • Implementation of evidence-based recommendations to improve eCM regional and national programs	• Increased student participation in other AEOP and DoD-sponsored 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 DoD STEM careers • Continuous improvement and sustainability of eCM

The eCM evaluation gathered information from multiple participant groups about eCM 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 eCM program objectives.

The assessment strategy for eCM included questionnaires, focus group interviews at the NJ&EE, observations at the NJ&EE, and the program information provided by NSTA. Questionnaires were administered to students who competed regionally, students who competed at the national (NJ&EE) level, and Team Advisors. Two focus groups were conducted with eCM students at the NJ&EE and one focus group with Team Advisors at the NJ&EE. Findings are reported herein for students who competed at the regional level (referred to as Regional students, eCM-R students, or overall students, since all participants competed at this level) and for students who competed at the NJ&EE (referred to as National students, eCM-N students or NJ&EE students). Tables 5-9 outline the information collected in student and Team Advisor questionnaires and focus groups as well as program information provided by NSTA that is relevant to this evaluation report.

Key Evaluation Questions

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

Table 5. 2019 Student Questionnaire	
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-program experience
	STEM Competencies: Gains in Knowledge of STEM, Science & Engineering Practices; contribution of AEOP
	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 AEOP
	AEOP Opportunities: Past participation, awareness of, and interest in participating in other AEOPs; contribution of AEOP, 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 AEOP, impact of AEOP resources
AEOP Goal 2 and 3	**Mentor Capacity:** Perceptions of mentor/teaching strategies (students respond to a subset)
	Comprehensive Marketing Strategy: impact of AEOP resources on awareness of AEOPs and Army/DoD STEM research and careers
Satisfaction & Suggestions	Benefits to participants, suggestions for improving programs, overall satisfaction

Table 6. 2019 Mentor Questionnaire	
Category	**Description**
Profile	**Demographics:** Participant gender, race/ethnicity, occupation, past participation
Satisfaction & Suggestions	Awareness of AEOP, satisfaction with and suggestions for improving HSAP programs, benefits to participants
AEOP Goal 1	**Capturing the Student Experience:** In-program experience
	STEM Competencies: Gains in Knowledge of STEM, Science & Engineering Practices; contribution of AEOP
	Transferrable Competencies: Gains in 21st Century Skills
	AEOP Opportunities: Past participation, awareness of other AEOPs; efforts to expose students to AEOPs, impact of AEOP resources on efforts; contribution of AEOP in changing student AEOP metrics
	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 AEOP in changing student Army/DoD career metrics
AEOP Goal 2 and 3	**Mentor Capacity:** Perceptions of mentor/teaching strategies
	Comprehensive Marketing Strategy: how mentors learn about AEOP, usefulness of AEOP resources on awareness of AEOPs and Army/DoD STEM research and careers
Satisfaction & Suggestions	Benefits to participants, suggestions for improving programs, overall satisfaction

Table 7. 2019 Student Focus Group Interviews	
Category	**Description**
Satisfaction & Suggestions	Awareness of AEOP, motivating factors for participation, awareness of implications of research topics, satisfaction with and suggestions for improving HSAP 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. 2019 Team Advisor Focus Group Interviews	
Category	**Description**
Satisfaction & Suggestions	Perceived value of eCM, benefits to participants suggestions for improving eCM
AEOP Goal 1 and 2 Program Efforts	**Army STEM: AEOP Opportunities –** Efforts to expose apprentices 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 eCM

Table 9. 2019 Program Information Provided by NSTA	
Category	**Description**
Program	Description of symposia categories and activities
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 – Exposure to Army STEM research and careers (varies by regional, national event); Participation of Army engineers and/or Army research facilities in event activities (varies by regional, national event)
	Mentor Capacity: Local Educators - University faculty and student involvement, teacher involvement

The eCM Evaluation included examination of participant outcomes and other areas that would inform program continuous improvement. A focus of the evaluation is on efforts toward the long-term goal of eCM 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 the factors that motivate students to participate in eCM, 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.[3] STEM competencies are necessary for a 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 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 eCM 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.

Also included is an evaluation of the Next Generation STEM Teaching Project (NGSTP), a teacher professional development program that targeted eCM teachers beginning in 2018 as part of a pilot program to expand teachers' capacity in STEM content and practices. This program was funded by the National Defense Education Program in year one. The second year of funding came from AEOP. The funding for this program is not included in program costs. A description of the NGSTP, the evaluation study sample, and findings from the evaluation are included within the section of this report that contains findings related to AEOP Priority #2, STEM Savvy Educators, that articulates the goal of supporting and empowering educators with unique Army research and technology resources.

Detailed information about methods and instrumentation, sampling and data collection, and analysis are described in the appendices. 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

[3] 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.

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.

significance are noted in the report narrative, with tables and footnotes providing results from tests for significance. Focus group protocols are provided in Appendix B (students) and Appendix C (Team Advisors); questionnaires are provided in Appendix D (Students), and Appendix E (Team Advisors). The 21st Century Skills Assessment instrument is provided in Appendix F, and the NGSTP interview protocol is provided in Appendix G. Major trends in data and analyses are reported herein.

Study Sample

Questionnaire respondents for the FY19 eCM evaluation included 629 regional eCM participants, 68 national students, and 145 Team Advisors. Team Advisors indicated their region on the evaluation questionnaire (Table 10).

Table 10. Team Advisor Identified Region on Evaluation Questionnaire (n=145)

eCM Region	Response Percent	Response Total
West	21.38%	31
North Central	7.59%	11
South Central	8.97%	13
North East	22.07%	32
South East	25.52%	37
Not Sure	14.48%	21

Table 11 provides an analysis of student and Team Advisor participation in the eCM questionnaires, the response rate, and the margin of error at the 95% confidence level (a measure of how representative the sample is of the population). The margin of error for Team Advisors is outside of the acceptable range, and therefore findings from Team Advisors should be interpreted with caution as they may not be generalizable to the overall population.

Table 11. 2019 eCM Questionnaire Respondents

Participant Group	Respondents (Sample)	Total Participants* (Population)	Participation Rate	Margin of Error @ 95% Confidence[4]
eCM-R Students	628	17,944	3.40%	± 3.84%
eCM-N Students	68	72	94.44%	± 2.82%
Team Advisors	145	489	29.65%	± 6.83%

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

[4] "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

Focus groups were conducted at the NJ&EE in Leesburg, VA. The two student focus groups included 21 students in grades 6 to 9, including 9 males and 12 females. The adult focus group conducted at the NJ&EE included 22 adults, 18 of whom were female and 4 of whom were male. Adult participants included 12 teachers, 1 scout leader, and 9 parents. Focus groups were not intended to yield generalizable findings; rather they were intended to provide additional evidence of, explanation for, or illustrations of questionnaire data. They add to the overall narrative of eCM's efforts and impact and highlight areas for future exploration in programming and evaluation.

Respondent Profiles

Participant Demographics

Table 12 provides demographic data for eCM FY19 participants who completed the evaluation questionnaire. Although more than 600 eCM regional students completed the questionnaire, gender information was only provided by 356 students. Among eCM regional students reporting gender, similar proportions reported being female (48%) and male (46%). Gender composition of respondents for eCM-NJ&EE was unevenly divided, with more than half female (58%) and slightly over a third male (38%). More eCM regional questionnaire participants identified with the race/ethnicity category of White (46%) than any other category, followed by Hispanic or Latino/a (24%). Responding NJ&EE level participants were primarily White (43%) and Asian (40%). More overall respondents were 7th graders (47%) compared to any other grade level, while more NJ&EE respondents were 8th (29%) and 9th (27%) graders. Approximately half (49%) of eCM and nearly all (88%) of NJ&EE of questionnaire respondents reported that they did not qualify for free or reduced-price lunch (FRL)—a common indicator of low-income status. Very few eCM (4%) and no NJ&EE students reported being English Language Learners. While suburban (41% eCM; 69% NJ&EE) was the most reported category for school location, more than a third (37%) of overall eCM respondents indicated they were from urban schools compared to none from NJ&EE. Few students reported being first generation college going students regardless of group (14% eCM; 0% NJ&EE). More than half of overall participants (53%) met the AEOP definition of U2 compared to a much smaller percentage for NJ&EE (16%).

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.

Table 12. 2019 eCM Student Respondent Profile				
Demographic Category	**eCM Questionnaire Respondents**		**eCM-NJ&EE Questionnaire Respondents**	
Respondent Gender (eCM n=356, eCM NJ&EE n=45)				
Female	172	48%	26	58%
Male	164	46%	17	38%
Choose Not to Report	20	6%	2	4%
Respondent Race/Ethnicity (eCM n=628, eCM NJ&EE n=68)				
Asian	72	11%	27	40%
Black or African American	29	5%	2	3%
Hispanic or Latino	149	24%	6	9%
Native American or Alaska Native	4	<1%	0	0%
Native Hawaiian or other Pacific Islander	7	1%	0	0%
White	287	46%	29	43%
Other race or ethnicity (specify):[†]	29	5%	3	4%
Choose Not to Report	51	8%	1	1%
English Language Learners – ELL (eCM n=628, eCM NJ&EE n=0)				
Yes	27	4%	0	0%
No	601	96%	0	0%
Choose Not to Report	0	0%	0	0%
Respondent Grade Level Fall of Next School Year (eCM n = 628, eCM NJ&EE n=68)				
6th	57	9%	3	4%
7th	295	47%	12	18%
8th	122	20%	20	29%
9th	89	14%	18	27%
Other	65	10%	15	22%
Respondent Eligible for Free/Reduced-Price Lunch – FARMS (eCM n=628, eCM NJ&EE n=68)				
Yes	267	43%	7	10%
No	310	49%	60	88%
Choose Not to Report	51	8%	1	2%
Respondent School Location (eCM n=628*, eCM NJ&EE n=35)				
Urban	230	37%	0	0%
Rural	89	14%	3	9%
Suburban	257	41%	24	69%
DoDEA	0	0%	2	6%
Home School	0	0%	0	0%
Online School	0	0%	3	9%
I don't know	81	13%	0	0%
Choose Not to Report	0	0%	3	9%
Respondent First Generation College (eCM n=628*, eCM NJ&EE n=45)				

Yes	86	14%	0	0%
No	433	69%	44	98%
I don't know	80	13%	0	0%
Choose Not to Report	41	6%	1	2%
AEOP Defined Underrepresented – U2 (eCM n=628, eCM NJ&EE n=68)				
Yes	332	53%	11	16%
No	296	47%	57	84%

† Other = Asian-Caucasian (3), Belize/Black/Hispanic, Black and white, European, European Indian, European white hispanic, French, Hispanic/African America, Indian, Indian/Jamaican, Indian/Italian, Korean, MexiAmerican, Mexican/American/Cuban, Mexican/Filipino, Mixed (3), Romanian, Two or more races, White, White and African American, White and Hispanic (2) , White and Mexican.

*Note: Some students selected more than one option for these responses, resulting in more than 100% response rate for these items.

Team Advisor Demographics

Table 13 summarizes adult/team advisor survey respondent demographic information. Three-quarters of adults who completed the evaluation survey were female and White. Nearly all adults reported being teachers (93%), and almost three-quarters (72%) indicated they were eCM Team Advisors.

Table 13. 2019 eCM Adult Respondent Profile		
Demographic Category	**Questionnaire Respondents**	
Respondent Gender (n=145)		
Female	108	75%
Male	35	24%
Choose not to report	2	1%
Respondent Race/Ethnicity (n=145)		
Asian	6	4%
Black or African American	14	10%
Hispanic or Latino	9	6%
Native American or Alaska Native	0	0%
Native Hawaiian or other Pacific Islander	0	0%
White	108	75%
Other race or ethnicity, (specify):†	2	1%
Choose not to report	6	4%
Respondent Occupation (n=145)		
Teacher	135	93%
Other school staff	2	1%
University educator	1	1%
Scientist, Engineer, or Mathematician in training (undergraduate or graduate student, etc.)	1	1%
Scientist, Engineer, or Mathematics professional	1	1%
Other, (specify):‡	5	3%
Respondent Role in eCM (n=274)*		
Research Mentor	3	2%
Team advisor	136	72%
Teacher	48	26%
Other, (specify)§	1	1%

*Note: Some adults selected more than one option for this response, resulting in more than 100% response rate for this item.

‡ No responses provided.

5

5 | Priority #1 Findings

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

Assessed Growth in Skills – 21st Century Findings

A 21st Century Skills Assessment (Johnson & Sondergeld, 2016) evaluation was completed for a small sample of eCM mini-grant awardees. Mentors assessed each participant in a pre/post manner. The first assessment was completed in the first days of the program (pre), and the second assessment was completed at the end of the program (post). The assessment was used to determine the growth toward mastery for each participant during their time in the eCM program. The assessment tool can be found in Appendix F. Mentors rated each participant's skills in six domains of 21st Century Skills:

1. Creativity and Innovation
2. Critical Thinking and Problem Solving
3. Communication, Collaboration, Social, and Cross-Cultural Skills
4. Information, Media, & Technological Literacy
5. Flexibility, Adaptability, Initiative, and Self-Direction
6. Productivity, Accountability, Leadership, and Responsibility

Mentors were asked to assess their student eCM participants in each of the domains they felt applied to the work students had completed with them over the course of the program. Between 111 and 114 eCM students were assessed for the 24 skills related to each of the six areas. An overall summary of the findings for each of the six domains of 21st Century Skills is presented in Table 14 and shown graphically in Figure 1.

There were significant increases in participants' observed skills from the beginning (pre-) to the end (post) of their eCM experiences ($p<.001$) for all six assessed domains of 21st Century Skills (Table 14). Participants experienced the greatest gains in growth in the areas of Communication skills and Productivity/Leadership skills. On average, participants' initial ratings were approaching the Progressing level while their post-eCM ratings were at the approaching Demonstrates Mastery level (above 2.50).

Table 14. Overall 21st Century Skill Set Observation Pre-Post Findings

Skill Set	*n*	Observation Time		Pre-Post Change	*t*-stat
		Pre - *M*(*SD*)	Post - *M*(*SD*)		
Creativity & Innovation	114	1.82(.57)	2.69(.48)	+0.87	16.45***
Critical Thinking & Problem Solving	114	1.81(.54)	2.66(.50)	+0.86	16.36***
Communication, Collaboration, Social, & Cross-Cultural	114	1.47(.52)	2.78(.49)	+1.31	29.30***
Information, Media, & Technological Literacy	113	1.82(.52)	2.66(.52)	+0.84	14.52***
Flexibility, Adaptability, Initiative, & Self-Direction	114	1.90(.59)	2.77(.46)	+0.87	15.72***
Productivity, Accountability, Leadership, & Responsibility	114	1.49(.41)	2.74(.48)	+1.25	26.66***

NOTE. Statistical significance levels provided in table by asterisks with *p<.05, **p<.01, ***p<.001

Figure 1. 21st Century Skill Set Pre-Post Comparison with Criteria Indicators

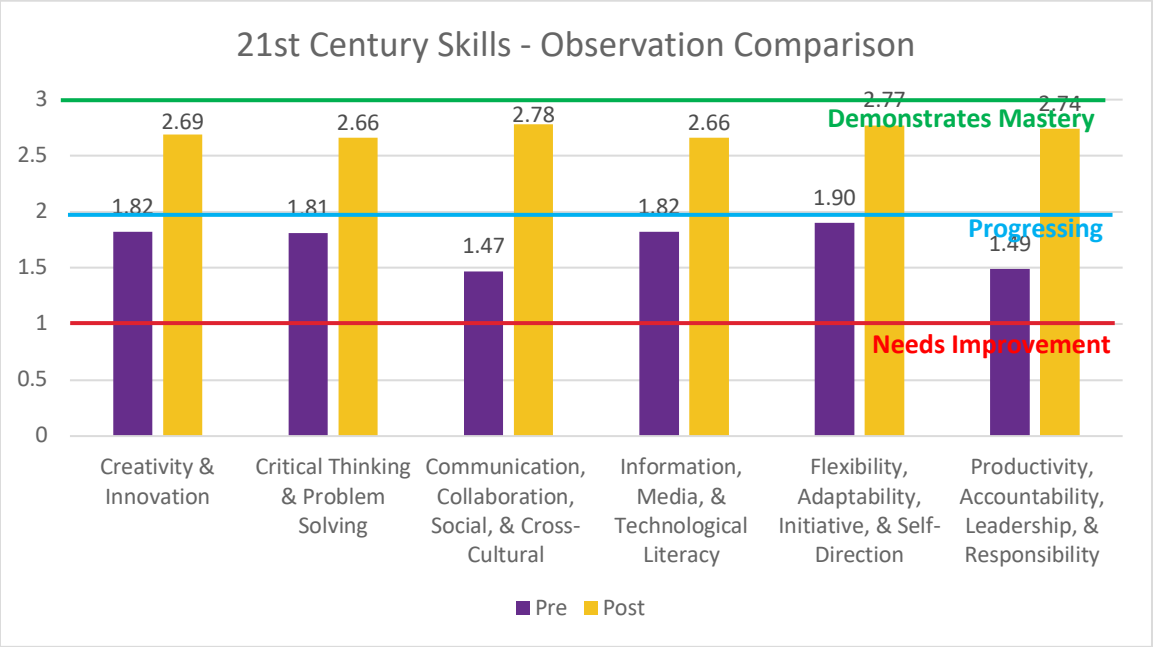


Table 15 displays findings for each of the 24 specific skills associated with the six domains of 21st Century Skills. Each of the 24 specific skills observed showed a statistically significant increase from pre- to post-ratings (p<.001) ranging from 0.79 to 0.98 points of growth.

Table 15. Overall 21st Century Skill Set Pre-Post Findings

Overall Skill Set *Item (Specific Skill Observed)*	*n*	Observation Time		Pre-Post Change	*t*-stat
		Pre - *M*(*SD*)	Post - *M*(*SD*)		
Creativity & Innovation					
Think creatively	113	1.82(0.64)	2.69(0.50)	+0.86	14.23***
Work creatively with others	112	1.83(0.66)	2.69(0.51)	+0.87	13.02***
Implement innovations	114	1.8(0.60)	2.66(0.61)	+0.86	13.31***
Critical Thinking & Problem Solving					
Reason effectively	113	1.85(0.65)	2.70(0.47)	+0.85	13.20***
Use systems thinking	113	1.73(0.61)	2.61(0.61)	+0.88	13.38***
Make judgments and decisions	112	1.81(0.62)	2.67(0.52)	+0.87	14.40***
Solve problems	114	1.81(0.58)	2.64(0.59)	+0.82	13.44***
Communication, Collaboration, Social, & Cross-Cultural					
Communicate clearly	114	1.84(0.63)	2.77(0.48)	+0.93	15.32***
Communicate with others	114	1.92(0.62)	2.77(0.48)	+0.84	13.63***
Interact effectively with others	114	1.87(0.55)	2.79(0.48)	+0.92	16.08***
Information, Media, & Technological Literacy					
Access and evaluate information	112	1.83(0.64)	2.72(0.50)	+0.89	13.98***
Use and manage information	113	1.78(0.66)	2.65(0.59)	+0.87	12.10***
Analyze media	102	1.74(0.65)	2.57(0.60)	+0.83	11.49***
Create media products	103	1.81(0.62)	2.61(0.61)	+0.80	11.24***
Apply technology effectively	113	1.92(0.52)	2.69(0.50)	+0.76	12.83***
Flexibility, Adaptability, Initiative, & Self-Direction					
Adapt to change	113	1.91(0.64)	2.77(0.43)	+0.87	13.66***
Be flexible	113	1.89(0.65)	2.81(0.41)	+0.92	14.32***
Manage goals and time	112	1.86(0.66)	2.77(0.49)	+0.91	14.49***
Work independently	110	1.88(0.68)	2.72(0.58)	+0.85	12.55***
Be a self-directed learner	113	1.93(0.67)	2.72(0.60)	+0.79	11.96***
Productivity, Accountability, Leadership, & Responsibility					
Manage projects	114	1.89(0.62)	2.75(0.55)	+0.86	13.31***
Produce results	112	1.81(0.60)	2.77(0.45)	+0.96	16.24***
Guide and lead others	111	1.73(0.56)	2.65(0.62)	+0.92	14.61***
Be responsible to others	111	1.81(0.63)	2.79(0.48)	+0.98	15.35***

NOTE. Statistical significance levels provided in table by asterisks with *$p<.05$, **$p<.01$, ***$p<.001$

STEM Practices

eCM actively seeks to engage students in practices associated with STEM research and innovation. STEM practices are ways that students "do STEM" by actively engaging in STEM research and with other STEM researchers. STEM practices include, for example, the extent to which students contribute their own ideas to research projects, use laboratory equipment and research techniques, analyze data, and work with professionals in STEM outside of their school settings. In order to understand how effectively eCM is engaging students in STEM research and innovation, the questionnaire included items in which participants were asked to report on the frequency with which they engaged in various STEM practices both in eCM and in their typical school experiences in STEM.

Students were asked how often they engaged in various STEM practices while in eCM (Tables 16 & 17). Overall, three-quarters or more of NJ&EE and one-third or more of overall eCM participants reported engaging in all STEM practices at least once during their program. Both eCM and NJ&EE students noted engaging in the following three practices most frequently (weekly or every day): working collaboratively as part of a team (eCM - 60%; NJ&EE - 85%); analyzing data or information and draw conclusions (eCM - 43%; NJ&EE - 66%); and identifying questions or problems to investigate (eCM - 42%; NJ&EE - 54%). Parallel items about STEM practices students engaged with during school were also asked, and those results are provided in Tables 18 and 19.

Composite scores were computed for each set of items for "Engaging in STEM Practices in eCM."[5] Response categories were converted to a scale of 1 = "Not at all" to 5 = "Every day" and the average across all items on each scale was calculated. Composite scores were used to test whether there were differences in student experiences by AEOP-defined underrepresented status (U2) and all subgroups that make up U2 (gender, race/ethnic group, school location, FARMS, ELL, and college first generation). Significant group differences were found in terms of engaging with STEM practices in eCM by school location[6], with urban/rural students reporting significantly greater engagement with STEM practices than students attending suburban schools (small effect size of d = 0.297). No differences were found by overall U2 status or any other student demographic examined.

Composite scores were also developed for the "Engaging in STEM Practices in School" items[7] to compare eCM STEM practice experiences to students' typical school STEM practice experiences. Students reported significantly greater engagement with STEM in eCM than in school[8] regardless of the competition level (NJ&EE - medium effect of d = 0.655; Regional - medium effect of d = 0.645) (see Chart 1).

[5] The Cronbach's alpha reliability for these 12 items was 0.881.
[6] Two-tailed independent samples t-test: $t(521) = 3.39$, $p < .001$.
[7] The Cronbach's alpha reliability for these 12 items was 0.866.
[8] Two-tailed dependent samples t-tests - Regional: $t(627) = 8.08$, $p < 0.001$; National: $t(66) = 2.66$, $p < 0.01$.

Table 16. STEM Practices During eCM for National Respondents (n=68)

	Not at all	At least once	Monthly	Weekly	Every day	Response Total
Work with a STEM researcher or company on a real-world STEM research project	29.4%	39.7%	8.8%	16.2%	5.9%	
	20	27	6	11	4	**68**
Work with a STEM researcher on a research project topic assigned by my teacher	35.3%	42.6%	7.4%	4.4%	10.3%	
	24	29	5	3	7	**68**
Design my own research or investigation based on my own question(s)	7.4%	36.8%	23.5%	19.1%	13.2%	
	5	25	16	13	9	**68**
Present my STEM research to a panel of judges from industry or the military	25.0%	57.4%	8.8%	5.9%	2.9%	
	17	39	6	4	2	**68**
Interact with STEM researchers	19.1%	36.8%	22.1%	10.3%	11.8%	
	13	25	15	7	8	**68**
Use laboratory procedures or tools	7.4%	14.7%	29.4%	32.4%	16.2%	
	5	10	20	22	11	**68**
Identify questions or problems to investigate	2.9%	17.6%	25.0%	30.9%	23.5%	
	2	12	17	21	16	**68**
Design and carry out an investigation	4.4%	19.1%	32.4%	26.5%	17.6%	
	3	13	22	18	12	**68**
Analyze data or information and draw conclusions	1.5%	11.8%	20.6%	42.6%	23.5%	
	1	8	14	29	16	**68**
Work collaboratively as part of a team	1.5%	4.4%	8.8%	25.0%	60.3%	
	1	3	6	17	41	**68**
Build or make a computer model	32.4%	35.3%	8.8%	13.2%	10.3%	
	22	24	6	9	7	**68**
Solve real world problems	7.4%	27.9%	16.2%	8.8%	39.7%	
	5	19	11	6	27	**68**

Table 17. STEM Practices During eCM for Regional Respondents (n=628)

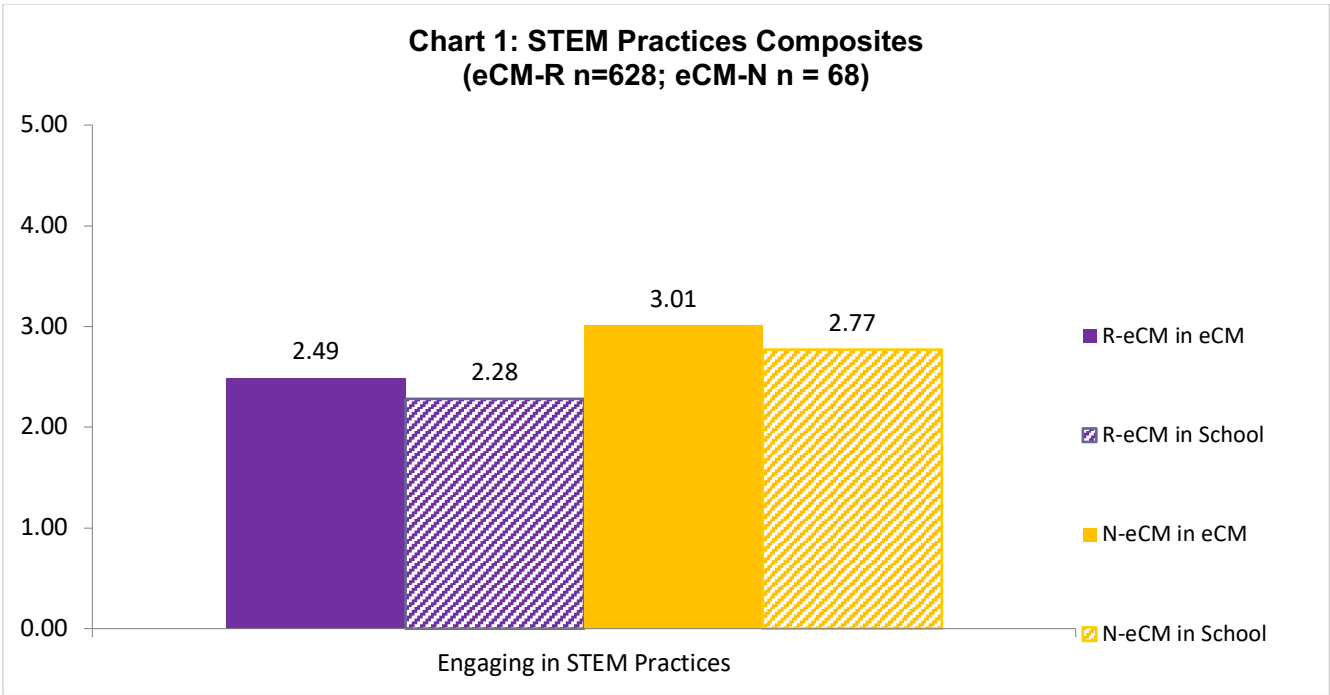
	Not at all	At least once	Monthly	Weekly	Every day	Response Total
Work with a STEM researcher or company on a real world STEM research project	56.7%	23.4%	9.6%	7.8%	2.5%	
	356	147	60	49	16	**628**
Work with a STEM researcher on a research project topic assigned by my teacher	48.2%	25.3%	12.3%	9.9%	4.3%	
	303	159	77	62	27	**628**
Design my own research or investigation based on my own question(s)	18.0%	38.7%	15.0%	17.7%	10.7%	
	113	243	94	111	67	**628**
Present my STEM research to a panel of judges from industry or the military	60.0%	26.9%	6.7%	4.3%	2.1%	
	377	169	42	27	13	**628**
Interact with STEM researchers	51.3%	22.9%	11.0%	9.6%	5.3%	
	322	144	69	60	33	**628**
Use laboratory procedures and tools	23.4%	28.8%	16.9%	21.5%	9.4%	
	147	181	106	135	59	**628**
Identify questions or problems to investigate	11.9%	29.3%	16.9%	26.4%	15.4%	
	75	184	106	166	97	**628**
Design and carry out an investigation	13.7%	35.0%	18.5%	19.6%	13.2%	
	86	220	116	123	83	**628**
Analyze data or information and draw conclusions	10.7%	27.7%	18.3%	26.4%	16.9%	
	67	174	115	166	106	**628**
Work collaboratively as part of a team	8.4%	19.4%	12.6%	24.0%	35.5%	
	53	122	79	151	223	**628**
Build or make a computer model	60.7%	20.5%	7.3%	7.6%	3.8%	
	381	129	46	48	24	**628**
Solve real world problems	14.2%	33.0%	15.3%	16.6%	21.0%	
	89	207	96	104	132	**628**

Table 18. STEM Practices During School for eCM National Respondents (n=68)

	Not at all	At least once	Monthly	Weekly	Every day	Response Total
Work with a STEM researcher or company on a real-world STEM research project	41.2%	29.4%	7.4%	13.2%	8.8%	
	28	20	5	9	6	**68**
Work with a STEM researcher on a research project topic assigned by my teacher	42.6%	32.4%	8.8%	7.4%	8.8%	
	29	22	6	5	6	**68**
Design my own research or investigation based on my own question(s)	8.8%	36.8%	26.5%	11.8%	16.2%	
	6	25	18	8	11	**68**
Present my STEM research to a panel of judges from industry or the military	48.5%	38.2%	7.4%	1.5%	4.4%	
	33	26	5	1	3	**68**
Interact with STEM researchers	27.9%	47.1%	10.3%	10.3%	4.4%	
	19	32	7	7	3	**68**
Use laboratory procedures and tools	14.7%	17.6%	30.9%	29.4%	7.4%	
	10	12	21	20	5	**68**
Design and carry out an investigation	1.5%	23.5%	44.1%	23.5%	7.4%	
	1	16	30	16	5	**68**
Analyze data or information and draw conclusions	0.0%	11.8%	25.0%	39.7%	23.5%	
	0	8	17	27	16	**68**
Work collaboratively as part of a team	0.0%	4.4%	17.6%	26.5%	51.5%	
	0	3	12	18	35	**68**
Build or make a computer model	35.3%	36.8%	13.2%	10.3%	4.4%	
	24	25	9	7	3	**68**
Solve real world problems	10.3%	29.4%	22.1%	10.3%	27.9%	
	7	20	15	7	19	**68**

Table 19. STEM Practices During School for eCM Regional Respondents (n=628)

	Not at all	At least once	Monthly	Weekly	Every day	Response Total
Work with a STEM researcher or company on a real world STEM research project	54.1%	26.3%	10.5%	6.1%	3.0%	
	340	165	66	38	19	**628**
Work with a STEM researcher on a research project topic assigned by my teacher	47.3%	31.2%	11.1%	7.5%	2.9%	
	297	196	70	47	18	**628**
Design my own research or investigation based on my own question(s)	26.1%	43.2%	17.7%	9.1%	4.0%	
	164	271	111	57	25	**628**
Present my STEM research to a panel of judges from industry or the military	73.9%	18.9%	4.0%	2.7%	0.5%	
	464	119	25	17	3	**628**
Interact with STEM researchers	57.5%	25.6%	7.2%	5.6%	4.1%	
	361	161	45	35	26	**628**
Use laboratory procedures and tools	20.9%	36.5%	23.6%	14.3%	4.8%	
	131	229	148	90	30	**628**
Identify questions or problems to investigate	14.8%	32.8%	18.5%	20.5%	13.4%	
	93	206	116	129	84	**628**
Design and carry out an investigation	19.4%	39.6%	21.5%	13.5%	5.9%	
	122	249	135	85	37	**628**
Analyze data or information and draw conclusions	12.1%	33.3%	22.5%	21.3%	10.8%	
	76	209	141	134	68	**628**
Work collaboratively as part of a team	7.3%	20.9%	20.4%	26.6%	24.8%	
	46	131	128	167	156	**628**
Build or make a computer model	62.6%	21.5%	7.3%	6.1%	2.5%	
	393	135	46	38	16	**628**
Solve real world problems	18.9%	36.6%	13.9%	14.0%	16.6%	
	119	230	87	88	104	**628**



STEM Knowledge and Skills

To measure to what extent students, build STEM knowledge and skills while engaging in in eCM activities, the questionnaire asked participants to report on gains in knowledge and specific skills related to STEM. More than half of overall eCM and all NJ&EE students indicated they experienced some degree of STEM knowledge gain as a result of participating in eCM (Tables 20 and 21). While overall gains were reported by nearly all students, approximately 60% or more of NJ&EE respondents reported large gains across the STEM knowledge items, while only 16%-23% of overall eCM respondents indicated large gains. STEM knowledge items with the greatest group differences (50% points or more) in student-reported large gains were knowledge of research processes, ethics, and rules for conduct in STEM (eCM - 59%; NJ&EE - 72%) and in depth knowledge of a STEM topic (eCM - 16%; NJ&EE - 68%).

Table 20. eCM--NJ&EE Participant Reports of Impact on STEM Knowledge (n=68)

	No gain	Small gain	Medium gain	Large gain	Response Total
In depth knowledge of a STEM topic(s)	0.0%	4.4%	27.9%	67.6%	
	0	3	19	46	**68**
Knowledge of research conducted in a STEM topic or field	0.0%	7.4%	20.6%	72.1%	
	0	5	14	49	**68**
Knowledge of research processes, ethics, and rules for conduct in STEM	0.0%	7.4%	33.8%	58.8%	
	0	5	23	40	**68**
Knowledge of how scientists and engineers work on real problems in STEM	0.0%	7.4%	32.4%	60.3%	
	0	5	22	41	**68**
Knowledge of what everyday research work is like in STEM	0.0%	10.3%	29.4%	60.3%	
	0	7	20	41	**68**

Table 21. eCM-Overall Participant Reports of Impact on STEM Knowledge (n=628)

	No gain	Small gain	Medium gain	Large gain	Response Total
In depth knowledge of a STEM topic(s)	14.2%	29.6%	40.3%	15.9%	
	89	186	253	100	**628**
Knowledge of research conducted in a STEM topic or field	14.2%	27.1%	40.6%	18.2%	
	89	170	255	114	**628**
Knowledge of research processes, ethics, and rules for conduct in STEM	15.9%	28.5%	37.3%	18.3%	
	100	179	234	115	**628**
Knowledge of how scientists and engineers work on real problems in STEM	17.7%	26.1%	33.8%	22.5%	
	111	164	212	141	**628**
Knowledge of what everyday research work is like in STEM	19.3%	26.1%	34.6%	20.1%	
	121	164	217	126	**628**

To evaluate differences in STEM knowledge gains by subgroup, survey items were combined into a composite variable.[9] Significant differences in STEM knowledge gains were only found by school

[9] The Cronbach's alpha reliability for these 5 items was 0.870.

location[10], with urban/rural students reporting significantly larger gains than suburban students (small effect size of d = 0.262). No differences in STEM knowledge gains were found by overall U2 status or other demographic variables explored.

Tables 22 and 23 summarize the impact of eCM on student STEM Competencies. Approximately half or more of survey participants reported medium or large gains on all STEM competency items. NJ&EE students indicated greater gains in STEM competencies compared to their regional peers across all similar items with a 15%-31% point difference. Items with the largest group differences in reported medium or large gains (30% points or more) were supporting an explanation with STEM knowledge or data from experiments (eCM - 55%; NJ&EE - 85%) and making a model to show how something works (eCM - 54%; NJ&EE - 84%). The two items with the greatest reported gains (60% or more of participants reporting medium to large gains across competition groups) were carrying out an experiment and recording data accurately (eCM - 62%; NJ&EE - 88%) and using knowledge and creativity to suggest a solution to a problem (eCM - 69%; NJ&EE - 84%).

Composite scores were calculated for gains in STEM competencies[11] and used to assess for differential impacts on STEM competencies depending on student group membership. Significant STEM competency differences were found by school location[12], with urban/rural students reporting greater gains compared to their suburban peers with (small effect size of d = 0.265). No significant differences were found in terms of STEM competencies by overall U2 Status or other student level demographics.

[10] Two-tailed independent samples t-test: $t(521) = 2.99$, $p < .01$.

[11] The STEM Competencies composite (14 items) has a Cronbach's alpha reliability of 0.943.

[12] Two-tailed independent samples t-test: $t(521) = 3.03$, $p < .01$.

Table 22 eCM-NJ&EE Participant Gains in their STEM Competencies – Science and Engineering Practices (n=68)

	No gain	Small gain	Medium gain	Large gain	Response Total
Asking a question that can be answered with one or more scientific experiments	1.5%	13.2%	44.1%	41.2%	
	1	9	30	28	**68**
Using knowledge and creativity to suggest a testable explanation (hypothesis) for an observation	1.5%	14.7%	36.8%	47.1%	
	1	10	25	32	**68**
Making a model of an object or system showing its parts and how they work	5.9%	10.3%	26.5%	57.4%	
	4	7	18	39	**68**
Carrying out procedures for an experiment and recording data accurately	2.9%	8.8%	35.3%	52.9%	
	2	6	24	36	**68**
Using computer models of objects or systems to test cause and effect relationships	14.7%	27.9%	20.6%	36.8%	
	10	19	14	25	**68**
Organizing data in charts or graphs to find patterns and relationships	4.4%	16.2%	26.5%	52.9%	
	3	11	18	36	**68**
Considering different interpretations of data when deciding how the data answer a question	1.5%	19.1%	35.3%	44.1%	
	1	13	24	30	**68**
Supporting an explanation for an observation with data from experiments	2.9%	11.8%	35.3%	50.0%	
	2	8	24	34	**68**
Defending an argument that conveys how an explanation best describes an observation	4.4%	19.1%	29.4%	47.1%	
	3	13	20	32	**68**
Integrating information from technical or scientific texts and other media to support your explanation of an observation	2.9%	20.6%	29.4%	47.1%	
	2	14	20	32	**68**
Communicating about your experiments and explanations in different ways (through talking, writing, graphics, or mathematics)	2.9%	11.8%	30.9%	54.4%	
	2	8	21	37	**68**

Table 23. eCM Overall Participant Gains in their STEM Competencies – Science and Engineering Practices (n=628)

	No gain	Small gain	Medium gain	Large gain	Response Total
Defining a problem that can be solved by developing a new or improved product or process	14.6%	29.0%	39.6%	16.7%	
	92	182	249	105	**628**
Creating a hypothesis or question that can be tested in an experiment	11.9%	25.0%	39.3%	23.7%	
	75	157	247	149	**628**
Using my knowledge and creativity to suggest a solution to a problem	11.5%	19.4%	42.4%	26.8%	
	72	122	266	168	**628**
Making a model to show how something works	18.9%	27.2%	30.9%	22.9%	
	119	171	194	144	**628**
Designing procedures or steps for an experiment that work	14.6%	26.9%	36.9%	21.5%	
	92	169	232	135	**628**
Identifying the limitations of the methods and tools used for collecting data	16.4%	29.0%	36.3%	18.3%	
	103	182	228	115	**628**
Carrying out an experiment and recording data accurately	14.6%	23.9%	37.3%	24.2%	
	92	150	234	152	**628**
Creating charts or graphs to display data and find patterns	16.7%	30.3%	33.9%	19.1%	
	105	190	213	120	**628**
Considering multiple interpretations of data to decide if something works as intended	16.7%	30.7%	38.4%	14.2%	
	105	193	241	89	**628**
Supporting an explanation with my STEM knowledge or data from experiments	17.5%	27.9%	37.3%	17.4%	
	110	175	234	109	**628**
Identifying the strengths and limitations of data or arguments presented in scientific or technical texts	19.9%	30.7%	34.1%	15.3%	
	125	193	214	96	**628**
Presenting an argument that uses data and/or findings from an experiment	17.4%	29.0%	36.8%	16.9%	
	109	182	231	106	**628**

	No gain	Small gain	Medium gain	Large gain	Response Total
Defending an argument based upon findings from an experiment or other data	16.9%	30.9%	33.0%	19.3%	
	106	194	207	121	**628**
Integrating information from technical or scientific texts or other media to support your explanation of an experiment or solution to a problem	17.8%	31.5%	34.1%	16.6%	
	112	198	214	104	**628**

Tables 24 and 25 show results from student responses about the impact of eCM on their 21st Century skills. While not all items were the same across surveys, in general overall eCM participants reported lower gains (40% to 72% medium/large gains) compared to NJ&EE participants (87% to 96% medium/large gains). Items with more than 70% of overall eCM participants reporting medium to large gains were working creatively with others (73%), solving problems (71%), and accessing/evaluating information efficiently and critically (71%). For the four similar items that both competition levels of students were asked to rate, NJ&EE students reported greater medium/large gains compared to overall eCM students. These items were communicating effectively/clearly with others (NJ&EE – 96%, eCM – 65%), making changes or adapting to change when things do not go as planned (NJ&EE – 87%, eCM – 67%), sticking with a task until it is finished (NJ&EE – 84%, eCM – 67%), and working well or collaborating with others from diverse backgrounds (NJ&EE – 81%, eCM – 67%).

For overall eCM survey participants, a 21st Century skills composite variable[13] was computed to test for differences between student subgroups. Significant differences were not found by overall U2 Status or any student demographics.

[13] The 21st Century Skills composite (23 items) had a Cronbach's alpha reliability of .963.

Table 24. eCM-NJ&EE Participant Reports of Impacts on 21st Century Skills (n=68)

	No gain	Small gain	Medium gain	Large gain	Response Total
Sticking with a task until it is finished	2.9%	13.2%	14.7%	69.1%	
	2	9	10	47	**68**
Making changes when things do not go as planned	1.5%	11.8%	20.6%	66.2%	
	1	8	14	45	**68**
Working well with students from all backgrounds	1.5%	17.6%	17.6%	63.2%	
	1	12	12	43	**68**
Including others' perspectives when making decisions	1.5%	8.8%	26.5%	63.2%	
	1	6	18	43	**68**
Communicating effectively with others	0.0%	4.4%	30.9%	64.7%	
	0	3	21	44	**68**
Viewing failure as an opportunity to learn	2.9%	10.3%	22.1%	64.7%	
	2	7	15	44	**68**

Table 25. eCM Overall Participant Reports of Impacts on 21st Century Skills (n=628)

	No gain	Small gain	Medium gain	Large gain	Response Total
Thinking creatively	11.3%	18.8%	34.9%	35.0%	
	71	118	219	220	**628**
Working creatively with others	9.2%	18.2%	33.9%	38.7%	
	58	114	213	243	**628**
Using my creative ideas to make a product	11.1%	18.9%	37.3%	32.6%	
	70	119	234	205	**628**
Thinking about how systems work and how parts interact with each other	13.7%	23.7%	38.4%	24.2%	
	86	149	241	152	**628**
Evaluating others' evidence, arguments, and beliefs	12.4%	23.7%	39.0%	24.8%	
	78	149	245	156	**628**
Solving problems	8.9%	19.7%	36.1%	35.2%	

	No gain	Small gain	Medium gain	Large gain	Response Total
	56	124	227	221	**628**
Communicating clearly (written and oral) with others	11.5%	23.4%	35.4%	29.8%	
	72	147	222	187	**628**
Collaborating with others effectively and respectfully in diverse teams	10.2%	22.5%	37.9%	29.5%	
	64	141	238	185	**628**
Interacting effectively with others in a respectful and professional manner	11.3%	21.0%	38.4%	29.3%	
	71	132	241	184	**628**
Accessing and evaluating information efficiently (time) and critically (evaluates sources)	12.4%	28.0%	40.0%	19.6%	
	78	176	251	123	**628**
Using and managing data accurately, creatively, and ethically	10.5%	25.2%	41.1%	23.2%	
	66	158	258	146	**628**
Analyzing media (news) - understanding points of view in the media	18.5%	25.3%	36.8%	19.4%	
	116	159	231	122	**628**
Creating media products like videos, blogs, social media	36.3%	23.6%	25.6%	14.5%	
	228	148	161	91	**628**
Use technology as a tool to research, organize, evaluate, and communicate information	11.5%	23.4%	36.8%	28.3%	
	72	147	231	178	**628**
Adapting to change when things do not go as planned	11.0%	21.8%	34.9%	32.3%	
	69	137	219	203	**628**
Incorporating feedback on my work effectively	12.1%	26.9%	39.6%	21.3%	
	76	169	249	134	**628**
Setting goals and utilizing time wisely	12.7%	25.2%	37.6%	24.5%	
	80	158	236	154	**628**
Working independently and completing tasks on time	14.0%	25.2%	35.7%	25.2%	
	88	158	224	158	**628**
	13.5%	23.7%	39.2%	23.6%	

	No gain	Small gain	Medium gain	Large gain	Response Total
Taking initiative and doing work without being told to	85	149	246	148	**628**
Prioritizing, planning, and managing projects to achieve completion	11.6%	24.5%	38.2%	25.6%	
	73	154	240	161	**628**
Producing results - sticking with a task until it is finished	11.1%	24.8%	37.7%	26.3%	
	70	156	237	165	**628**
Leading and guiding others in a team or group	13.9%	20.9%	35.4%	29.9%	
	87	131	222	188	**628**
Being responsible to others - thinking about the larger community	11.0%	19.9%	36.5%	32.6%	
	69	125	229	205	**628**

STEM Identity and Confidence

Both overall eCM and NJ&EE students were asked a series of similar survey questions to measure the impact of eCM on their STEM identities. Because students are unlikely to pursue STEM if they do not see themselves as capable of succeeding in STEM[14], deepening students' STEM knowledge and skills is important for increasing the likelihood that they will pursue STEM education and/or careers. The reported impact of eCM on participants' STEM identities was more intense for NJ&EE (ranging from 75% to 94% medium/large impact) compared to overall eCM participants (ranging from 39% to 56% medium/large impact) (Tables 26 and 27). The three items with the largest difference (40% points or more) in STEM identity by competition level were a desire to build relationships with mentors who work in STEM (eCM - 43%; NJ&EE - 88%), feeling prepared for more challenging STEM activities (eCM - 54%; NJ&EE - 94%), and interest in a new STEM topic (eCM - 42%; NJ&EE - 84%). Regardless of competition level, students reported the most impact (half or more students reporting medium to large impact) in their sense of accomplishing something in STEM (eCM - 56%; NJ&EE - 93%).

[14] 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.

Table 26. eCM-NJ&EE Participant Reports on Impacts on STEM Identity (n=68)

	No gain	Small gain	Medium gain	Large gain	Response Total
Interest in a new STEM topic	1.5%	14.7%	23.5%	60.3%	
	1	10	16	41	**68**
Deciding on a path to pursue a STEM career	8.8%	16.2%	30.9%	44.1%	
	6	11	21	30	**68**
Sense of accomplishing something in STEM	1.5%	5.9%	23.5%	69.1%	
	1	4	16	47	**68**
Feeling prepared for more challenging STEM activities	0.0%	5.9%	22.1%	72.1%	
	0	4	15	49	**68**
Thinking creatively about a STEM project or activity	1.5%	14.7%	17.6%	66.2%	
	1	10	12	45	**68**
Desire to build relationships with mentors who work in STEM	2.9%	8.8%	26.5%	61.8%	
	2	6	18	42	**68**
Connecting a STEM topic or field to my personal values	4.4%	11.8%	23.5%	60.3%	
	3	8	16	41	**68**

Table 27. eCM Overall Participant Reports on Impacts on STEM Identity (n=628)

	No gain	Small gain	Medium gain	Large gain	Response Total
Interest in a new STEM topic	30.3%	27.4%	27.1%	15.3%	
	190	172	170	96	**628**
Deciding on a path to pursue a STEM career	34.1%	26.9%	26.3%	12.7%	
	214	169	165	80	**628**
Sense of accomplishing something in STEM	20.4%	24.0%	32.0%	23.6%	
	128	151	201	148	**628**
Feeling prepared for more challenging STEM activities	20.4%	26.1%	33.9%	19.6%	
	128	164	213	123	**628**
Confidence to try out new ideas or procedures on my own in a STEM project	22.0%	28.8%	28.8%	20.4%	
	138	181	181	128	**628**
Desire to build relationships with mentors who work in STEM	31.2%	26.1%	26.9%	15.8%	
	196	164	169	99	**628**

A composite score for STEM Identity items[15] was computed to assess for differential eCM program impact on subgroups of students. No differences in STEM Identity were found by overall U2 Status or student level demographics.

[15] The Cronbach's alpha reliability for these 6 STEM Identity items was 0.912.

6

6 | Priority #2 Findings

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

Mentor Strategies and Support

Team Advisors and other adults play a critical role in the eCM program. Adults/Team Advisors provide one-on-one support to students, chaperone students, advise students on educational and career paths, may provide opportunities for students to use laboratory space and/or equipment, and generally serve as STEM role models for eCM students. Adults were asked whether or not they used a number of strategies when working with students. These strategies comprised five main areas of effective team advising:[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.

[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.

Adults were asked about their use of multiple strategies related to effective team advising. Tables 28-32 display eCM adult responses and show that the majority of adults reported using various effective mentoring strategies in their team advising.

Two-thirds or more of eCM adults reported using all strategies associated with establishing the relevance of learning activities (Table 28). Strategies that nearly all (93% or more) Team Advisors reported using were asking students to relate real-life events to eCM topics (95%), becoming familiar with student backgrounds and interests at the beginning of eCM (95%), and helping students understand how STEM can help them improve their communities (93%).

Table 28. Team Advisors Using Strategies to Establish the Relevance of Learning Activities (n=145)

	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 eCM experience	94.5%	5.5%	
	137	8	**145**
Giving students real-life problems to investigate or solve	91.0%	9.0%	
	132	13	**145**
Selecting readings or activities that relate to students' backgrounds	66.9%	33.1%	
	97	48	**145**
Encouraging students to suggest new readings, activities, or projects	85.5%	14.5%	
	124	21	**145**
Helping students become aware of the role(s) that STEM plays in their everyday lives	91.0%	9.0%	
	132	13	**145**
Helping students understand how STEM can help them improve their own community	93.1%	6.9%	
	135	10	**145**
Asking students to relate real-life events or activities to topics covered in eCYBERMISSION	95.2%	4.8%	
	138	7	**145**

Approximately two-thirds or more of eCM Team Advisors indicated using all strategies to support the diverse needs of learners (Table 29). Strategies used by nearly all respondents were using a variety of teaching and/or mentoring activities to meet the needs of all students (95%) and interacting with students and other personnel the same way regardless of their background (92%). Highlighting under-representation of women and racial/ethnic minority populations in STEM and/or their contributions in STEM (64%) was the strategy least used by eCM Team Advisors.

Table 29. Team Advisors Using Strategies to Support the Diverse Needs of Learners (n=145)

	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 eCM experience	82.8%	17.2%	
	120	25	**145**
Interact with students and other personnel the same way regardless of their background	91.7%	8.3%	
	133	12	**145**
Use a variety of teaching and/or mentoring activities to meet the needs of all students	95.2%	4.8%	
	138	7	**145**
Integrating ideas from education literature to teach/mentor students from groups underrepresented in STEM	76.6%	23.4%	
	111	34	**145**
Providing extra readings, activities, or learning support for students who lack essential background knowledge or skills	76.6%	23.4%	
	111	34	**145**
Directing students to other individuals or programs for additional support as needed	89.0%	11.0%	
	129	16	**145**
Highlighting under-representation of women and racial and ethnic minority populations in STEM and/or their contributions in STEM	64.1%	35.9%	
	93	52	**145**

Two-thirds or more of eCM Team Advisors completing the survey reported using all strategies to support participants' development of collaboration and interpersonal skills (Table 30). Two strategies reportedly used most often were having participants listen to the ideas of others with an open mind (96%) and having participants exchange ideas with others whose backgrounds/viewpoints are different from their own (89%). The least implemented strategy for developing collaboration and interpersonal skills was having participants tell other people about their backgrounds and interests (66%).

Table 30. Team Advisors Using Strategies to Support Participant Development of Collaboration and Interpersonal Skills (n=145)

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Having participant(s) tell other people about their backgrounds and interests	66.2%	33.8%	
	96	49	**145**
Having participant(s) explain difficult ideas to others	85.5%	14.5%	
	124	21	**145**
Having participant(s) listen to the ideas of others with an open mind	95.9%	4.1%	
	139	6	**145**
Having participant(s) exchange ideas with others whose backgrounds or viewpoints are different from their own	89.0%	11.0%	
	129	16	**145**
Having participant(s) give and receive constructive feedback with others	88.3%	11.7%	
	128	17	**145**

More than three-quarters of eCM Team Advisors reported implementing all strategies to support participants' engagement in authentic STEM activities (Table 31). Nearly all Team Advisors reported using the following three strategies: supervising participants while they practice STEM research skills (98%), providing participants with constructive feedback to improve STEM competencies (97%), and allowing participants to work independently to improve their self-management abilities (97%).

Table 31. Team Advisors Using Strategies to Support Participant Engagement in Authentic STEM Activities (n=145)

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Teaching (or assigning readings) about specific STEM subject matter	78.6%	21.4%	
	114	31	**145**
Having participant(s) search for and review technical research to support their work	88.3%	11.7%	
	128	17	**145**
Demonstrating laboratory/field techniques, procedures, and tools for my student(s)	87.6%	12.4%	
	127	18	**145**
Supervising participant(s) while they practice STEM research skills	97.9%	2.1%	
	142	3	**145**
Providing participant(s) with constructive feedback to improve their STEM competencies	97.2%	2.8%	
	141	4	**145**
Allowing participant(s) to work independently to improve their self-management abilities	97.2%	2.8%	
	141	4	**145**

The final set of strategies Team Advisors were asked about were related to supporting students' STEM educational and career pathways (Table 32). As in FY18, these strategies were used by fewer eCM adults than any of the other previous strategy sets. For approximately half of the items, 50% or more eCM adults reported implementation. The two most frequently used strategies for supporting students' STEM educational and career pathways were providing guidance about educational pathways that will prepare participants for a STEM career (68%) and asking participants about their educational and/or career goals (72%).

Although one goal of AEOP is to increase participants' awareness of DoD STEM career opportunities, less than half of adults (41%) reported discussing STEM career opportunities within the DoD or other government agencies with students. Similarly, another AEOP goal is to increase participants' awareness of AEOP opportunities, however only 34% of adults reported recommending other AEOPs that align with student goals. Although these are less than desirable responses, they represent slight increases from FY18.

Table 32. Team Advisors Using Strategies to Support Participant STEM Educational and Career Pathways (n=145)

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Asking participant(s) about their educational and/or career goals	72.4%	27.6%	
	105	40	**145**
Recommending extracurricular programs that align with participants' goals	56.6%	43.4%	
	82	63	**145**
Recommending Army Educational Outreach Programs that align with participants' goals	33.8%	66.2%	
	49	96	**145**
Providing guidance about educational pathways that will prepare participant(s) for a STEM career	68.3%	31.7%	
	99	46	**145**
Discussing STEM career opportunities within the DoD or other government agencies	40.7%	59.3%	
	59	86	**145**
Discussing STEM career opportunities in private industry or academia	63.4%	36.6%	
	92	53	**145**
Discussing the economic, political, ethical, and/or social context of a STEM career	51.0%	49.0%	
	74	71	**145**
Recommending student and professional organizations in STEM to my student(s)	51.0%	49.0%	
	74	71	**145**
Helping participant(s) build a professional network in a STEM field	39.3%	60.7%	
	57	88	**145**
Helping participant(s) with their resume, application, personal statement, and/or interview preparations	30.3%	69.7%	
	44	101	**145**

Aside from eCM (91%), very few Team Advisors reported discussing any AEOPs explicitly (<1% - 8%) with students during the program (Table 33). However, roughly a quarter (27%) of Team Advisors indicated they discussed AEOP in general with their students.

Table 33. Team Advisors' Responses to AEOPs that were Explicitly Discussed with Participants (n=145)

	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)	8.3%	91.7%	
	12	133	**145**
UNITE	0.7%	99.3%	
	1	144	**145**
Junior Science & Humanities Symposium (JSHS)	4.1%	95.9%	
	6	139	**145**
Science & Engineering Apprenticeship Program (SEAP)	5.5%	94.5%	
	8	137	**145**
Research & Engineering Apprenticeship Program (REAP)	4.1%	95.9%	
	6	139	**145**
High School Apprenticeship Program (HSAP)	3.4%	96.6%	
	5	140	**145**
GEMS Program	6.2%	93.8%	
	9	136	**145**
College Qualified Leaders (CQL)	0.7%	99.3%	
	1	144	**145**
GEMS Near Peer Mentor Program	1.4%	98.6%	
	2	143	**145**
Undergraduate Research Apprenticeship Program (URAP)	1.4%	98.6%	
	2	143	**145**
Science Mathematics, and Research for Transformation (SMART) College Scholarship	6.2%	93.8%	
	9	136	**145**
National Defense Science & Engineering Graduate (NDSEG) Fellowship	0.7%	99.3%	
	1	144	**145**
I discussed AEOP with participant(s) but did not discuss any specific program	26.9%	73.1%	
	39	106	**145**
eCYBERMISSION	91.0%	9.0%	
	132	13	**145**

Program Features and Feedback/Satisfaction

Tables 34 and 35 present student responses regarding their satisfaction with eCM program features. Overall, NJ&EE participants reported higher levels of satisfaction compared to regional participants. Features that both national and regional participants were somewhat or very much satisfied with included applying or registering for the program (eCM - 50%; NJ&EE - 81%), the submission process (eCM - 53%; NJ&EE - 82%), and the eCM website (eCM - 60%; NJ&EE - 82%). Many participants (20%-51%) at both the regional and national levels indicated not experiencing eCM features related to Cyber Guides, including live chats (eCM - 51%; NJ&EE - 31%), discussion forums (eCM - 44%; NJ&EE - 28%), and feedback (eCM - 37%; NJ&EE - 19%). A third or more of national and regional students also indicated not experiencing eCM features related to Mission Control communications, including phone response time (eCM - 44%; NJ&EE - 34%) and email response time (eCM - 42%; NJ&EE - 38%).

Table 34. Student Satisfaction with eCM-N Program Features (n=68)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Applying or registering for the program	10.3%	1.5%	7.4%	29.4%	51.5%	
	7	1	5	20	35	**68**
Submission process	4.4%	2.9%	10.3%	23.5%	58.8%	
	3	2	7	16	40	**68**
Value of Cyber Guide live chat	30.9%	2.9%	8.8%	19.1%	38.2%	
	21	2	6	13	26	**68**
Variety of STEM Mission Challenges available	5.9%	4.4%	8.8%	14.7%	66.2%	
	4	3	6	10	45	**68**
Value of Cyber Guides feedback	19.1%	1.5%	10.3%	20.6%	48.5%	
	13	1	7	14	33	**68**
Value of Cyber Guides discussion form	27.9%	1.5%	11.8%	22.1%	36.8%	
	19	1	8	15	25	**68**
Educational materials (e.g., online resources, etc.) used during program activities	8.8%	1.5%	11.8%	26.5%	51.5%	
	6	1	8	18	35	**68**
eCYBERMISSION website	4.4%	0.0%	13.2%	36.8%	45.6%	
	3	0	9	25	31	**68**
Mission control (phone) response time	33.8%	4.4%	1.5%	14.7%	45.6%	
	23	3	1	10	31	**68**
Mission control (email) response time	38.2%	4.4%	1.5%	14.7%	41.2%	
	26	3	1	10	28	**68**

Table 35. Student Satisfaction with eCM-R Program Features (n=628)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Applying or registering for the program	15.1%	10.4%	24.2%	25.3%	25.0%	
	95	65	152	159	157	**628**
Submission process	11.8%	12.1%	23.2%	26.9%	26.0%	
	74	76	146	169	163	**628**
Value of Cyber Guide live chat	51.8%	10.4%	16.1%	12.9%	8.9%	
	325	65	101	81	56	**628**
Variety of STEM Mission Challenges available	25.6%	9.7%	25.5%	23.6%	15.6%	
	161	61	160	148	98	**628**
Value of Cyber Guides feedback	36.9%	9.7%	20.5%	18.6%	14.2%	
	232	61	129	117	89	**628**
Value of Cyber Guides discussion form	43.6%	9.4%	19.3%	16.7%	11.0%	
	274	59	121	105	69	**628**
Educational materials (e.g., online resources, etc.) used during program activities	17.4%	8.3%	24.7%	27.9%	21.8%	
	109	52	155	175	137	**628**
eCYBERMISSION website	6.7%	9.7%	23.6%	28.5%	31.5%	
	42	61	148	179	198	**628**
Mission control (phone) response time	43.6%	10.8%	17.0%	15.0%	13.5%	
	274	68	107	94	85	**628**
Mission control (email) response time	41.9%	11.9%	16.9%	16.7%	12.6%	
	263	75	106	105	79	**628**

In order to understand more about students' satisfaction with their overall eCM experience, eCM-R and eCM-N students were asked to respond to an open-ended item on the questionnaire asking them to comment on their satisfaction with eCM. Three-quarters (75%) of the 517 eCM-R students who provided a response were unreservedly positive about their experiences. Another 67 (13%) of eCM-R students made positive comments but included caveats about their experiences. Most of the 62 student respondents (59, or 95%) who competed at the national level also had only positive things to say about eCM, and only 3 eCM-N students included caveats to their positive comments. Those who provided explanations of their satisfaction with their eCM experiences commented on their learning, the

opportunity to solve real-world problems, having fun, teamwork, the support of their mentors, and the career information the program provided. For example, eCM students said,

> *"I was very happy with my experience in eCYBERMISSION. I think this competition is a great experience for all new researchers to 'dip their toes in the water' of the vast pool that is the world of STEM. As this was my first research competition, I can definitely say that I have a newfound interest in widening my horizons and continuing to explore STEM."* (eCM-R Student)

> *"I definitely had a lot of fun while doing this project! My team earned many valuable skills and have become more aware of the problems that are in our world. Hopefully our ideas can continue to grow and become actual inventions that could help those in need. I am definitely happy that I did this project!"* (eCM-R Student)

> *"eCYBERMISSION has helped me get a clear vision of what a STEM career and education look like. It was very fun working with my partners trying to solve our problem."* (eCM-R Student)

> *"I am very satisfied with eCYBERMISSION, it helped me to learn how to participate with others even when you are frustrated with each other. It was very fun and challenging, and we also ran into lots of problems which challenged us to think of a solution and figure out how we were going to make our model work."* (eCM-R Student)

> *"I am thankful for being able to learn about more STEM careers and meeting professionals. I am glad to have had this experience."* (eCM-N Student)

> *"I loved the experience and the mentors were funny and nice! I am excited to come back. I loved the activities we did!!"* (eCM-N Student)

> *"It was amazing. I've met so many great people and learned so many things. Will definitely recommend to future friends. Thank you for hosting this event! It was a blast!"* (eCM-N Student)

The eCM-R students who included caveats qualifying their positive comments mentioned problems working with their teammates, website problems, not having fun, being bored, or commented on mandatory participation. The eCM-N students' caveats focused on scheduling issues such as the long program day. For example,

> *"It was okay, would've liked to do it with my friends. One person in our group did everything at home without asking for help and blamed us for it, he was a pain to work with."* (eCM-R Student)

> *"I was very satisfied, but the questions never saved when you left the site; you need to change that to make it easier."* (eCM-R Student)

"In my opinion I think that eCYBERMISSION is a good program…. In my opinion it should be an extracurricular activity for students to join if they want to. I think this because in my school this was a required experience even though many weren't motivated to do their missions…I feel eCyber is really good for people that are motivated to participate in this but for us we were forced to do eCyber." (eCM-R Student)

"I enjoyed eCYBERMISSION greatly and was satisfied with my overall experience. However, the days were long and tiring." (eCM-N Student)

Some eCM-R students (60, or 12%) had no positive comments to make about their eCM experience. These students cited problems with teamwork, lack of choice in project, an unprepared instructor, stress, the website, and lack of fun or boredom as reasons for their dissatisfaction. For example,

"It was not my most favorite thing to do because there was no freedom as to what type of project we could do. We were only given two categories, and I personally wished we were offered more." (eCM-R Student)

"Our main issues didn't come from a lack of skill in the STEM process. Our main issues came from the limitations of the website. As once we uploaded a picture it was extremely difficult to change its caption. This forced us to have to re-upload many images. Another thing that really decreased my satisfaction with this project was the website's inability to upload videos, because a large amount of our test could only be shown through videos. So, overall eCYBERMISSION is a great concept, but it's execution could be a lot better." (eCM-R Student)

"I disliked the eCYBERMISSION experience because of the way my team adviser led us through the process. There was no instructional content, and the majority of my time during eCYBERMISSION was spent confused, and trying to find out how to get through the day…I have never felt more stressed in my life, and in the end, I learned almost nothing about STEM related activities and careers. I definitely think I would've had a great time in eCYBERMISSION if I had a more instructional team adviser who had actually helped me through the process…maybe provide training for the team advisers in the future." (eCM-R Student)

Students were also asked in an open-ended questionnaire item to list three ways in which eCM could be improved. Of the 165 eCM-R student responses sampled, the most often-mentioned improvements were:

- providing more or different topics or options for projects (37, or 22%)
- providing more or better support or resources for student research (for example, extending the times of live chats and improving the contents of the "care package") (34, or 21%)
- improving the website by making it easier to navigate, allowing more than one person at a time to edit the mission folder, autosaving work, and making the submission process more user-friendly (34, or 21%)

- providing better or clearer instructions, questions, and/or deadlines (33, or 20%)
- making eCM more interesting or fun (27, or 16%)
- reducing the requirements for the mission folder or requiring less or easier work (24, or 15%)
- allowing more time to complete the mission folder (18, or 11%)

Another 18 eCM-R students (11%) indicated that no improvements were needed. Other improvements mentioned by less than 10% of students included:

- providing more examples or tutorials
- providing more interactive/hands-on activities
- providing more flexibility in group sizes (larger groups, smaller groups, or options for individual participation)
- providing more opportunities for or more support for teamwork
- requiring less writing or typing
- providing more or better prizes
- providing more publicity and/or more participants
- providing more or better feedback on projects
- including a greater variety of disciplines, or disciplines other than engineering
- providing better mentors or better information for mentors or Team Advisors
- shortening the questionnaire

The 61 eCM-N students who offered suggestions for improvements focused on elements of the NJ&EE. The most frequently mentioned improvement, mentioned by 21 (34%) eCM-N student respondents, was to provide more free time and/or more time for sleep at the NJ&EE. Other improvements suggested for the NJ&EE included less sitting time (14 students, or 23%); providing more free time or time for students to socialize (13 students, or 21%); general comments about improvements to the schedule (11 students, or 18%); and improvements to the DC trip such as moving the trip to Tuesday, allowing more time to talk to congressional representatives, offering a longer trip, or providing better communication about the trip (10 students, or 16%). Improvements mentioned by between three and seven eCM-N students (5%-11%) included:

- improvements to the food choices
- providing more hands-on activities
- improvements to the rules
- improvements to communication about or organization of the event
- improvements to the website such as allowing videos in the mission folders or allowing more than 1 person at a time to edit the folder
- providing incentives or pay to teachers to increase the reach of the program
- providing more or better feedback from judges

eCM-N students participating in focus groups also offered several suggestions for improvements. These suggestions included allowing more time for the project, more time for hands-on activities, less time sitting, more information or more time for the DC trip, more opportunity to socialize with others or meet other students, and publicizing eCM more widely. Students said, for example,

> "*I think it would be better for [eCM to provide] more time so I could get more data on [our project] and have more information about our topic to be able to present. I feel like the amount of data we have isn't enough. If we could have more time, then we'd be able to have more to present and prove our problem statement and hypothesis.*" (eCM-N Student)

> "*[At the national event] we sat for a long time just listening to people talk. I know that's super important, but Monday, we sat for six hours just listening to people talk. Maybe spread it out?*" (eCM-N Student)

A pattern similar to students' satisfaction with eCM program features was evident in Team Advisors' responses to a survey item asking about their satisfaction with various eCM features (Table 36). More than 80% of eCM Team Advisors reported being somewhat or very much satisfied with the submission process (89%), eCM website (86%), application/registration process (85%), and the variety of STEM Mission Challenges available (82%). Additionally, more than half of eCM Team Advisors indicated they did not experience Cyber Guide features (discussion forum – 58%, live chat – 59%, feedback – 61%).

Like the student questionnaire, the Team Advisor questionnaire included open-ended items asking participants to share their opinions about the program. Adult respondents were asked to comment on their overall satisfaction with the program. Of the 118 adults who responded to this item, nearly all (95%) made positive comments about the program, focusing on the program resources, the staff support, the opportunity for students to engage in authentic investigations, and the opportunity for students to develop 21st Century skills. Adults said, for example,

> *"I've participated in eCYBERMISSION for 17 years and absolutely LOVE this competition. The experience is unmatched in the middle school competition-world for benefits to students and the quality of the competition. From the high-quality interactions with cyber guides and NSTA personnel to the process itself, eCM can't be beaten... Solving real-world problems using STEM and working as a team are obvious benefits but our students learn so much more in a comprehensive program like this. They not only learn science, they learn many types of technology skills, interpersonal skills, skills for interviews and phone calls, work etiquette with professionals and much more."* (eCM Team Advisor)

> *"The program is excellent the materials and opportunities afforded to students is awesome. It caused my students to use critical thinking skills and teamwork to accomplish their goals."* (eCM Team Advisor)

"The support we got from the office when we called in was amazing. They were always helpful answering questions and directing us in the right direction."

Table 36. Team Advisor Satisfaction with eCM Program Features (n=145)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Application or registration process	1.4%	3.4%	10.3%	19.3%	65.5%	
	2	5	15	28	95	**145**
Communication with National Science Teachers Association (NSTA)	19.3%	0.7%	6.9%	18.6%	54.5%	
	28	1	10	27	79	**145**
Submission process	0.7%	1.4%	9.0%	20.7%	68.3%	
	1	2	13	30	99	**145**
Value of Cyber Guide live chat	59.3%	0.7%	6.2%	11.7%	22.1%	
	86	1	9	17	32	**145**
The variety of STEM Mission Challenges available	9.0%	0.7%	8.3%	24.8%	57.2%	
	13	1	12	36	83	**145**
Value of Cyber Guides' feedback	61.4%	1.4%	4.8%	9.0%	23.4%	
	89	2	7	13	34	**145**
Value of Cyber Guides discussion forum	57.9%	1.4%	7.6%	7.6%	25.5%	
	84	2	11	11	37	**145**
eCYBERMISSION website	0.7%	0.0%	13.8%	20.0%	65.5%	
	1	0	20	29	95	**145**
Educational materials	9.0%	1.4%	16.6%	18.6%	54.5%	
	13	2	24	27	79	**145**
Mission control (phone) response time	47.6%	2.1%	1.4%	8.3%	40.7%	
	69	3	2	12	59	**145**
Mission control (email) response time	18.6%	2.1%	4.1%	10.3%	64.8%	
	27	3	6	15	94	**145**

Of the Team Advisors who made positive comments about their satisfaction, 14 (12%) added caveats, pointing to issues such as lack of flexibility in team membership, registration requirements, the difficulty of completing eCM requirements while meeting learning standards within their classrooms, the need for additional resource support, and the difficulty some of their students had with the program. For example, Team Advisors said,

> *"It's just too vast for me to undertake in addition to everything else I do in my lab all year. The amount of materials in this program could be used as an entire year's curriculum alone… I wish there were different levels of participation available or something… I love this as a concept. But these 2 years I have tried it, I only get as far as introducing it and projecting what they SHOULD be doing."* (eCM Team Advisor)

> *"I enjoy this project. The limitation I experience is that students move away and other students move here. Therefore, some students end up finishing individually while new students can't participate at all... I would like to see an opportunity for the grant money every year. It's a huge incentive for all of the work to be taught, checked, graded, etc. on top of the curriculum we teach. Some students do not have access to virtual resources, so I provide class time often, which takes away time and focus from our curriculum."* (eCM Team Advisor)

> *"It was a good experience for my average and above average students. For my struggling students it was not a very positive experience."* (eCM Team Advisor)

Only eight (7%) of Team Advisor respondents made no positive comments about eCM in their responses. These respondents commented upon the difficulty of the program, the lack of flexibility in group requirements, lack of teacher resources or Team Advisor training, lack of communication from the program, registration requirements, and a mismatch between eCM requirements and local science fair criteria. Team Advisors commented, for example

> *"It was difficult to implement in my context. Without having a Chrome Cart dedicated to my classroom, we did eCYBERMISSION activities intermittently which wasn't ideal."* (eCM Team Advisor)

> *"This program frustrates me - It feels rushed and it doesn't correspond well with our county science fair program, so students who participate in it do not have the opportunity to advance in a local fair where they may be more successful. There are students who do not work well in a group and having to be in a group of 3 or 4 is not fair."* (eCM Team Advisor)

> *"I teach the higher functioning special needs students that sit in regular classes, and this project was very difficult for them. They really struggled with it. My school requires all science classes to participate in eCYBERMISSION regardless of academic level, so there should be a simplified version of eCYBERMISSION for special needs students."* (eCM Team Advisor)

Adults were asked in another open-ended questionnaire item to list the three most important strengths of eCM. Nearly half of the 131 respondents (63, or 48%) cited student teamwork as a strength of eCM. Over a third of adult respondents (45, or 34%) cited the real-world application of concepts as a strength, and a similar number (43, or 33%) mentioned the opportunity for students to develop research or STEM skills as a strength of eCM. More than a quarter of respondents (37, or 28%) cited the usefulness of program resources such as the live chats, rubrics, examples, and CyberGuides as strengths of the program. Twenty-five respondents (19%) noted that the organization or structure of eCM, including the quality of the lessons was a strength. Other benefits, mentioned by between 10 and 16 respondents (8%-12%) included:

- the student-driven nature of eCM
- the ease of using the website
- the challenges or topics available
- students' exposure to STEM or STEM learning
- the online format
- eCM staff and/or communication with the program

Adult focus group participants at the NJ&EE mentioned similar strengths of eCM, noting the real-world connections, writing and communication skills, STEM learning, research skills, increases in motivation, the value of student-led work, and increases in students' confidence as program strengths. Team Advisors also noted that they have benefited from participating in eCM by the opportunity to work with small groups of students, the ease of use of the program, learning from students, and the opportunity to share their students' success stories with other teachers. Adults said, for example,

> *I think the entire process end-to-end is really great opportunity for all the students…the questions, how detailed they have to go, what all documents they have to turn in, the deadline, the time limit."* (eCM Team Advisor)

> "*I teach engineering [and eCM] reinforces all the concepts, and the kids get to see that there's real-world application through this process. It just ties everything together beautifully.* (eCM Team Advisor)

> *"The confidence of my kids has really increased. At the beginning, when we start the year, we always throw out the question, 'Do you think you can make a difference? Do you think you can actually do something?' Nobody does. They think it's just for bigger kids or for adults. They go through this process and they see that they really can make a difference. Their ideas are so much more powerful, and they have strength. That is invaluable.*" (eCM Team Advisor)

"I liked [eCM] because the variation of projects is so wide. It didn't pigeonhole them into something [where] they had to do one type of thing. I had a lot of teams. I had a lot of really different projects. It played to their interests." (eCM Team Advisor)

Adults were also asked to respond to an open-ended questionnaire item asking them to describe three ways eCM could be improved for future participants. The 116 respondents offered a wide variety of potential program improvements. The most frequently mentioned improvement was to provide more or better program resources (39, or 33%). These responses referred to a variety of program resources, and included suggestions to update videos, provide more project examples, provide examples of scored rubrics, and improve the timing of the online chats. The next most frequently mentioned improvement, commented upon by 24 (21%) of respondents was improvements to the Mission Folder, including allowing video uploads, providing an autosave feature, and allowing more than one student at a time to work on the folder. About 20% of Team Advisors (23) also suggested clarifying or simplifying the rules or guidelines, including the IRB requirements and rubrics, and allowing flexibility in team size. Of the 23 respondents who suggested revisions to team size requirements, 10 suggested smaller teams, 3 suggested larger teams, and 10 suggested flexibility in team size generally. Adults said, for example,

"All the chats are EST which makes them inaccessible to our Hawaii students who are in class." (eCM Team Advisor)

"More explicit examples by students for students of the steps of the process." (eCM Team Advisor)

"I think the IRB requirements need clearer language. What is a 'survey' versus just a 'test'?" (eCM Team Advisor)

"Students should be able to all work on their mission folder at the same time." (eCM Team Advisor)

"More flexibility to adjust teams based on school enrollment." (eCM Team Advisor)

Other improvements, mentioned by between seven and 11 respondents (6%-9%) included:

- improvements to the website, including updating it and making it easier to use
- improvements to registration, including eliminating questions about citizenship and SES
- improving communication
- providing a greater variety in topics or categories
- making the content more age appropriate for middle school or generally easier/simpler
- providing more guidance for Team Advisors
- providing guest speakers or DoD information

Adults participating in the focus group at NJ&EE were also asked to for their ideas about how the program could be improved. Suggested improvements included providing earlier payment of grant funds, providing teacher incentives, and revising program materials to link the scientific method to the engineering design process. Team Advisors noted that they are not compensated for the time it takes to complete the administrative tasks associated with advising their teams or for the out of school time associated with attending the national event. Team Advisors were particularly vocal about ways that the program could serve more underrepresented and underserved populations, commenting on the necessity of financial support for participation, and noting the burden that can fall on even those teachers who receive grant funding. As one teacher said,

> *"We did apply for the mini grant, but the payout was really late. I personally paid for all the supplies… If there was a teacher that wasn't able to do that, then [eCM] wouldn't have been in the school."* (eCM Team Advisor)

Next Generation STEM Teaching Project (NGSTP) Evaluation Findings

In recognition of the critical role that teachers play in developing students' STEM literacy and STEM-specific skills, the U.S. Army Combat Capabilities Development Command (CCDC) partnered with NSTA to pilot a professional learning experience for teachers beginning in the 2017-2018 school year and extending across three consecutive years. The goal of NGSTP is to provide in-service teachers with a robust understanding of the Next Generation Science Standards (NGSS) in the context of real-world research through mentoring by Army S&Es. The learning experience has three vital and intertwined components:

- Face to face training and follow-up webinars providing teachers with knowledge and resources about incorporating NGSS-aligned three-dimensional instruction in their classrooms.
- Pairing teachers with Army S&Es to act as mentors in developing and delivering curricular content.
- Grants of up to $2,600 per year to purchase supplies for classroom activities related to the curriculum teachers developed during their professional learning experience.

Teachers participating in NGSTP develop curricular materials based upon their workshop and mentoring experiences that they then deliver in their own classrooms (as part of a science class or as part of eCM activities). The expectation is that the program will strengthen teachers' content knowledge and teaching capacities by providing them with a structured learning opportunity and mentoring from content experts to develop curricular materials. Ultimately, the program aims to achieve the following outcomes:

1. Increase teacher awareness of and interest in STEM and STEM careers
2. Increase teacher understanding of and ability to facilitate three-dimensional learning (as described in the NGSS) with their students
3. Increase students' awareness of and interest in STEM content and using authentic real-world content developed by their teachers.

The program is national in scope, and the NGSTP project coordinator worked with NSTA to recruit teachers participating in eCM. In the 2018-19 school year, ten teachers participated in NGSTP, eight as first-time teacher participants and two as mentors who had participated in NGSTP in 2017-18. Nine of the participants were female and one was male. These teachers were from states across the U.S., including Colorado, Georgia, Idaho, Louisiana, Pennsylvania, Massachusetts, Vermont, and Wisconsin. All but one participating teacher indicated that they taught at a Title I school.

Because of the small population size, the evaluation was conducted using participant interviews. Phone interviews were conducted with nine participating teachers. Eight of the teachers participating in the phone interviews were female and one was male. Seven of the participants taught science, although one of these also taught social studies and one was a fourth-grade teacher who taught all subjects. One teacher was a STEM lab teacher and one was an assistant principal who was a former high school science

teacher and sponsored a 3rd grade after school class. Three participants were K-5 teachers, three were middle school (6th-8th grade) teachers, two were high school (9th-12th grade) teachers, and one participant was an assistant principal for a K-5 school. Four of the teachers acted as Team Advisors for eCM, one has had a student participate in JSHS in the past, and four teachers have never participated in AEOP.

The evaluation of NGSTP is organized according to the program outcomes outlined above, and also includes a discussion of strengths and successes of the program and participants' suggestions for program improvements.

Outcome #1: Increase teacher awareness of and interest in STEM and STEM careers

Teachers participating in interviews already had a strong awareness of and interest in STEM. They appreciated the opportunity to work with Army S&Es and were often able to connect what they learned from their mentors to the lesson plans they created. All but one teacher communicated with Army S&Es about their lesson plans. Participants appreciated the opportunities to collaborate with research professionals, receive support in disciplinary content, and receive feedback. For example, participating teachers said:

> "*[The Army scientist[recommended an instrument that would help us explore weather erosion of a salt block. It's just a simple, little, tiny refractometer. The kids just, they loved it. It was simple to use. They thought it was really interesting. It gave us some interesting data*." (NGSTP Participant)

> "*[The Army scientist] gave me so much information. She loved working with the students. I wish I could have utilized her more...She definitely gave me really good feedback."* (NGSTP Participant)

One teacher noted that while she valued the collaboration with the S&E, the match to the S&E was made relatively late in the program so that she was unable to make full use of the S&E as a resource in her lesson design. She said,

> *"I think having the scientists maybe set up earlier, maybe in September, when you're still in the design process, would be really helpful. I would love to utilize them more. She gave me so much information. She was very helpful. I just didn't get to take full advantage."* (NGSTP Participant)

Likewise, another teacher noted that the timing of the connection with S&Es limited her ability to collaborate, noting that,

> *"I wish I could have more time with [the scientist]. We only could interact through email because he was far away …I had to work about his timeframe… I needed more time basically."* (NGSTP Participant)

The one teacher who had not interacted with a S&E indicated that the program had been unable to identify an S&E who was willing to work with her on the topic of her lesson plan. She noted, however, that the program made considerable efforts to connect her with a STEM professional, saying

> *"They really struggled to find anybody that was able and willing to pick up and mentor from an algae perspective. I spoke with Matt Hartman, the director of the program, multiple times. What we ended up doing, because they couldn't find an Army mentor, was he did connect me to two of the judges for the eCYBERMISSION program. I contacted both of them. Neither one had any background I think in algae…I just think they struggled to find somebody that was matched with the topic focus."* (NGSTP Participant)

Outcome #2: Increase teacher understanding of and ability to facilitate three-dimensional learning with their students

Teachers participating in NGSTP were all positive about the NGSS and three-dimensional learning information incorporated into the workshops. Teachers particularly noted the intensive nature of the learning, the implementation-focused approach of the workshops, and the hands-on content. Participants said, for example,

> *"It's one thing to read about what 3D learning is supposed to be, it's another thing to get to spend two whole days with people who really know how to make [it] work, and immersing you, and treating you like you're the students, and getting to see how it works."* (NGSTP Participant)

> *"All of my units have changed since then because of [the workshop]. It was very, very helpful. I'm so glad that I went."* (NGSTP Participant)

> *"I thought the professional development experience was awesome. It was incredibly helpful. It was an immersive experience. I got a good sense of what the NGSS standards are looking for in terms three-dimensional teaching and learning."* (NGSTP Participant)

Teachers also valued connecting with other teachers via the workshops and the webinars. Participants said,

> *"It's invaluable to be able to meet up with other teachers and to just learn what's happening. I think that's one of the most important things, to be able to collaborate with other teachers and see what they're doing, and what kind of cool things that you could bring back to your classroom."* (NGSTP Participant)

"You got to see different perspectives as people were presenting how they used [NGSS] in their school. I think to me was probably one of the most meaningful. To see how teachers had used it successfully with their kids." (NGSTP Participant)

"We had a webinar with [the two mentors]. That was really, really helpful, just to see in the classroom hands on. They had videos. They had tips, advice, and examples with what they did with NGSTP. That was really good. I really liked those two webinars that we did." (NGSTP Participant)

Outcome #3: Increase students' awareness of and interest in STEM content and STEM careers in the DoD using authentic real-world content developed by their teachers

As part of the NGSTP experience, participating teachers formulated lesson plans incorporating the NGSS and three-dimensional learning approach. Teachers' lesson plans spanned a wide variety of topics and included the following:

- Matter and chemical reactions
- Plant growth in various environments
- Techniques to detect chemicals using bacteria
- Changes over time (earth science)
- Computer science and electricity and magnetism
- Climate change and global warming
- Algae
- Ecosystems and interactions
- Solar energy and energy conversions

Teachers valued the real-world expert input of the S&Es as they created their lesson plans. The S&Es brainstormed with teachers, provided feedback, made suggestions for supplies, provided examples of practical applications and suggested classroom activities. Communication with the S&Es was primarily through email correspondence, and all but one teacher reported successful correspondences with at least one S&E, although one other participant noted that scheduling conflicts made it difficult to communicate with the scientist with whom he had been matched. As one teacher said,

"[The S&Es] had some really, really good ideas, and insights, and suggestions about how to make some things work, which we put into practice, and really helped out. Then when we were trying to figure out what some of the results meant, because things had expanded beyond what we had originally anticipated, some of the insights we got from the letters from the Army scientists were extremely helpful. (NGSTP Participant)

Other than their connections with Army S&Es, NGSTP participants reported gaining little information about STEM careers in the Army and DoD. When asked if they were more aware of these careers after participating in NGSTP, four participants answered negatively. One other participant noted that career connections were part of the lesson plan she developed, and she found information on a website regarding STEM careers. Two participants noted that they had gained some of this career information from participating in other AEOPs (JSHS and eCM), and two noted that the S&Es they communicated with had either spoken with them about or sent them information about Army or DoD STEM careers. Learning about careers from the S&Es was particularly impactful for one participant who noted,

> *"I just remember saying, 'Oh, wow, they have this type of people in the army, not just those that go in and they're on the front lines.' You have these engineers who deal with electricity and different engineering skills...I told my kids that. They're just thinking, 'Oh, Army's like what they see on TV, all the fighting.' I tell them there are doctors, there are engineers, there are just a wide range of careers in the Army."* (NGSTP Participant)

Likewise, most teachers had not learned about the range of other AEOPs during NGSTP. Six interview participants indicated that they had not learned about AEOPs during NGSTP. Two of these participants indicated that although they had not received AEOP information as part of NGSTP they were aware of other AEOPs through their participation in other programs (eCM and JSHS). Three interview participants indicated that they had learned about eCM during their NGSTP participation.

Program Strengths and Successes

Participants in phone interviews were asked to comment upon the strengths of NGSTP. All participants noted at least one strength. In addition to those noted above (opportunity to collaborate with other teachers, connecting with Army S&Es, webinars, and learning NGSS content), participants listed several other program strengths. These included the funding for classroom equipment, increasing their skills and confidence in their teaching, building student confidence in STEM skills, and the help and communication they received from program staff. Participants said, for example,

> *"If I had to do this on my own, I would have probably not done it. I might have done some demonstrations, but I would not have done it as thoroughly as I could do it with all the equipment and the supplies. That was huge. It made it a variable, rich experience for my kids...They got much more hands on with it, so they were more engaged."* (NGSTP Participant)

> *"The best thing of all was how much I think it helped my kids. I got to see a lot of confidence increasing. It was really challenging. They were really stressed out for a while…We figured it out,*

we got through it, and the one student who went to the JSHS and was nominated as the [state's] US Presidential Scholar Award nominee really got a lot out of it." (NGSTP Participant)

"I like how [program staff] kept us on task with the monthly reports. That was really good, very reflective on my part". (NGSTP Participant)

All phone interview participants had positive things to say about how their NGSTP experiences impacted their students and their classroom practice. For example

"I feel really fortunate that I was part of the program. Ultimately, it affected my kids significantly…This is my 18th year of teaching. The kind of thinking that I'm seeing after implementing all this learning that I've done has been pretty amazing." (NGSTP Participant)

"I have used the NGSS to develop all new units for both sixth and seventh grade, in addition to the one that I wrote for the grant, and probably, at this point, eight new units based on all my learning." (NGSTP Participant)

Suggestions for Program Improvement

All but one teacher answered affirmatively when asked if NGSTP had been helpful to them, however most offered suggestions when asked about ways the program could be improved for the future. The one teacher who indicated that the program was not helpful was participating for a second year and noted that although the name of the course provided by NSTA had changed, the content was largely a repeat of the previous year's course. She said,

"While it looked like I was going to a different professional development, I, in fact, was going to pretty much the same thing that I had gone to already. When I mentioned this to the people who were running it…they shrugged and said, 'Oh yeah, ha ha ha,' [and] kind of laughed. They changed a few things around but 90 percent of it was the exact same. That was a waste of time for me to go to it twice." (NGSTP Participant)

Teachers' suggestions for improvement included the following:

- Altering the funding stream so that teachers do not have to pay up front for supplies
- Providing earlier connections with Army S&Es
- Providing content targeted to specific grade bands
- Providing different content for a "part 2" course
- Providing more content about assessments
- Providing more interaction on the webinars

- Providing additional webinars
- Providing more structure for interactions between mentors and participants
- Providing more support and feedback on lesson plan development at the workshop
- Providing a greater variety of lesson plan presentations at workshops (e.g., more information for K-2)
- Allow teachers who teach multiple grade bands to participate for more than one year
- Adjust the timing of workshops so they are closer to the school year
- Providing a forum for a wrap-up where participating teachers can share their experiences and lesson plans

Participants said, for example,

> *"They were trying to do…so many different grade levels. Sometimes it didn't pertain to me…Maybe make it separated by grade bands, like three through fifth, sixth through eighth, and then a high school section."* (NGSTP Participant)

> *"The other thing that we desperately need is the assessment piece. I think we need to focus more on, 'This is great. We've written this great phenomenon, but now what are you going to do to assess it?' I think that could be the third of the webinars."* (NGSTP Participant)

> *"I couldn't buy all the equipment I wanted to buy because I had limited funds. I did explain that to them. I said, 'We don't get pay raises.' I haven't had a pay raise in seven years'...I couldn't keep putting it on my credit account."* (NGSTP Participant)

> *"I think the thing that I would have liked would have been a wrap up at the end, where we were all able to share our experiences... Maybe like a Facebook page or somehow to share out, 'Well, what did you do?' We're learning from each other at the same time."* (NGSTP Participant)

Overall, NGSTP had a successful year in 2018-19. All participants interviewed reported substantial benefits of the program and reported that their participation impacted their classroom practice. Connections with Army S&Es were more successful than in 2017-18, and participants valued the efforts of program staff to make these connections. Many participants were able to enhance the lesson plans they created through the input and feedback of these industry professionals, and there was a consensus that the training and support they received in NGSS three-dimensional learning was valuable. Relatively few of the interview participants had gained information about Army and DoD STEM careers and AEOPs during NGSTP, suggesting that this is an area for potential program growth.

7

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 evaluate effectiveness of recruitment methods, students were asked to identify all of the ways they learned about eCM (Table 37). Results are similar to those of past years, with a majority of students (87%) reporting they learned about eCM from their teachers.

Table 37. How eCM Students Learned about eCM (n=307)

Choice	Response Percentage	Response Total
Army Educational Outreach Program (AEOP) Website	1.3%	4
AEOP on Facebook, Twitter, Instagram, or other social media	1.0%	3
School or university newsletter, email, or website	0.7%	2
Past participant of program	0.7%	2
Friend	8.5%	26
Family Member	4.2%	13
Someone who works at the school or university I attend	1.0%	3
Someone who works with the Department of Defense (Army, Navy, Air Force, etc.)	0.3%	1
Community group or program	1.3%	4
Teacher	87.0%	267
Print Advertising	0.0%	0
eCM Website	7.2%	22
Choose Not to Report	7.8%	24

Students in the NJ&EE focus groups reported learning about eCM through teachers, family friends, past participants, or club or Girl Scout leaders.

Table 38 shows combined national and regional eCM participant motivational factors. The two most frequently cited factors were external motivators: teacher encouragement to participate (58%) and academic requirement or school grade (23%). More than 10% of students also cited the following internal motivators: interest in STEM (16%), the desire to learn something new or interesting (13%), and the opportunity to have fun with friends (13%). It should be noted, however, that over a quarter (26%) of respondents selected "choose not to report" as their response for this item.

Focus group participants were also asked about their motivations for participating. Some focus group participants indicated that they had participated in eCM as a school requirement. Others cited learning opportunities, the opportunity to impact their communities, past participation, or simply having fun as reasons for participating in eCM. Students said, for example,

> "*We participated in eCYBERMISSION because we felt it would be really fun and it was a way to expand our minds.*" (e-CM-N Student)
>
> *"We [participated in eCM] last year too. We found that it was really fun, and we thought we were actually making a really big impact on our community that we wouldn't be able to do otherwise."* (e-CM-N Student)

Table 38. Factors Motivating Students to Participate in eCM (n=270)

Choice	Response Percentage	Response Total
My teacher encouraged me to participate	58.1%	157
Academic requirement or school grade	22.6%	61
Opportunity to have some fun with my friends	11.9%	32
Interest in STEM	15.9%	43
Desire to learn something new or interesting	13.3%	36
Building college application or résumé	6.7%	18
Exploring how school learning applies to real life	6.7%	18
Earning awards and recognition	7.4%	20
Exploring education and/or career goals	8.1%	22
Serving the community or country	3.3%	9
Interest in expanding my laboratory or research skills	5.6%	15
Interest in STEM careers with the Army	4.1%	11
Having fun	1.1%	3
Learning in ways that are not possible in school	0.7%	2
Seeing how school learning applies to real life	7.0%	19
Desire to expand laboratory or research skills	1.9%	5
Exploring a unique work environment	0.4%	1
Opportunity to use advanced laboratory technology	1.1%	3
Earning stipends or awards for doing STEM	0.0%	0
Recommendations of past participants	0.0%	0
Networking opportunities	0.4%	1
The mentor(s)	0.0%	0
Choose not to report	25.6%	69

Previous Program Participation and Future Interest

eCM participants reported on their previous participation in AEOPs as part of the registration process (Table 39). Half of the 52 respondents who provided a response (50%) reported never having participated in any AEOP in the past. The most frequently reported program for past participation was eCM (39%)

followed by Junior Solar Sprint (JSS) (8%) and Gains in the Education of Mathematics and Science (GEMS) (6%). Additionally, 4% reported previous participation in Camp Invention, and 19% reported participating in "other" STEM programs.

Table 39. Previous Program Participation (n=52)

Choice	Response Percentage	Response Total
Camp Invention	3.8%	2
eCYBERMISSION	38.5%	20
Junior Solar Sprint (JSS)	7.7%	4
Gains in the Education of Mathematics and Science (GEMS)	5.8%	3
UNITE	0.0%	0
Junior Science & Humanities Symposium (JSHS)	0.0%	0
Science & Engineering Apprenticeship Program (SEAP)	0.0%	0
Research & Engineering Apprenticeship Program (REAP)	0.0%	0
High School Apprenticeship Program (HSAP)	0.0%	0
College Qualified Leaders (CQL)	0.0%	0
Undergraduate Research Apprenticeship Program (URAP)	0.0%	0
Science Mathematics & Research for Transformation (SMART) College Scholarship	0.0%	0
I've never participated in any AEOP programs	50.0%	26
Other STEM Program	19.2%	10

Results for students' interest in participating in AEOPs in the future are provided in Tables 40 and 41. Half or more of students across program levels indicated they were somewhat or very much interested in participating in eCM again (eCM – 50%, NJ&EE – 93%). Fewer students were interested in other programs, although more NJ&EE participants expressed interest than overall eCM participants (eCM: 12%-22%; NJ&EE: 34%-69%). It should be noted that more than half of eCM students reported never hearing of all programs other than eCM (54%-63%). Students in the NJ&EE focus groups indicated that they had learned about AEOPs from the alumni panel and the showcase at the national event.

Table 40. eCM-NJ&EE Participant Interest in Future AEOPs (n=68)

	I've never heard of this program	Not at all	A little	Somewhat	Very much	Response Total
Camp Invention	50.0%	1.5%	14.7%	13.2%	20.6%	
	34	1	10	9	14	**68**
eCYBERMISSION	0.0%	2.9%	4.4%	10.3%	82.4%	
	0	2	3	7	56	**68**
Junior Solar Sprint (JSS)	19.1%	7.4%	22.1%	23.5%	27.9%	
	13	5	15	16	19	**68**
Gains in the Education of Mathematics and Science (GEMS)	16.2%	10.3%	25.0%	25.0%	23.5%	
	11	7	17	17	16	**68**
UNITE	32.4%	7.4%	23.5%	20.6%	16.2%	
	22	5	16	14	11	**68**
Junior Science & Humanities Symposium (JSHS)	19.1%	4.4%	13.2%	26.5%	36.8%	
	13	3	9	18	25	**68**
Science & Engineering Apprenticeship Program (SEAP)	26.5%	2.9%	22.1%	17.6%	30.9%	
	18	2	15	12	21	**68**
Research & Engineering Apprenticeship Program (REAP)	27.9%	2.9%	20.6%	16.2%	32.4%	
	19	2	14	11	22	**68**
High School Apprenticeship Program (HSAP)	22.1%	5.9%	20.6%	19.1%	32.4%	
	15	4	14	13	22	**68**
College Qualified Leaders (CQL)	30.9%	8.8%	11.8%	17.6%	30.9%	
	21	6	8	12	21	**68**
GEMS Near Peer Mentor Program	33.8%	7.4%	22.1%	17.6%	19.1%	
	23	5	15	12	13	**68**
Undergraduate Research Apprenticeship Program (URAP)	36.8%	7.4%	11.8%	16.2%	27.9%	
	25	5	8	11	19	**68**
Science Mathematics, and Research for Transformation (SMART) College Scholarship	20.6%	4.4%	5.9%	25.0%	44.1%	
	14	3	4	17	30	**68**
National Defense Science & Engineering Graduate (NDSEG) Fellowship	32.4%	5.9%	13.2%	8.8%	39.7%	
	22	4	9	6	27	**68**

Table 41. eCM Overall Participant Interest in Future AEOPs (n=628)

	I've never heard of this program	Not at all	A little	Somewhat	Very much	Response Total
eCYBERMISSION	7.5%	22.1%	20.4%	20.7%	29.3%	
	47	139	128	130	184	**628**
Junior Solar Sprint (JSS)	58.1%	13.4%	12.3%	8.8%	7.5%	
	365	84	77	55	47	**628**
Gains in the Education of Mathematics and Science (GEMS)	55.6%	14.2%	11.5%	9.6%	9.2%	
	349	89	72	60	58	**628**
UNITE	64.2%	13.9%	9.9%	7.5%	4.6%	
	403	87	62	47	29	**628**
Junior Science & Humanities Symposium (JSHS)	61.5%	12.7%	11.1%	8.9%	5.7%	
	386	80	70	56	36	**628**
Science & Engineering Apprenticeship Program (SEAP)	54.5%	14.2%	12.7%	9.4%	9.2%	
	342	89	80	59	58	**628**
Research & Engineering Apprenticeship Program (REAP)	57.2%	13.5%	9.9%	11.1%	8.3%	
	359	85	62	70	52	**628**
High School Apprenticeship Program (HSAP)	59.9%	14.0%	10.7%	9.2%	6.2%	
	376	88	67	58	39	**628**
College Qualified Leaders (CQL)	61.0%	12.9%	11.0%	8.9%	6.2%	
	383	81	69	56	39	**628**
GEMS Near Peer Mentor Program	63.2%	13.4%	10.4%	7.3%	5.7%	
	397	84	65	46	36	**628**
Undergraduate Research Apprenticeship Program (URAP)	62.1%	13.9%	8.3%	10.0%	5.7%	
	390	87	52	63	36	**628**
Science Mathematics, and Research for Transformation (SMART) College Scholarship	54.8%	12.6%	11.1%	10.7%	10.8%	
	344	79	70	67	68	**628**
National Defense Science & Engineering Graduate (NDSEG) Fellowship	59.1%	13.9%	10.0%	8.4%	8.6%	
	371	87	63	53	54	**628**

Awareness of STEM Careers and DoD STEM Careers and Research

An AEOP goal is to increase both the number and diversity of students who pursue STEM careers. As such, the student survey asked how many STEM jobs/careers in general (Tables 42 and 43) as well as DoD STEM jobs/careers (Tables 44 and 45) students learned about during their eCM experience. Almost all NJ&EE students (98%) and three-quarters (74%) of regional participants reported hearing about at least one STEM job/career through eCM. NJ&EE participants, however, indicated they had learned about considerably more STEM jobs/careers than regional participants, with 77% of national students reporting learning about 5 or more as compared to only 13% of regional students.

Table 42. Number of STEM Jobs/Careers National Students Learned About During eCM (n=68)

Choice	Response Percentage	Response Total
None	2%	1
1	0%	0
2	4%	3
3	6%	4
4	12%	8
5 or more	76%	52

Table 43. Number of STEM Jobs/Careers Regional Students Learned About During eCM (n=628)

Choice	Response Percentage	Response Total
None	26%	161
1	13%	83
2	19%	121
3	24%	149
4	5%	33
5 or more	13%	81

Similarly, findings revealed that NJ&EE students learned about more DoD jobs/careers than regional participants. Nearly all NJ&EE (98%) and over a third (43%) of regional students indicated learning about one or more DoD STEM job/career. Two-thirds (66%) of NJ&EE students reported learning about 5 or more DoD STEM Jobs/Careers as compared with only 6% of overall eCM students.

Table 44. Number of DoD STEM Jobs/Careers National Students Learned About During eCM (n=68)

Choice	Response Percentage	Response Total
None	2%	1
1	0%	0
2	9%	6
3	16%	11
4	7%	5
5 or more	66%	45

Table 45. Number of DoD STEM Jobs/Careers Regional Students Learned About During eCM (n=628)

Choice	Response Percentage	Response Total
None	57%	357
1	12%	74
2	12%	79
3	10%	63
4	3%	18
5 or more	6%	37

Students participating in focus groups at the NJ&EE were also asked about whether and how they had learned about STEM career opportunities in the DoD during eCM. Students reported learning about these careers at the national event only, and cited activities and speakers at the NJ&EE as sources of information about STEM careers in the Army or DoD.

Team Advisors participating in the NJ&EE focus group concurred that Army career information was available at the national event but not at the regional level. These adults had several ideas for disseminating career information more widely within eCM and suggested adding DoD STEM career videos to the website resources, providing Skype sessions between students in the classroom and DoD mentors, recording sessions from the national event and providing them to Team Advisors, and providing virtual lab tours via the eCM website. Adults noted that students often do not know about civilian careers with the Army. As one adult noted,

> *"[The career information at NJ&EE] takes them away a little bit from thinking it's just about combat. There's a lot of civilian work, there's research, and it's behind the scenes. Even though we're a military school, we still associate [the Army] with being deployed and in combat. Just to see that here you can work in the lab, that's a different type of perspective."* (eCM Team Advisor)

Attitudes about the importance of DoD research are an important prerequisite to continued student interest in the field and potential future DoD STEM involvement. Thus, students were asked to rate their agreement with a series of statements about what DoD researchers do and the value of DoD research more broadly (Tables 46 & 47). Nearly all NJ&EE students (97%-99%) agreed or strongly agreed with all statements, and approximately half of eCM students (46%-52%) reported similarly. It is notable that over a third of eCM students expressed no opinion (selecting the response "neither agree nor disagree") for each item, suggesting that these students may have had little exposure to DoD research and researchers during eCM.

Table 46. eCM-NJ&EE Participant Opinions about DoD Researchers and Research (n=68)

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Response Total
DoD researchers advance science and engineering fields	0.0%	0.0%	1.5%	35.3%	63.2%	
	0	0	1	24	43	**68**
DoD researchers develop new, cutting edge technologies	0.0%	1.5%	1.5%	25.0%	72.1%	
	0	1	1	17	49	**68**
DoD researchers solve real-world problems	0.0%	0.0%	2.9%	23.5%	73.5%	
	0	0	2	16	50	**68**
DoD research is important to society	0.0%	1.5%	1.5%	16.2%	80.9%	
	0	1	1	11	55	**68**

Table 47. eCM Overall Participant Opinions about DoD Researchers and Research (n=628)

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Response Total
DoD researchers advance science and engineering fields	9.7%	5.6%	39.2%	31.2%	14.3%	
	61	35	246	196	90	**628**
DoD researchers develop new, cutting edge technologies	6.5%	8.1%	38.5%	32.2%	14.6%	
	41	51	242	202	92	**628**
DoD researchers solve real-world problems	5.7%	5.3%	36.8%	32.6%	19.6%	
	36	33	231	205	123	**628**
DoD research is important to society	6.4%	4.1%	37.9%	30.7%	20.9%	
	40	26	238	193	131	**628**

Interest and Future Engagement in STEM

To evaluate the AEOP goal of developing a STEM-literate society, students were asked about their interest in engaging with STEM activities outside of required school courses as a result of participating in eCM. In general, overall eCM student responses were evenly spread across categories with approximately a third falling into the following three categories: more/much more likely, about the same before and after, and less/much less likely. For NJ&EE students, on the other hand, approximately half or more (49%-82%) indicated they were more likely or much more likely to engage in these activities after eCM participation. Activities with the greatest discrepancy between eCM and NJ&EE in future interest (more/much more likely) were working on a STEM project or experiment in a university or professional setting (eCM - 31%, NJ&EE - 82%); mentoring or teaching other students about STEM (eCM - 28%, NJ&EE - 75%); and participating in a STEM camp, club, or competition (eCM - 31%, NJ&EE - 77%).

A composite score[17] was computed from these Future STEM Engagement items to compare subgroups of students. Statistical differences were found by overall U2 status[18] (U2 higher - small effect size of d = 0.210) and school location[19] (urban/rural higher - small effect size of d = 0.322).

The educational aspirations of eCM students after participating in the program are reported in Tables 50 and 51. More than three-quarters of overall eCM students (84%) and nearly all NJ&EE students (98%) reported intending to at a minimum finish college (get a bachelor's degree). In terms of a more advanced post-secondary education, more NJ&EE students (63%) reported a desire to continue their education after college than regional students (39%).

[17] These 10 items for Future STEM Engagement had a Cronbach's alpha reliability of 0.947.
[18] Two-tailed independent samples t-test: $t(584) = 2.54$, $p < .05$.
[19] Two-tailed independent samples t-test: $t(521) = 3.68$, $p < .001$.

Table 48. eCM-NJ&EE Impact on Participants' Intent to Engage in STEM Out of School (n=68)

	Much less likely	Less likely	About the same before and after	More likely	Much more likely	Response Total
Watch or read non-fiction STEM	1.5%	1.5%	48.5%	32.4%	16.2%	
	1	1	33	22	11	**68**
Tinker (play) with a mechanical or electrical device	0.0%	4.4%	26.5%	42.6%	26.5%	
	0	3	18	29	18	**68**
Work on solving mathematical or scientific puzzles	0.0%	4.4%	29.4%	42.6%	23.5%	
	0	3	20	29	16	**68**
Use a computer to design or program something	0.0%	2.9%	30.9%	33.8%	32.4%	
	0	2	21	23	22	**68**
Talk with friends or family about STEM	0.0%	2.9%	23.5%	29.4%	44.1%	
	0	2	16	20	30	**68**
Mentor or teach other students about STEM	1.5%	8.8%	14.7%	39.7%	35.3%	
	1	6	10	27	24	**68**
Help with a community service project related to STEM	0.0%	1.5%	20.6%	33.8%	44.1%	
	0	1	14	23	30	**68**
Participate in a STEM camp, club, or competition	0.0%	2.9%	20.6%	26.5%	50.0%	
	0	2	14	18	34	**68**
Take an elective (not required) STEM class	0.0%	1.5%	23.5%	35.3%	39.7%	
	0	1	16	24	27	**68**
Work on a STEM project or experiment in a university or professional setting	1.5%	1.5%	14.7%	26.5%	55.9%	
	1	1	10	18	38	**68**

Table 49. eCM Overall Impact on Participants' Intent to Engage in STEM Out of School (n=628)

	Much less likely	Less likely	About the same before and after	More likely	Much more likely	Response Total
Watch or read non-fiction STEM	21.7%	12.1%	42.2%	16.7%	7.3%	
	136	76	265	105	46	**628**
Tinker (play) with a mechanical or electrical device	15.3%	11.1%	33.8%	26.4%	13.4%	
	96	70	212	166	84	**628**
Work on solving mathematical or scientific puzzles	14.8%	13.7%	39.8%	20.9%	10.8%	
	93	86	250	131	68	**628**
Use a computer to design or program something	13.9%	11.6%	36.6%	25.2%	12.7%	
	87	73	230	158	80	**628**
Talk with friends or family about STEM	18.9%	11.5%	38.9%	20.2%	10.5%	
	119	72	244	127	66	**628**
Mentor or teach other students about STEM	20.9%	14.0%	37.3%	18.0%	9.9%	
	131	88	234	113	62	**628**
Help with a community service project related to STEM	16.6%	11.5%	35.2%	25.5%	11.3%	
	104	72	221	160	71	**628**
Participate in a STEM camp, club, or competition	21.5%	13.1%	34.2%	18.5%	12.7%	
	135	82	215	116	80	**628**
Take an elective (not required) STEM class	20.7%	13.7%	33.0%	21.3%	11.3%	
	130	86	207	134	71	**628**
Work on a STEM project or experiment in a university or professional setting	19.1%	12.9%	36.9%	19.1%	11.9%	
	120	81	232	120	75	**628**

Table 50. Participant Education Aspirations After eCM-NJ&EE (n=68)

Choice	Response Percentage	Response Total
Graduate from high school	2%	1
Go to a trade or vocational school	0%	0
Go to college for a little while	0%	0
Finish college (get a Bachelor's degree)	35%	24
Get more education after college	63%	43

Table 51. Participant Education Aspirations After eCM Overall (n=628)

Choice	Response Percentage	Response Total
Graduate from high school	8%	48
Go to a trade or vocational school	1%	9
Go to college for a little while	7%	43
Finish college (get a Bachelor's degree)	45%	285
Get more education after college	39%	243

Resources

Team Advisors were asked which resources were most valuable for exposing students to AEOPs (Table 52). The two resources reported as somewhat useful or very useful by more than half of adults were participation in eCM (83%) and the AEOP website (55%). Approximately half to three-quarters of Team Advisors (48%-75%) reported not experiencing the other resources.

Team Advisors were asked how useful the same resources were for exposing students to DoD STEM careers (Table 53). A similar pattern of resource usefulness emerged, but the responses were not as favorable. Adults were again most likely to rate participation in eCM (74%) and the eCM website (44%) as somewhat/very useful for exposing students to DoD STEM careers. More than half of adults (57%-78%) reported having not experienced the remaining AEOP resources.

Table 52. Usefulness of Resources for Exposing Students to AEOPs (n=145)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Army Educational Outreach Program (AEOP) website	39.3%	1.4%	4.1%	20.7%	34.5%	
	57	2	6	30	50	**145**
AEOP on Facebook, Twitter, Pinterest or other social media	69.7%	2.8%	9.0%	9.7%	9.0%	
	101	4	13	14	13	**145**
AEOP printed materials	47.6%	0.7%	12.4%	18.6%	20.7%	
	69	1	18	27	30	**145**
NSTA staff	52.4%	1.4%	9.0%	15.2%	22.1%	
	76	2	13	22	32	**145**
Invited speakers or "career" events	75.2%	2.1%	4.8%	6.2%	11.7%	
	109	3	7	9	17	**145**
Participation in eCYBERMISSION	4.1%	2.8%	10.3%	16.6%	66.2%	
	6	4	15	24	96	**145**

Table 53. Usefulness of Resources for Exposing Students to DoD STEM Careers (n=145)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Army Educational Outreach Program (AEOP) website	48.3%	3.4%	4.1%	14.5%	29.7%	
	70	5	6	21	43	**145**
AEOP on Facebook, Twitter, Pinterest or other social media	76.6%	4.1%	3.4%	8.3%	7.6%	
	111	6	5	12	11	**145**
AEOP printed materials	57.2%	1.4%	11.7%	11.0%	18.6%	
	83	2	17	16	27	**145**
NSTA staff	65.5%	2.8%	6.2%	11.7%	13.8%	
	95	4	9	17	20	**145**
Invited speakers or "career" events	77.9%	0.7%	4.1%	6.2%	11.0%	
	113	1	6	9	16	**145**
Participation in eCYBERMISSION	11.0%	4.1%	11.0%	20.0%	53.8%	
	16	6	16	29	78	**145**

Overall Impact

The overall impact of eCM on students was assessed through a series of items on the survey. While NJ&EE students were more likely to report positive impacts, half or more of students at both the regional and national level agreed that eCM impacted them in their confidence in STEM knowledge, skills, and abilities (eCM - 62%, NJ&EE - 97%) and their interest in participating in STEM activities outside of school requirements (eCM - 49%, NJ&EE - 88%). Items with the greatest difference in eCM impact by competition level (50% or more) were all related to AEOP and DoD and included the following: having a greater appreciation of Army/DoD STEM research (eCM - 47%, NJ&EE - 97%), having more interest in participating in other AEOPs (eCM - 38%, NJ&EE - 91%), being more aware of other AEOPs (eCM - 43%, NJ&EE - 99%), and being more aware of Army/DoD STEM research and careers (eCM - 43%, NJ&EE - 99%).

A composite variable[20] was calculated for Overall eCM Impact survey items to look for differences between student subgroups. No significant differences were found by overall U2 status or student level demographics in terms of Overall eCM Impact.

[20] The Cronbach's alpha reliability for these 10 Overall eCM Impact items was 0.940.

Table 54. Participant Opinion of eCM-NJ&EE Impacts (n=68)

	Disagree - This did not happen	Disagree - This happened but not because of eCM	Agree - eCM somewhat made me feel this way	Agree - eCM was primary reason	Response Total
I am more confident in my STEM knowledge, skills, and abilities	0.0%	2.9%	44.1%	52.9%	
	0	2	30	36	**68**
I am more interested in participating in STEM activities outside of school requirements	2.9%	8.8%	42.6%	45.6%	
	2	6	29	31	**68**
I am more aware of other AEOPs	0.0%	1.5%	25.0%	73.5%	
	0	1	17	50	**68**
I am more interested in participating in other AEOPs	4.4%	4.4%	26.5%	64.7%	
	3	3	18	44	**68**
I am more interested in taking STEM classes in school	2.9%	11.8%	42.6%	42.6%	
	2	8	29	29	**68**
I am more interested in earning a STEM degree	7.4%	10.3%	41.2%	41.2%	
	5	7	28	28	**68**
I am more interested in pursuing a career in STEM	5.9%	13.2%	39.7%	41.2%	
	4	9	27	28	**68**
I am more aware of Army or DoD STEM research and careers	0.0%	1.5%	25.0%	73.5%	
	0	1	17	50	**68**
I have a greater appreciation of Army or DoD STEM research	0.0%	2.9%	17.6%	79.4%	
	0	2	12	54	**68**
I am more interested in pursuing a STEM career with the Army or DoD	11.8%	8.8%	20.6%	58.8%	
	8	6	14	40	**68**

Table 55. Participant Opinion of eCM Overall Impacts (n=628)

	Disagree - This did not happen	Disagree - This happened but not because of eCM	Agree - eCM somewhat made me feel this way	Agree - eCM was primary reason	Response Total
I am more confident in my STEM knowledge, skills, and abilities	21.8%	16.7%	47.0%	14.5%	
	137	105	295	91	**628**
I am more interested in participating in STEM activities outside of school requirements	28.7%	22.3%	35.5%	13.5%	
	180	140	223	85	**628**
I am more aware of other AEOPs	40.1%	16.6%	32.2%	11.1%	
	252	104	202	70	**628**
I am more interested in participating in other AEOPs	44.6%	17.7%	26.6%	11.1%	
	280	111	167	70	**628**
I am more interested in taking STEM classes in school	29.0%	22.9%	35.4%	12.7%	
	182	144	222	80	**628**
I am more interested in earning a STEM degree	33.6%	22.9%	32.5%	11.0%	
	211	144	204	69	**628**
I am more interested in pursuing a career in STEM	36.5%	24.0%	26.9%	12.6%	
	229	151	169	79	**628**
I am more aware of Army or DoD STEM research and careers	39.5%	17.5%	31.2%	11.8%	
	248	110	196	74	**628**
I have a greater appreciation of Army or DoD STEM research	35.4%	17.5%	33.8%	13.4%	
	222	110	212	84	**628**
I am more interested in pursuing a STEM career with the Army or DoD	45.2%	19.4%	25.6%	9.7%	
	284	122	161	61	**628**

In order to further understand the impact of eCM, an open-ended item on the questionnaire asked students to list the three most important ways they benefited from participating. In a sample of 165 responses from eCM-R students, the most often cited benefit, mentioned by more than half (93, or 56%) of students was teamwork. The next most frequently mentioned benefit by regional students was STEM

learning (70, or 34%), followed by the opportunity to gain research or STEM skills (48, or 29%), and the real-life application or opportunity to solve real-world problems in eCM (31, or 19%). Other benefits mentioned by eCM-R students included the opportunity to develop critical thinking or problem-solving skills (24, or 15%), the opportunity to improve public speaking or communication skills (24, or 15%), and the career information they gained (18, or 11%). Other benefits, mentioned by between 10 and 14 students (6%-8%) included:

- increasing motivation for or interest in STEM
- having fun
- gaining Army/DoD or AEOP information
- gaining confidence or developing leadership skills
- making friends

Students competing at the national level cited similar benefits. Of the 64 eCM-N student respondents, the most often mentioned benefits were collaboration or teamwork (23, or 36%), STEM learning (22, or 34%), gaining career information (22, or 34%), gaining Army or DoD information (16, or 25%), improving social skills or making friends (12, or 20%), improving communication or public speaking skills (12, or 20%), gaining confidence (12, or 20%), and increasing interest in or motivation for STEM (11, or 18%). Other benefits, mentioned by between six and 10 (10%-16%) eCM-N students included:

- the real-world application of knowledge
- working with or networking with STEM professionals
- developing critical thinking or problem-solving skills
- developing research or STEM skills
- being exposed to others' ideas and research
- developing work ethic or responsibility
- having fun

Students participating in focus groups at the NJ&EE mentioned similar benefits of participating in eCM, and emphasized some benefits unique to the national event. For example, students reported that they valued the career information they received and the opportunity to meet people from other places at the national event. As one participant noted, "You meet new people and make life-long friends."

8 | Findings and Recommendations

Summary of Findings

The FY19 evaluation of eCM collected data about participants; their 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 Table 56.

Table 56. 2019 eCM Evaluation Findings	
Priority #1: *Broaden, deepen, and diversify the pool of STEM talent in support of our Defense Industry Base*	
Participation in eCM decreased in FY19 as compared to previous years. The demographics of students participating in the NJ&EE are somewhat different than the demographics of students competing at regional levels.	In FY19, eCM regional sites registered 17,944 students, a decrease of 11% compared to the 20,004 students registered in FY18 and 19% compared to FY17 (21,277).
	Overall, over half of students (59%) met the AEOP definition of underserved (U2). As in previous years, both males and females were relatively equally represented at the regional level (49% female and 48% male).
	Less than half (40%) of regional students identified themselves as White, 22% identified themselves as Hispanic or Latino/a, 13% identified themselves as Black or African American, 9% as Asian, and 9% chose not to report their race/ethnicity.
	NJ&EE participants included a smaller percentage (40%) of underserved students than at the regional level (59%). As with regional participants, less than half of NJ&EE participants (40%) were White. Over a third (38%) of NJ&EE participants were Asian (compared to 9% at the regional level). While White and Asian students composed the majority of the NJ&EE population, 7% were Hispanic or Latino/a (compared to 22% at the regional level), and 3% were Black or African American (compared to 13% at the regional level).

Mentors reported that they observed gains in students' 21st Century skills over the course of their eCM participation.	Students whose schools participated in the eCM Mini-Grant experienced significant growth in assessed 21st Century skills from the beginning (pre-) to the end (post-) of their eCM experiences for all six assessed domains. Participants experienced the greatest gains in growth in the areas of Communication skills and Productivity/Leadership skills. On average, participants' initial ratings were approaching the Progressing level while their post-eCM ratings were at the approaching Demonstrates Mastery level.
eCM student participants reported engaging in STEM practices more frequently in eCM than in their typical school experiences; urban and rural students reported greater engagement with STEM practices than their peers.	Three-quarters or more of NJ&EE and one-third or more of eCM participants reported engaging in all STEM practices at least once during the program. Both eCM and NJ&EE students noted engaging in the following three practices most frequently (weekly or every day): working collaboratively as part of a team (eCM - 60%; NJ&EE - 85%); analyzing data or information and draw conclusions (eCM - 43%; NJ&EE - 66%); and identifying questions or problems to investigate (eCM - 42%; NJ&EE - 54%).
	No significant differences in engagement in STEM practices were found by overall U2 status, however urban and rural students reported significantly greater engagement with STEM practices than students in suburban schools (small effect size).
Most eCM student participants reported gains in their STEM knowledge as a result of participating in eCM, although NJ&EE students were more likely to report large knowledge gains; urban and rural students reported larger gains than their peers.	More than half of overall eCM and all NJ&EE students indicated they experienced some degree of STEM knowledge gain as a result of participating in eCM. Approximately 60% or more of NJ&EE respondents reported large gains across the STEM knowledge items, while only 16%-23% of overall eCM respondents indicated large gains.
	No significant differences in STEM knowledge gains were found by overall U2 status, however urban and rural students reported significantly larger gains compared to suburban students (small effect size)
eCM student participants reported gains in their STEM competencies, although students competing at the NJ&EE were more likely to report large STEM competency gains; urban and rural students reported larger gains than their peers.	Approximately half or more of survey participants reported medium or large gains on all STEM competency items, although NJ&EE students indicated greater gains in STEM competencies as compared to their regional peers across all similar items with a 15%-31% point difference. The two items with the greatest reported gains (60% or more of participants reporting medium to large gains across competition groups) were carrying out an experiment and recording data accurately (eCM - 62%; NJ&EE - 88%) and using knowledge and creativity to suggest a solution to a problem (eCM - 69%; NJ&EE - 84%).
	No differences in STEM competencies were found by overall U2 status, however urban and rural students reported significantly larger gains compared to suburban students (small effect size)

Student participants reported that eCM had positive impacts on their 21st Century skills, although students competing at the NJ&EE were more likely to report large gains.	While nearly half or more of all students reported that eCM impacted their 21st Century skills, in general overall eCM participants reported lower gains (40% to 72% medium/large gains) as compared to NJ&EE participants (87% to 96% medium/large gains).
	No significant differences in 21st Century skills gains were found by U2 status or any of the demographic subgroups associated with U2 status.
Students reported gains in their STEM identities as a result of participating in eCM, although students competing at the NJE&E were more likely to report large gains.	Over a third of overall eCM participants reported medium or large gains in their STEM identities as a result of participating in eCM. The reported impact of eCM on participants' STEM Identities was more intense for NJ&EE (ranging from 75% to 94% medium/large impact) compared to overall eCM participants (ranging from 39% to 56% medium/large impact). The three items with the largest difference (40% points or more) in STEM Identity by competition level were a desire to build relationships with mentors who work in STEM (eCM - 43%; NJ&EE - 88%), connecting a STEM topic or field to personal values (eCM - 42%; NJ&EE - 84%), and interest in a new STEM topic (eCM - 42%; NJ&EE - 84%).
	No significant differences in STEM identity gains were found by U2 status or any of the demographic subgroups associated with U2 status.
Priority #2: *Support and empower educators with unique Army research and technology resources*	
Team Advisors used a range of mentoring strategies with students.	A majority of mentors reported using strategies to establish the relevance of learning activities (86%-95%), support the diverse needs of students as learners (64%-95%), support students' development of collaboration and interpersonal skills (66%-96%), and support students' engagement in authentic STEM activities (79%-98%). Most mentors also used several strategies to support students' STEM educational and career pathways (30% -72%), although less than half of mentors reported using strategies such as discussing STEM career opportunities within the DoD or other government agencies with students (41%) and recommending other AEOPs that align with student goal (34%). The use of strategies related to the DoD and AEOPs represent slight increases as compared to FY18 data.
Very few eCM Team Advisors discussed any AEOP other than eCM with students.	Very few Team Advisors (<1% - 8%) reported discussing specific AEOPs other than eCM (91%) with students during the program. About a quarter (27%) of Team Advisors indicated they discussed AEOP in general with their students.
eCM students reported being satisfied with program features that they had experienced,	Very few NJ&EE participants (4% or fewer) reported being dissatisfied with any feature of eCM about which they were asked, and most had experienced each of the features and were at least somewhat satisfied

although students competing at the NJE&E were more likely to report high levels of satisfaction. Students offered various suggestions for program improvement.	with each feature they had experienced. Regional students were more likely not to have experienced various program features (7%-52%), and were more likely (9%-12%) to express being "not at all" satisfied with features such as the submission process (12%) and Mission Control response times. (11%-12%). Features that both national and regional participants reported being somewhat or very much satisfied with included applying or registering for the program (eCM - 50%; NJ&EE - 81%), the submission process (eCM - 53%; NJ&EE - 82%), and the eCM website (eCM - 60%; NJ&EE - 82%).
	Regional eCM students' suggestions for improvement included: • providing more or different topics or options for projects provide more or better support or resources for student research (for example, extending the times of live chats and improving the contents of the "care package") • improving the website by making it easier to navigate, allowing more than one person at a time to edit the mission folder, autosaving work, and making the submission process more user-friendly provide better or clearer instructions, questions, and/or deadlines • making eCM more interesting or fun • reducing the requirements for the mission folder or requiring less or easier work • allowing more time to complete the mission folder.
	NJ&EE students' suggestions for improvement focused on elements of the NJ&EE, including: • providing more free time and/or more time for sleep at the NJ&EE and less sitting time • providing more free time or time for students to socialize • general comments about improvements to the schedule • improvements to the DC trip providing more freedom and/or free time for students • improving the quality and/or choice of food • providing more and/or longer field trips, shorter program days and/or more time to sleep, more time to socialize with other teams • providing more hands-on/interactive activities.
eCM Team Advisors reported being satisfied with program features that they had experienced. Mentors cited strengths of the program and also offered various	Very few Team Advisors (3% or less) expressed dissatisfaction with any program features. More than half of Team Advisors reported not experiencing CyberGuide live chats, CyberGuides feedback, and CyberGuide discussion forums. Most mentors were at least somewhat satisfied with all program features that they had experienced. More than 80% of eCM Team Advisors reported being somewhat or very much satisfied with the submission process (89%), eCM website (86%),

suggestions for program improvements.	application/registration process (85%), and the variety of STEM Mission Challenges available (82%).
	Team Advisors cited a number of strengths of eCM, including the real-world application of concepts, the opportunity for students to develop research or STEM skills, the usefulness of program resources, and the organization or structure of eCM.
	Team Advisors suggested improvements focused on improving program resources (updating videos, providing examples, improving timing of online chats), improving the Mission Folder (allowing video uploads, providing autosave, permitting multiple students to work within the folder at one time), and revising or clarifying rules or guidelines (clarifying IRB requirements and rubrics, and allowing flexibility in team sizes).
Priority #3: *Develop and implement a cohesive, coordinated and sustainable STEM education outreach infrastructure across the Army*	
Most eCM students learned about eCM from their teachers.	Few students (1%-7%) learned about eCM from any source other than from their teachers (87%).
Students were primarily externally motivated to participate in eCM by teacher encouragement and academic requirements.	The two most frequently cited motivating factors were teacher encouragement to participate (58%) and academic requirements or school grades (23%).
eCM participants were likely to express interest in participating in eCM again, however the majority of students at the regional level had not heard of other AEOPs.	A large majority of students (93%) competing at the NJ&EE were at least a somewhat interested in competing in eCM again, and 50% of students at the regional level were at least somewhat interested in participating in eCM again in the future.
	Findings suggest that students are exposed to other AEOPs at NJ&EE to a greater extent than at the regional competition level. Most NJ&EE students reported that they had heard of most other AEOPs, and more (34%-69%) were at least somewhat interested in participating in programs in the future than were overall eCM students (12%-22%). As compared with FY18, NJ&EE students' awareness of JSS increased (38% had not heard of it in FY17; 22% in FY18). More than half of overall eCM students reported never having heard of AEOPs other than eCM (54%-63%).

	Adults cited participation in eCM (83%) and the AEOP website (55%) as the most useful resources for exposing students to AEOPs. Approximately half to three-quarters o Team Advisors (48%-75%) reported not experiencing the other resources.
eCM students at all competition levels learned about STEM careers generally, however students competing at the NJ&EE level were much more likely to be familiar with DoD STEM jobs or careers; adults made several suggestions for increasing students' exposure to DoD STEM jobs or careers.	Almost all NJ&EE students (98%) and three-quarters (74%) of regional participants reported hearing about at least one STEM job/career through eCM. However, NJ&EE students reported learning about more DoD jobs/careers than regional participants. Nearly all NJ&EE (98%) and less than half (43%) of regional students indicated learning about one or more DoD STEM job/career. Two-thirds (66%) of NJ&EE students reported learning about 5 or more DoD STEM Jobs/Careers as compared with only 6% of overall eCM students.
	Adults were most likely to rate participation in eCM (74%) and the eCM website (44%) as at least somewhat useful for exposing students to DoD STEM careers. More than half of adults (57%-78%) reported not having experienced the remaining AEOP resources.
	NJ&EE students in focus groups cited activities and speakers at the NJ&EE as sources of information about STEM careers in the Army or DoD.
	Adults' ideas for disseminating career information more widely within eCM included adding DoD STEM career videos to the website resources, providing Skype sessions between students in the classroom and DoD mentors, recording sessions from the national event and providing them to Team Advisors, and providing virtual lab tours via the eCM website.
eCM students expressed positive opinions about DoD research and researchers, although regional students were less likely to have an opinion when asked about these topics.	Nearly all NJ&EE students (97%-99%) and approximately half of eCM students (46%-52%) agreed with various statements about DoD research and researchers.
	Over a third of eCM students (37%-39%) expressed no opinion (selecting the response "neither agree nor disagree") for each item related to DoD research and researchers (compared to 2%-3% for NJ&EE students), suggesting that students competing at only the regional level may have had little exposure to DoD research and researchers during eCM.
Most eCM students competing at the NJ&EE level reported that they were more likely to engage in various STEM activities in the future after participating in eCM; regional students reported substantially less increase in the likelihood of future STEM engagement, and there were significant	Overall eCM students' responses about their likelihood of participating in STEM activities in the future were evenly spread across categories with approximately a third falling into each of the following three categories: more/much more likely, about the same before and after, and less/much less likely. For NJ&EE students, on the other hand, approximately half or more (49%-82%) indicated they were more/much more interested after eCM participation. Activities with the greatest discrepancy between eCM and NJ&EE in future interest (more/much more likely) were working on a STEM project or experiment in a university or professional setting (eCM - 31%, NJ&EE - 82%); mentoring

differences by U2 status and school location.	or teaching other students about STEM (eCM - 28%, NJ&EE - 75%); and participating in a STEM camp, club, or competition (eCM - 31%, NJ&EE - 77%).
	Students meeting the AEOP definition of U2 and students attending rural and urban schools were significantly more likely to report increases in their likelihood of future STEM engagement than non-U2 students and students attending suburban schools (small effect sizes).
Most eCM students planned to at least complete a bachelor's degree.	Regardless of competition level, large majorities of students (eCM - 84%, NJ&EE - 98%) expected to, at minimum, complete a bachelor's degree. More than half of NJ&EE students (63%) reported aspirations to continue their education after college while fewer than half of regional students (39%) indicated that they intended to pursue post-Baccalaureate education.
eCM had positive impacts for students at all levels of competition, however NJ&EE students were more likely to report impacts; students identified a number of program strengths.	Half or more of all students agreed that eCM impacted them in the following areas: more confidence in STEM knowledge, skills, and abilities (eCM - 62%, NJ&EE - 97%) and more interested in participating in STEM activities outside of school requirements (eCM - 49%, NJ&EE - 88%). Items with the greatest difference between eCM impact by competition level (50% or more) were all related to AEOP and DoD and included having a greater appreciation of Army/DoD STEM research (eCM - 47%, NJ&EE - 97%), having more interest in participating in other AEOPs (eCM - 38%, NJ&EE - 91%), being more aware of other AEOPs (eCM - 43%, NJ&EE - 99%), and being more aware of Army/DoD STEM research and careers (eCM - 43%, NJ&EE - 99%).
	No significant differences in eCM impacts were found by U2 status or any of the demographic subgroups associated with U2 status.
	Both students at the regional and national competition levels cited benefits of participating in eCM. Regional students were most likely to identify teamwork, STEM learning, the opportunity to gain research or STEM skills, and the opportunity to solve real-word problems as benefits. National students were most likely to identify teamwork, STEM learning, career information, Army or DoD information, making friends, improving communication or public speaking skills, gaining confidence, and increasing interest in or motivation for STEM as program benefits.

Recommendations for FY20 Program Improvement/Growth

Evaluation findings indicate that FY19 was another successful year for the eCM program. Over 50% of students participating in eCM were from underserved populations. eCM mini-grant participants demonstrated significant growth in assessed 21st Century skills across the program duration. On multiple outcomes measured in the evaluation, eCM had a greater impact on students from underserved

populations. While these successes are commendable, there are some areas that remain with potential for growth and/or improvement. The evaluation team therefore offers the following recommendations for FY20 and beyond:

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

The overall participation in eCM has continued on a downward trend in FY19, dropping to 17,944 students (compared to 21,277 in FY18. This represents a 11% decrease for FY19, and a 19% decrease from the previous year). As in FY18, the evaluation team recommends that eCM employ strategies to reach new participants as well as supports for previous participants to engage again. Through multiple years of participation, it is likely that students will grow their knowledge, skills, and experience with competition programs and this in and of itself may increase their chances of success in the future. Therefore, reaching out to underserved groups of past participants may be a strategy that may help with both of these areas for future growth.

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

eCM is a key program in the AEOP consortium portfolio which enrolls by far the most students of any single program or other programs combined. There is a great opportunity to use eCM as a vehicle for exposing students to the many other opportunities that exist in AEOP and across DoD STEM. However, this is not happening currently in the program, as only NJ&EE students have consistent opportunities to learn about the DoD and Army, as well as other programs, etc. In FY19, less than 10% of Team Advisors reported discussing specific AEOPs with students other than eCM. Further, less than 50% of mentors discussed DoD or other government agencies with students. It is recommended that eCM make the inclusion of eCM materials regarding DoD and other AEOPs mandatory for Team Advisors to include in their work with students beginning this year.

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

As in FY17 and FY18, eCM students overall continue to report having little knowledge of other programs in the AEOP besides eCM (more than 50%). It is recommended that NSTA develop a coordinated strategy to address this across eCM overall for FY20, and it is also recommended that NSTA work with the consortium to utilize current and develop other additional resources that teachers/Team Advisors can use as tools to communicate with students about future AEOP opportunities and DoD STEM careers overall.