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Army Educational Outreach Program

High School Research Apprenticeship Program (HSAP)

2017 Annual Program Evaluation Report

PART 2: Evaluation Findings

February 2018

aeop
ARMY EDUCATIONAL OUTREACH PROGRAM

1

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2 | Table of Contents

3 | Introduction

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

AEOP 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.

This report documents the evaluation of one of the AEOP elements, the High School Apprentice Program (HSAP). HSAP is managed by the Academy of Applied Science (AAS) and the U.S. Army Research Office (ARO). The evaluation study was performed by Purdue University in cooperation with Battelle, the Lead Organization (LO) in the AEOP CA consortium. Data analyses and reports were prepared using data collected Purdue University.

Program Overview

HSAP, managed by the Academy of Applied Science (AAS) and the U.S. Army Research Office (ARO), is an Army Educational Outreach Program (AEOP) commuter program for high school students who demonstrate an interest in STEM. Students work as apprentices in Army-funded university or college research laboratories. HSAP is designed so that students (herein called apprentices) can apprentice in fields of their choice with experienced scientists and engineers (S&Es, herein called mentors) during the summer.

Apprentices receive an educational stipend equivalent to $10 per hour, and are allowed to work up to 300 hours total. The apprentices contribute to the laboratory's research while learning research skills and techniques. This hands-on experience gives apprentices a broader view of their fields of interest and

shows them what kind of work awaits them in their future careers. At the end of the program, the apprentices prepare abstracts for submission to the ARO's Youth Science Programs office.

In 2017, HSAP was guided by the following priorities:

1. Provide hands-on science and engineering research experience to high school students;
2. Educate students about the Army's interest and investment in science and engineering research and the associated educational opportunities available to students through the AEOP;
3. Provide students with experience in developing and presenting scientific research;
4. Provide students with the benefit of exposure to the expertise of a scientist or engineer as a mentor; and
5. Develop students' skills and background to prepare them for competitive entry to science and engineering undergraduate programs.

Table 1 contains an overview of demographic information for the 54 students who participated as HSAP apprentices in 2017. Over half of apprentices (60%) were female, representing an increase in participation of females compared to 2016 when only 49% of participants were female. HSAP served students from a variety of races and ethnicities. The most commonly reported races/ethnicities were White (42%) and Asian (25%), a slight increase compared to 2016 when 37% of apprentices were White and 20% were Asian. As in 2016, 15% of apprentices identified themselves as Black or African American. A slightly smaller percentage of apprentices (14%) identified as Hispanic or Latino than in 2016 (18%). A large majority of students came from either suburban (48% in 2017; 46% in 2016) or urban (43% in 2017; 43% in 2017) schools. Most apprentices (75%) reported that they did not receive free or reduced-price school lunches, a commonly used indicator of low-income status.

Table 1. 2017 HSAP Apprentice Participant Profile		
Demographic Category		
Respondent Gender (n =54)		
Female	31	60%
Male	23	40%
Choose not to report	0	0%
Respondent Race/Ethnicity (n =54)		
Asian	14	25%
Black or African American	8	15%
Hispanic or Latino	7	14%
Native American or Alaska Native	0	0%
Native Hawaiian or Other Pacific Islander	0	0%
White	22	42%
Other race or ethnicity	1	4%
Choose not to report	2	3%
School setting (n=54)		
Urban (city)	23	43%
Suburban	26	48%
Rural (country)	4	7%
Frontier or tribal School	0	0%
DoDDS/DoDEA School	0	0%
Home school	1	2%
Online school	0	0%
Choose not to report	0	0%
Receives free or reduced-price lunch (n=54)		
Yes	9	17%
No	41	76%
Choose not to report	4	7%

HSAP awards were made at 36 colleges and universities in 22 U.S. States and the District of Columbia (see Table 2). Nineteen of the sites were Historically Black Colleges and Universities or Minority Serving Institutions (HBCU/MIs). This is an increase from 016 when 16 HBCU/MI sites participated. A total of 54 apprentices participated in 2017. This is a decrease of 20% compared to 2016 when 65 apprentices were funded. 2017 enrollment failed to meet the program's goal of 70 apprentices. These apprentices were chosen from a total of 629 applicants; it is noteworthy that the number of applications received far exceeded the program's 2017 goal of 380 applications.

Table 2. 2017 HSAP Sites			
2017 HSAP Site	**City**	**State**	**No. of Participants**
Adams State University*	Alamosa	Colorado (CO)	2
Arizona State University*	Tempe	Arizona (AZ)	1

Table 2. 2017 HSAP Sites			
2017 HSAP Site	**City**	**State**	**No. of Participants**
City University of New York*	New York	New York (NY)	2
Clarkson University	Potsdam	New York (NY)	1
Duke University	Durham	North Carolina (NC)	1
Florida International University*	Miami	Florida (FL)	2
Howard University	Washington	District of Columbia (DC)	2
Louisiana State University*	Baton Rouge	Louisiana (LA)	1
NC A&T*	Greensboro	North Carolina (NC)	3
Northwestern University	Evanston	Illinois (IL)	1
Portland State University	Portland	Oregon (OR)	2
Purdue University	West Lafayette	Indiana (IN)	2
Rutgers – Camden Campus*	Camden	New Jersey (NJ)	1
San Jose State University*	San Jose	California (CA)	1
Savannah State University*	Savannah	Georgia (GA)	2
Stony Brook University of New York	Stony Brook	New York (NY)	2
Texas State University*	San Marcos	Texas (TX)	1
Tufts University	Medford	Massachusetts (MA)	1
University of Alabama	Tuscaloosa	Alabama (AL)	1
University of Arizona*	Tucson	Arizona (AZ)	1
University of California – Los Angeles*	Los Angeles	California (CA)	1
University of Central Florida	Orlando	Florida (FL)	2
University of Colorado	Boulder	Colorado (CO)	1
University of Houston*	Houston	Texas (TX)	2
University of Houston – Downtown*	Houston	Texas (TX)	1
University of Houston – Victoria*	Victoria	Texas (TX)	1
University of Kansas Center for Research	Lawrence	Kansas (KS)	3
University of Maryland - College Park*	College Park	Maryland (MD)	2
University of Minnesota	Minneapolis	Minnesota (MN)	3
University of New Hampshire	Durham	New Hampshire (NH)	1
University of North Carolina - Charlotte*	Charlotte	North Carolina (NC)	1
University of South Florida	Tampa	Florida (FL)	1
University of Texas - Arlington*	Arlington	Texas (TX)	1
University of Texas - El Paso*	El Paso	Texas (TX)	2
Washington State University	Pullman	Washington (WA)	1
Yale University	New Haven	Connecticut (CT)	1

The total cost of the 2017 HSAP program was $237,146, including $185,311 in stipends. The average cost per HSAP participant was $4,392. Table 3 summarizes these 2017 HSAP program costs.

Table 3. 2017 HSAP Program Costs	
2017 HSAP - Cost Per Participant	
Total Participants (Apprentices)	54
Total Cost	$237,146
Total Stipends	$185,311
Administrative Costs	$49,512
Other Operational Costs	$2,323
Cost Per Participant	**$4,392**

4 | Evidence - Based Program Change

All AEOP apprenticeship programs are administered by the Academy of Applied Science and are combined into an overall apprenticeship portfolio. Objectives and activities for the apprenticeship programs were developed and implemented collectively for all programs and included the following:

1. Expand apprenticeship opportunities for underserved populations in cooperation with HBCUs/MSIs and other affinity groups, and in cooperation with recruitment objectives of LPCs by disseminating program information to a broader and more diverse audience. (Supports Priority 1)

- Distributed program information to various organizations to increase diverse audience:
    - Published apprenticeship opportunities to high schools and universities located near Army labs and universities using direct mail and email campaigns.
    - Expanded outreach efforts to include superintendents of Title I high schools close to universities and DoD laboratories.
    - Received high school and community outreach assistance from The SEED School of Maryland, Center for Excellence in Education in McLean, Virginia, Iowa Education Services Officer (National Guard) and Educational Services Specialist (Army) in New Jersey.
    - Approximately 300 universities posted apprenticeship opportunities on career assistance pages.
- University directors provided outreach to local schools with materials supplied by AAS, such as, the AEOP brochure with rack cards, apprenticeship flyers, thumb drives, pencils and stickers.
- Improved program awareness and mentor participation by:
    - Sending mentors certificates of appreciation and letters of appreciation, as well as sending letters to the university deans, as appropriate.
    - Working with Widmeyer and Metriks to profile mentors (and students) in AEOP blogs and Alumni Spotlights – 10 in FY17 with 7 more apprenticeship spotlights in development. It is

anticipated that mentor blogs and spotlights will spark interest in future program participation.

- Since last year's ongoing summer communication was successful, continued this effort in FY17, sending student and mentor information on the following topics:
  - STEM Career links and FY17 STEM Career flyer
  - DoD STEM Webinar
  - Other AEOP programs
  - AEOP Travel Award
  - 21st Century Skill Assessment Pilot Program
  - Program Evaluation
  - Poster tips

2. Expand cross-marketing and outreach of apprenticeship programs to include other AEOP programs to mentors and LPCs. (Supports Priority 1 & 3)

- Published AEOP program and DoD opportunities to directors/mentors and students through email throughout the summer such as, DoD STEM Webinar information, STEM Career links and the FY17 STEM Career flyer.
- Assisted CAM office to implement a new STEM Career Opportunity Webinar; encouraged mentors and students to participate.
- All directors/mentors, students and lab coordinators received AEOP brochures/rack cards, AEOP notebooks, flash drives and pens. In addition, students received lab coats to promote all AEOP programs.
- Continued with social media campaign, including AAS Instagram account and hashtag campaign to engage participants.
- Cross marketing by sharing posts about all AEOP programs.
- Provided photos and newsworthy items to Widmeyer throughout the summer.
- Participated on marketing committee to share program content and cross promote AEOP.
- Supplied news stories and photos to Widmeyer and assisted with AEOP blogs and Alumni spotlights
- AEOP program information and outreach was done at the following events/site locations in FY17:
  - Massachusetts STEM Summit
  - The SEED School of Maryland
  - Vermont Tech Jam
  - NSTA conference
  - e-Cybermission 9th grade students
  - Young Inventors' Program Regional Invention Convention
  - All JSHS Regions
  - NC A&T University - 4 sites
  - City University of NY - 2 sites
  - Fayetteville State University
  - Duke University
  - University of Houston

- University of Houston, Downtown
- UNC Charlotte

3. Encourage apprentices to continue pursuit of AEOP STEM/Army STEM careers (Supports Priority 1)

- Worked with the Army to develop and publicize DoD STEM Career webinars for all apprenticeships showcasing Army scientists and engineers.
- Students learned about Army STEM careers through direct engagement with Army scientists and engineers in DoD laboratories.
- Worked with Widmeyer and Metriks to profile mentors in universities and DoD laboratories to showcase STEM careers in AEOP blogs and Alumni Spotlights.
- Since last year's ongoing summer communication was successful, continued this effort in FY17, sending student and mentor information on the following topics:
    - STEM Career links and FY17 STEM Career flyer
    - DoD STEM Webinar
    - Alumni Survey Link
    - Other AEOP programs
    - AEOP Travel Award
    - 21st Century Skill Assessment Pilot Program
    - Program Evaluation
    - Poster tips

4. Encourage more students already in the AEOP pipeline to continue with an apprenticeship program by utilizing Alumni and CVENT databases to collect past participant information in order to send out alert emails of program application openings. (Supports Priority 1 & 3)

- Worked with Metriks to secure Alumni information. Apprenticeship announcement flyers were sent to over 3,000 alumni from the GEMS, UNITE, JSS, SEAP, HSAP, REAP, JSHS.
- Distributed alumni survey link to directors, mentors and students.
- Distributed Alumni Spotlight to current participants to showcase other programs.
- Worked with partners (e-Cybermission, UNITE and JSHS) to distribute program information to cross promote.
- Reviewed and provided feedback to Widmeyer regarding the updates to the AEOP website.
- 26% of student participants in apprentice programs participated in GEMS or SEAP. However, it is important to note that 243 students (or 42%) participated in at least one other AEOP program. In addition, 23 REAP students are former UNITE students, representing 19% of the REAP student participant population in FY17.

5. Increase participant's knowledge of other AEOP programs and STEM careers (Supports Priority 1)

- Apprenticeship flyers were distributed to high schools, alumni and after school programs located near underserved/under-represented communities close to universities and DoD laboratories. Emails also included a link to the AEOP website outlining other AEOP opportunities.
- Welcome packets were distributed to participants comprised of: Lab coats, flash drives, notebooks, pens/pencils, AEOP brochures/rack cards and all AEOP program opportunities.
- Weekly communication to participants highlighted all AEOP programs and AEOP 2017 STEM Career Guide, AEOP blogs, AEOP social media info about other AEOP opportunities.
- Assisted university directors plan a Meet & Greet where students and mentors from other AEOP programs came together to talk about their experience. AAS provided additional AEOP material that talked about AEOP programs. Although the events were great for students, mentors could talk about their experiences, as well, and gained a better knowledge of AEOP. Each event was unique, however, some of the activities included:
  - Poster and/or power point presentations
  - Luncheon
  - Invited guest speakers
- Many universities provided an avenue where students presented their work to faculty, mentors, students and community members, and many attended (and presented at some) STEM venues, such as the Cancer Research Symposium in Opelika, Alabama, the Research Experience for Undergraduates (REU) and the Minority Science and Engineering Improvement Program (MSEIP) in Alabama, and the Summer Research Symposium in North Carolina.
- Visited WRAIR and spoke with mentors and apprentices about the student experience in a DoD laboratory, their research project, and their overall apprenticeship experience. Students indicated that this experience has increased their STEM knowledge and affirmed their choice to continue in a STEM related field in the future.
- Worked with the Army to develop and publicize DoD STEM Career webinars for all apprenticeships showcasing Army scientists and engineers.
- Worked with Widmeyer and Metriks to profile mentors (and students) in AEOP blogs and Alumni Spotlights.

6. Improve the overall participant and mentor apprenticeship experience. (Supports Priority 1 & 3)

- Worked with university directors/mentors to develop best practices.
- Developed and distributed poster guidelines to students and mentors.
- Distributed AEOP travel award information to participations. Twelve (12) apprenticeship participants were awarded in FY17.
- Assisted mentors with the 21st Century Pilot Program Evaluations.
- Developed student orientation & welcome document.
- Worked with the Army to research, develop, and present the DoD STEM Career webinar series to showcase Army scientists and engineers.
- Instituted a new stipend policy to ensure prompt stipend processing.
- Regular communication with students and mentors regarding program outcomes and expectations.

- Disseminated information about the AEOP Travel Award and received several interests.
- Applications opened earlier, and in some cases, closed earlier to allow for more time to complete security clearance and issuing of CAC cards at DoD laboratories. One of the primary goals of an earlier close date was to implement the notification process for selected and non-selected participants so that students would have time to apply to other summer STEM opportunities.
- The Mentor Toolkit provided valuable ideas for assisting mentors. The Toolkit suggested ideas to develop an ongoing conversation with mentors about how to assist students in research and life skills, develop best practices in mentoring, and security issues. The Toolkit is a resource for IPA's and LC's to use in helping mentors.

5 | Evaluation At-A-Glance

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

Inputs	Activities	Outputs	Outcomes (Short term)	Impact (Long Term)
• ARO and AEOP co-sponsorship • ARO providing administration of program • Operations conducted by 39 Army-funded university/ college labs • 59 apprentices participating in HSAP apprenticeships • 49 university/college S&Es serving as HSAP mentors • Apprenticeship funds administered to university/college research labs to support apprentice participation • Centralized branding and comprehensive marketing • Centralized evaluation	• Apprentices engage in authentic STEM research experiences through hands-on summer apprenticeships at Army-funded university/college labs • University/college S&Es supervise and mentor apprentices' research • Program activities that expose students to AEOP programs and/or STEM careers in the Army or DoD	• Number and diversity of apprentice participants engaged in HSAP • Number and diversity of university / college S&Es engaged in HSAP • Apprentices, university / college S&Es, and ARO contributing to evaluation	• Increased apprentice STEM competencies (confidence, knowledge, skills, and/or abilities to do STEM) • Increased apprentice interest in future STEM engagement • Increased apprentice awareness of and interest in other AEOP opportunities • Increased apprentice awareness of and interest in STEM research and careers • Increased apprentice awareness of and interest in Army/DoD STEM research and careers • Implementation of evidence-based recommendations to improve HSAP programs	• Increased apprentice participation in other AEOP opportunities and Army/DoD-sponsored scholarship/ fellowship programs • Increased apprentice pursuit of STEM degrees • Increased apprentice pursuit of STEM careers • Increased apprentice pursuit of Army/DoD STEM careers • Continuous improvement and sustainability of HSAP

The HSAP evaluation gathered information from apprentice and mentor participants about HSAP processes, resources, activities, and their effects in order to address key evaluation questions related to program strengths and challenges, benefits to participants, and overall effectiveness in meeting AEOP and HSAP program objectives.

The assessment strategy for HSAP included post-program apprentice and mentor questionnaires and individual interviews with 5 apprentices and 4 mentors (via telephone), and information from the Annual Program Report (APR) prepared by AAS using data from all HSAP sites. Tables 4-7 outline the information collected in apprentice and mentor questionnaires and apprentice and mentor interviews.

Key Evaluation Questions

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

Table 4. 2017 Apprentice Questionnaires	
Category	**Description**
Profile	**Demographics:** Participant gender, age, grade level, race/ethnicity, and socioeconomic status indicators
	Education Intentions: Degree level, confidence to achieve educational goals, field sought
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 AEOP programs; 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 5. 2017 Mentor Questionnaires	
Category	**Description**
Profile	**Demographics:** Participant gender, race/ethnicity, occupation, past participation
Satisfaction & Suggestions	Awareness of HSAP, 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 AEOP programs; 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 6. 2017Apprentice Interviews	
Category	**Description**

Satisfaction & Suggestions	Awareness of HSAP, 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 apprentices were exposed to other AEOP opportunities
	Army STEM: Army/DoD STEM Careers – Extent to which apprentices were exposed to STEM and Army/DoD STEM jobs

Table 7. 2017 Mentor Interviews	
Category	**Description**
Satisfaction & Suggestions	Perceived value of HSAP, benefits to participants suggestions for improving HSAP programs
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 apprentices to STEM and Army/DoD STEM jobs
	Mentor Capacity: Local Educators – Strategies used to increase diversity/support diversity in HSAP

Detailed information about methods and instrumentation, sampling and data collection, and analysis are described in the appendices, found in Part 3 of the HSAP Evaluation Report. The reader is strongly encouraged to review Appendix A, the evaluation plan, to clarify how data are summarized, analyzed, and reported in this document. Findings of statistical and/or practical significance are noted in the report narrative, with tables and footnotes providing results from tests for significance. Interview protocols are provided in Appendix B (apprentices) and Appendix C (mentors); the apprentice questionnaire is provided in Appendix D and the mentor questionnaire is provided in Appendix E. The new assessment of apprentices' 21st Century Skills was piloted in 2017 and the tool is included in Appendix F. Major trends in data and analyses are reported herein.

Study Sample

Table 8 provides an overview of questionnaire participation. More than half of HSAP apprentices and mentors (57% and 60% respectively) responded to the questionnaire, an increase in participation from the 55% of apprentices and the 12% of mentors who responded to the 2016 questionnaire. In spite of the increases in participation, the margin of error for both apprentices and mentors is larger than generally acceptable and therefore caution is warranted when interpreting questionnaire data, as the responses may not be representative of the overall population of apprentices and mentors participating in HSAP.

Table 8. 2017 HSAP Questionnaire Participation

Participant Group	Respondents (Sample)	Total Participants (Population)	Participation Rate	Margin of Error @ 95% Confidence[1]
Apprentices	31	54	57%	±11.6%
Mentors	24	40	60%	±12.8%

Individual interviews were conducted with 5 apprentices and 4 mentors recruited by the ARO. The interviews were not intended to yield generalizable findings; rather they were intended to provide additional evidence of, explanation for, or illustrations of apprentice questionnaire data. They add to the overall narrative of HSAP's efforts and impact, and highlight areas for future exploration in programming and evaluation.

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

Respondent Profiles

Apprentice Demographics

Demographic information about HSAP apprentices who completed the questionnaire is provided in Table 9. Approximately equal numbers of males (48%) and females (52%) completed the survey. Participant race/ethnicity was reported to be largely White (34%) or Asian (34%) with fewer minority students responding. These respondent demographics are similar to the demographic data for all HSAP apprentices. An overwhelming majority of survey respondents were seniors in high school (85%) with very few in any other grade level.

Table 9. 2017 HSAP Apprentice Respondent Profile

Demographic Category	Questionnaire Respondents	
Respondent Gender (n = 29)		
Female	14	48%
Male	15	52%
No Response	0	0%
Respondent Race/Ethnicity (n = 29)		
Asian	10	34%
Black or African American	4	14%
Hispanic or Latino	4	14%
Native American or Alaska Native	0	0%
Native Hawaiian or Other Pacific Islander	0	0%
White	10	34%
Other race or ethnicity	0	0%
Choose not to report	1	4%
Respondent Grade Level (n = 32)		
9th	0	0%
10th	1	3%
11th	2	6%
12th	27	85%
Choose not to report	1	3%
Other	1	3%

Mentor Demographics

Table 10 summarizes demographic data for HSAP mentor questionnaire respondents. A large majority of participating mentors reported being female (88%) and White (46%) or Asian (42%). Most mentors indicated their occupation was university educator (63%) or scientist, engineer, or mathematician in training (21%).

Table 10. 2017 HSAP Mentor Respondent Profile

Demographic Category	Questionnaire Respondents	
Respondent Gender (n = 24)		
Female	3	88%
Male	21	12%
No Response	0	0%
Respondent Race/Ethnicity (n = 24)		
Hispanic or Latino	1	4%
Asian	10	42%
Black or African American	1	4%
Native American or Alaska Native	0	0%
Native Hawaiian or Other Pacific Islander	0	0%
White	11	46%
Choose not to report	1	4%
Respondent Occupation (n = 24)		
University educator	15	63%
Scientist, Engineer, or Mathematician in training (undergraduate or graduate apprentice, etc.)	5	21%
Scientist, Engineer, or Mathematics professional	3	12%
Teacher	1	4%
Other	0	0%

In order to determine the effectiveness of the AEOP pipeline, apprentices were asked about their participation in other AEOPs in the past (Table 11). Approximately two-thirds (76%) reported never having participated in any other AEOP. Only 1 participant indicated having previously participated in JSHS (3%) and 1 in SEAP (3%), although over a third (38%) reported having participated in other STEM programs.

Table 11. Apprentice Participation in Previous AEOP Programs (n=29)

Choice	Response Percent	Response Total
Camp Invention	0%	0
eCYBERMISSION	0%	0
Junior Solar Sprint (JSS)	0%	0
Gains in the Education of Mathematics and Science (GEMS)	0%	0
UNITE	0%	0
Junior Science & Humanities Symposium (JSHS)	3%	1
Science & Engineering Apprenticeship Program (SEAP)	3%	1
Research & Engineering Apprenticeship Program (REAP)	0%	0
High School Apprenticeship Program (HSAP)	0%	0
College Qualified Leaders (CQL)	0%	0
Undergraduate Research Apprenticeship Program (URAP)	0%	0
Science Mathematics & Research for Transformation (SMART) College Scholarship	0%	0
I've never participated in any AEOP programs	76%	22
Other STEM Program	38%	11

6 | Actionable Program Evaluation

The Actionable Program Evaluation is intended to provide assessment and evaluation of program processes, resources, and activities for the purpose of recommending improvements as the program moves forward. This section highlights information outlined in the Satisfaction & Suggestions sections of Tables 4-7.

A focus of the Actionable Program Evaluation is efforts toward the long-term goal of HSAP 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. HSAP sites are primarily responsible for local marketing of the program—including any outreach that is done with the specific intention of recruiting apprentices from traditionally underrepresented and underserved populations. Thus, it is important to consider how HSAP is marketed and ultimately recruits apprentice participants, the factors that motivate apprentices to participate in HSAP, participants' perceptions of and satisfaction with activities, what value participants place on program activities, and what recommendations participants have for program improvement. The following sections report perceptions of apprentices and mentors that pertain to current programmatic efforts and recommend evidence-based improvements to help HSAP achieve outcomes related to AEOP programs and objectives. Specifically, this information is intended to help HSAP continue to expand participation from and support STEM education for students from underrepresented and underserved groups.

Marketing and Recruiting Underrepresented and Underserved Populations

HSAP apprentices are recruited primarily at the site level, using connections or mechanisms available to the university or college site. As a result, the ability of HSAP to recruit underserved or under-represented populations of students depends upon the diversity of the universities or colleges in which recruitment takes place.

In addition to site-level marketing efforts, AAS conducted a coordinated marketing effort among apprenticeship programs. Marketing was conducted for apprenticeship programs overall rather than for individual programs, a strategy that AAS has reported to be successful. In particular, AAS noted that consistent messaging to directors, mentors, and students continues to be a successful way to keep participants informed of other AEOP programs. According to the annual program report submitted by AAS, a number of strategies were used to disseminate information about the apprenticeship programs to diverse audiences:

- Since last year's ongoing summer communication was successful, continued this effort in FY17, sending student and mentor information on the following topics:
    - STEM Career links and FY17 STEM Career flyer
    - DoD STEM Webinar
    - Alumni Survey Link
    - Other AEOP programs
    - AEOP Travel Award
    - 21st Century Skill Assessment Pilot Program
    - Program Evaluation
    - Poster tips
- Monthly marketing efforts were targeted to high schools located within a two-hour radius of each SEAP lab.
- Updated the Apprenticeship flyer showing diversity and individual program descriptions.
- Cross marketing and outreach for all AEOP programs, in addition to specific cross promotion, such as:
    - Provided apprenticeship flyers to NSTA and JSHS for distribution at events.
    - Assisted e-Cybermission with virtual judge recruitment by notifying apprenticeship directors and mentors of the opportunity.
    - Assisted RESET in recruiting mentors in Army labs to mentor a teacher, in addition to an apprentice. This resulted in recruiting some interested mentors for RESET.
- Distributed program information to various organizations to increase diverse audience:
    - Published apprenticeship opportunities to high schools and universities located near Army labs and universities using direct mail and email campaigns.
    - Expanded outreach efforts to include superintendents of Title I high schools close to universities and DoD laboratories.
    - Received high school and community outreach assistance from The SEED School of Maryland, Center for Excellence in Education in McLean, Virginia, Iowa Education Services Officer (National Guard) and Educational Services Specialist (Army) in New Jersey.

University directors provided outreach to local schools with materials supplied by AAS, such as, the AEOP brochure with rack cards, apprenticeship flyers, thumb drives, pencils and stickers.

In order to understand which marketing methods are most effective HSAP apprentices were asked to identify the ways they heard about AEOP (Table 12). The most common sources of information about AEOP were related to apprentices' schools and personal contacts. School sources of information included school or university newsletters, emails, or websites (38%) and someone who works at the school or university apprentices attend (34%). Nearly half of participants (48%) reported learning about AEOP through personal contacts (past participant – 17%; friend – 17%; or family member – 14%).

Table 12. How Apprentices Learned About AEOP (n=29)

Choice	Response Percent	Response Total
Army Educational Outreach Program (AEOP) Website	14%	4
AEOP on Facebook, Twitter, Instagram, or other social media	0%	0
School or university newsletter, email, or website	38%	11
Past participant of program	17%	5
Friend	17%	5
Family Member	14%	4
Someone who works at the school or university I attend	34%	10
Someone who works with the program	3%	1
Someone who works with the Department of Defense (Army, Navy, Air Force, etc.)	7%	2
Community group or program	7%	2
Choose Not to Report	0%	0

Mentors were also asked how they learned about AEOP (Table 13). Over half of mentor respondents (53%) indicated that they learned about AEOP from the AEOP website or someone who works with the DoD. A third of mentors (33%) reported learning about AEOP from past participants in the program. Another 20% reported that they learned about the program through someone who works at their school or university.

Table 13. How Mentors Learned About AEOP (n=15)

Choice	Response Percent	Response Total
Army Educational Outreach Program (AEOP) Website	53%	8
AEOP on Facebook, Twitter, Instagram, or other social media	0%	0
School or university newsletter, email, or website	0%	0
Past participant of program	33%	5
Friend	0%	0
Family Member	0%	0
Someone who works at the school or university I attend	20%	3
Someone who works with the program	13%	2
Someone who works with the Department of Defense (Army, Navy, Air Force, etc.)	53%	8
Community group or program	0%	0
Choose Not to Report	0%	0

Factors Motivating Apprentice Participation

In order to understand what features of the program motivate HSAP apprentices to apply, apprentices were asked about the factors that motivated them to participate (Table 14). The most frequently reported motivators were related to the learning opportunities in HSAP, including the desire to learn something new or interesting (100%), interest in STEM (100%), and desire to expand laboratory skills (93%). Likewise, 86% of students reported that they were motivated by the opportunity to learn in ways not possible in school and 86% by the opportunity to use advanced laboratory technology.

Table 14. Factors Motivating Apprentice Participation in HSAP (n=29)

Choice	Response Percent	Response Total
Teacher or professor encouragement	34%	10
An academic requirement or school grade	3%	1
Desire to learn something new or interesting	100%	29
The mentor(s)	55%	16
Building college application or résumé	62%	18
Networking opportunities	76%	22
Interest in science, technology, engineering, or mathematics (STEM)	100%	29
Interest in STEM careers with the Army	45%	13
Having fun	79%	23
Earning stipends or awards for doing STEM	48%	14
Opportunity to do something with friends	28%	8
Opportunity to use advanced laboratory technology	86%	25
Desire to expand laboratory or research skills	93%	27
Learning in ways that are not possible in school	86%	25
Serving the community or country	66%	19
Exploring a unique work environment	79%	23
Figuring out education or career goals	72%	21
Seeing how school learning applies to real life	69%	20
Recommendations of past participants	14%	4
Choose Not to Report	0%	0

Apprentices participating in interviews reported similar motivations for participating in HSAP, with nearly all participants also focusing on career exploration as a motivator for participating. For example:

> *I really wanted skills within the field my particular specialty pertains to. In addition to that, I wanted to gain experience within the more professional world, especially within research. It's something that I'm considering to pursue as a full-time career in the future.* (HSAP Apprentice)

The HSAP Experience

A goal of HSAP is to provide high school students with STEM experiences they would not normally experience in traditional school environments. In order to understand these experiences, apprentices were asked to respond to several questions about their HSAP experiences.

When asked about their projects and input into the design of their projects, approximately half (52%) of apprentices reported being given a project to work on by their mentors. The rest had some degree of input into their project (42%), and none reported designing the project entirely on their own.

Table 15. Apprentice Input on Design of Their Project (n=31)

Choice	Response Percent	Response Total
I did not have a project	6.45 %	2
I was assigned a project by my mentor	51.61 %	16
I worked with my mentor to design a project	16.13 %	5
I had a choice among various projects suggested by my mentor	9.68 %	3
I worked with my mentor and members of a research team to design a project	16.13 %	5
I designed the entire project on my own	0.00 %	0

Nearly all apprentices (97%) reported collaborating to some degree during HSAP. For example, 42% reported working with a group on the same project and 35% reported working with others in a shared lab but on different projects (35%).

Table 16. Apprentice Participation in a Research Group (n=31)

Choice	Response Percent	Response Total
I worked alone (or alone with my research mentor)	3.23 %	1
I worked with others in a shared laboratory or other space, but we work on different projects	35.48 %	11

I worked alone on my project and I met with others regularly for general reporting or discussion	3.23 %	1
I worked alone on a project that was closely connected with projects of others in my group	16.13 %	5
I work with a group who all worked on the same project	41.94 %	13

A goal of HSAP is to increase the number and diversity of students who purse STEM careers. Therefore, questions were included on the apprentice questionnaire asking about the number of jobs and careers in STEM in general and specifically STEM jobs and careers in the DoD that apprentices learned about during HSAP (Tables 17 & 18). More than half (61%) of apprentices reported learning about three or more STEM jobs and careers in general and almost all (91%) reported learning about at least one. Fewer apprentices reported learning about STEM jobs and careers within the DoD, with 42% of responding apprentices reporting learning about three or more and 71% reporting learning about at least one. Over a quarter (29%) of apprentices had not learned about any DoD STEM jobs and careers.

To better understand what resources are most effective in informing apprentices about DoD STEM careers, apprentices were asked to rate the impact of various resources on their awareness of these careers (Table 19). Most (81%) reported that simply participating in HSAP was at least somewhat impactful. Over two-thirds (65%) of apprentices indicated their mentors and the AEOP website were at least somewhat useful for impacting their awareness of DoD STEM careers. Most (71%) had not experienced AEOP on social media and over a quarter (26%) had not experienced the AEOP brochure.

Table 17. Number of STEM Jobs/Careers Apprentices Learned About During HSAP (n=36)

Choice	Response Percent	Response Total
None	3.23 %	1
1	12.90 %	4
2	22.58 %	7
3	12.90 %	4
4	6.45 %	2
5 or more	41.94 %	13

Table 18. Number of Army or DoD STEM Jobs/Careers Apprentices Learned About During HSAP (n=31)

Choice	Response Percent	Response Total
None	29.03 %	9
1	16.13 %	5

2	12.90 %	4
3	19.35 %	6
4	9.68 %	3
5 or more	12.90 %	4

Table 19. Impact of Resources on Apprentice Awareness of DoD STEM Careers (n=31)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Army Educational Outreach Program (AEOP) website	12.9%	6.5%	16.1%	38.7%	25.8%	
	4	2	5	12	8	**31**
AEOP on Facebook, Twitter, Pinterest or other social media	71.0%	9.7%	16.1%	3.2%	0.0%	
	22	3	5	1	0	**31**
Army Research Office (ARO) website	45.2%	0.0%	12.9%	35.5%	6.5%	
	14	0	4	11	2	**31**
AEOP brochure	25.8%	6.5%	19.4%	35.5%	12.9%	
	8	2	6	11	4	**31**
My Apprenticeship Program mentor	3.2%	3.2%	29.0%	16.1%	48.4%	
	1	1	9	5	15	**31**
Presentations or information shared in the Apprenticeship Program	9.7%	9.7%	22.6%	35.5%	22.6%	
	3	3	7	11	7	**31**
	3.2%	3.2%	12.9%	25.8%	54.8%	

Participation in the Apprenticeship Program	1	1	4	8	17	**31**

In order to further understand their HSAP experiences, apprentices were asked how often they engaged in various STEM practices during HSAP (Table 20). Approximately half or more reported engaging in all STEM practices listed either weekly or daily while in HSAP. For example, 97% reported interacting with STEM researchers weekly or daily, 90% reported working with a STEM researcher on a real-world STEM problem weekly or daily, and 90% reported working collaboratively as part of a team weekly or daily. Over half of apprentices (61%) had not presented their STEM research to a panel of judges from industry or the military, and 48% had not worked with a STEM research on a project of the apprentices' choosing or created a computer model.

Table 20. Apprentice Engagement in STEM Practices in HSAP (n=31)

	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	6.5% 2	3.2% 1	0.0% 0	32.3% 10	58.1% 18	**31**
Work with a STEM researcher on a research project of your own choosing	48.4% 15	3.2% 1	0.0% 0	22.6% 7	25.8% 8	**31**
Design my own research or investigation based on my own question(s)	32.3% 10	19.4% 6	3.2% 1	22.6% 7	22.6% 7	**31**
Present my STEM research to a panel of judges from industry or the military	61.3% 19	29.0% 9	0.0% 0	6.5% 2	3.2% 1	**31**
Interact with STEM researchers	3.2% 1	0.0% 0	0.0% 0	22.6% 7	74.2% 23	**31**
Use laboratory procedures and tools	12.9% 4	6.5% 2	6.5% 2	16.1% 5	58.1% 18	**31**
Identify questions or problems to investigate	0.0% 0	6.5% 2	6.5% 2	32.3% 10	54.8% 17	**31**
Design and carry out an investigation	19.4% 6	9.7% 3	3.2% 1	25.8% 8	41.9% 13	**31**
Analyze data or information and draw conclusions	0.0% 0	6.5% 2	3.2% 1	35.5% 11	54.8% 17	**31**

Work collaboratively as part of a team	9.7%	0.0%	0.0%	19.4%	71.0%	
	3	0	0	6	22	**31**
Build or make a computer model	48.4%	6.5%	6.5%	9.7%	29.0%	
	15	2	2	3	9	**31**
Solve real-world problems	6.5%	6.5%	3.2%	29.0%	54.8%	
	2	2	1	9	17	**31**

A composite score[2] was calculated for this set of items and a parallel set of items asking the same questions about how often students engaged in the same activities in school.[3] Response categories were converted to a scale of 1 = "Not at all" to 5 = "Every day" and the average across all items in each set was calculated. Composite scores were used to test whether there were differences in apprentice experiences by gender and race/ethnic group (minority vs. non-minority apprentices)[4]. No statistically significant differences were found by gender or race/ethnicity. Chart 1 shows that there was a statistically significant difference in student STEM Engagement in school versus during HSAP, with apprentices reporting significantly higher STEM Engagement in HSAP as compared to in school (effect size is large with d = 2.07).

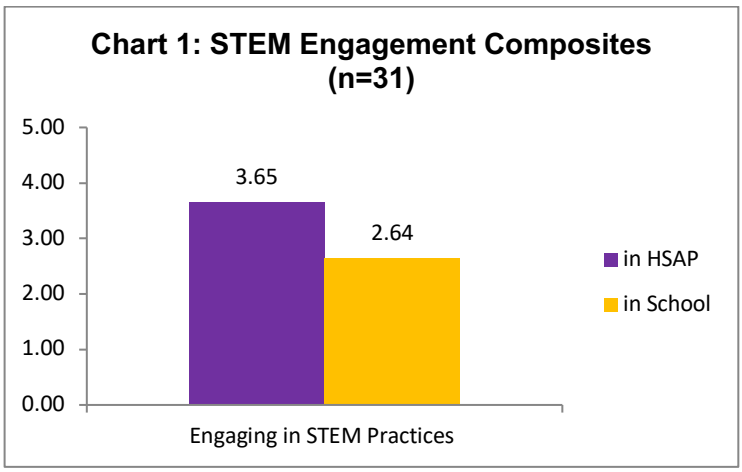
Apprentices participating in interviews were asked to reflect on how their HSAP experiences compared with their STEM experiences in school. All participants responded that HSAP offered substantially different learning opportunities than their school experiences, and focused on the opportunity for hands-on experiences and the opportunity to apply their learning in a setting where creativity and independent work is valued. For example,

> *We're able to learn a lot in such a short amount of time, and it's really thorough and comprehensive conversations that we have, which I think is different from school.* (HSAP Apprentice)

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

[3] The Cronbach's alpha reliability for STEM Engagement in HSAP = 0.791 (12 items); Cronbach's alpha reliability for STEM Engagement in School = 0.808 (12 items).

[4] Dependent Samples t-test for STEM Engagement: t(30)=5.67, p<.001.



The Role of Mentors

Mentors play a critical role in HSAP. Mentors supervise and support apprentices' work, advise apprentices on educational and career paths, and generally serve as STEM role models for HSAP apprentices. The majority of mentors (58%) responding to the mentor questionnaire reported working with 1 apprentice, while 29% of mentors worked with 2 apprentices and 12% reported working with 3 or 4 apprentices.

Mentors were asked whether or not they used a number of strategies when working with their apprentices (note: the questionnaires used the term "students"; consequently, the data in this section are reported using that term as well). These strategies comprised five main areas of effective mentoring:[5]

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;

[5] 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.

4. Supporting students' engagement in "authentic" STEM activities; and
5. Supporting students' STEM educational and career pathways.

Mentors reported using most strategies associated with each of the five mentoring areas listed above. Mentor responses for each of the five areas of mentoring are presented in Tables 21 – 26.

Large majorities of mentors (79% - 96%) reported using each strategy associated with establishing the relevance of learning activities in HSAP (Table 21). For example, nearly all (96%) reported becoming familiar with student backgrounds and interests, giving student real-life problems to investigate, and encouraging students to suggest new readings, activities, or projects.

Table 21. Mentors Using Strategies to Establish Relevance of Learning Activities (n=24)

	Yes – I used this strategy	No – I did not use this strategy	Response Total
Become familiar with my student(s) background and interests at the beginning of the HSAP experience	95.8%	4.2%	
	23	1	**24**
Giving students real-life problems to investigate or solve	95.8%	4.2%	
	23	1	**24**
Selecting readings or activities that relate to students' backgrounds	87.5%	12.5%	
	21	3	**24**
Encouraging students to suggest new readings, activities, or projects	95.8%	4.2%	
	23	1	**24**
Helping students become aware of the role(s) that STEM plays in their everyday lives	83.3%	16.7%	
	20	4	**24**
Helping students understand how STEM can help them improve their own community	79.2%	20.8%	
	19	5	**24**
Asking students to relate real-life events or activities to topics covered in HSAP	87.5%	12.5%	
	21	3	**24**

Most mentors (67% - 100%) also reported using each of the strategies associated with supporting the diverse needs of students as learners (Table 22). All mentors reported using a variety of teaching and/or

mentoring activities to meet the needs of students, and nearly all (96%) reported identifying students' learning styles at the start of HSAP.

Table 22. Mentors Using Strategies to Support the Diverse needs of Students as Learners (n=24)

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Identify the different learning styles that my student (s) may have at the beginning of the HSAP experience	95.8%	4.2%	
	23	1	**24**
Interact with students and other personnel the same way regardless of their background	91.7%	8.3%	
	22	2	**24**
Use a variety of teaching and/or mentoring activities to meet the needs of all students	100.0%	0.0%	
	24	0	**24**
Integrating ideas from education literature to teach/mentor students from groups underrepresented in STEM	75.0%	25.0%	
	18	6	**24**
Providing extra readings, activities, or learning support for students who lack essential background knowledge or skills	87.5%	12.5%	
	21	3	**24**
Directing students to other individuals or programs for additional support as needed	87.5%	12.5%	
	21	3	**24**
Highlighting under-representation of women and racial and ethnic minority populations in STEM and/or their contributions in STEM	66.7%	33.3%	
	16	8	**24**

Large majorities of mentors (88% - 100%) also used each strategy associated with supporting student development of collaboration and interpersonal skills (Table 23). For example, all mentors reported listening to students with an open mind, having students exchange ideas with others whose backgrounds or viewpoints are different from their own, and having students work on collaborative activities as a member of a team.

Table 23. Mentors Using Strategies to Support Student Development of Collaboration and Interpersonal Skills (n=24)

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Having my student(s) tell other people about their backgrounds and interests	95.8%	4.2%	
	23	1	**24**
Having my student(s) explain difficult ideas to others	95.8%	4.2%	
	23	1	**24**
Having my student(s) listen to the ideas of others with an open mind	100.0%	0.0%	
	24	0	**24**
Having my student(s) exchange ideas with others whose backgrounds or viewpoints are different from their own	100.0%	0.0%	
	24	0	**24**
Having my student(s) give and receive constructive feedback with others	87.5%	12.5%	
	21	3	**24**
Having students work on collaborative activities or projects as a member of a team	100.0%	0.0%	
	24	0	**24**
Allowing my student(s) to resolve conflicts and reach agreement within their team	87.5%	12.5%	
	21	3	**24**

Mentors were also asked about their use of strategies to support student engagement in authentic STEM activities (Table 24). Again, large majorities of mentors (83% - 100%) reported using each strategy. For example, all mentors reported supervising their students while they practiced STEM research skills. Nearly all (96%) encouraged students to work collaboratively and demonstrated laboratory/field techniques, procedures, and tools for students.

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

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Teaching (or assigning readings) about specific STEM subject matter	91.7%	8.3%	
	22	2	**24**
Having my student(s) search for and review technical research to support their work	83.3%	16.7%	
	20	4	**24**
Demonstrating laboratory/field techniques, procedures, and tools for my student(s)	95.8%	4.2%	
	23	1	**24**
Supervising my student(s) while they practice STEM research skills	100.0%	0.0%	
	24	0	**24**
Providing my student(s) with constructive feedback to improve their STEM competencies	95.8%	4.2%	
	23	1	**24**
Allowing students to work independently to improve their self-management abilities	91.7%	8.3%	
	22	2	**24**
Encouraging students to learn collaboratively (team projects, team meetings, journal clubs, etc.)	95.8%	4.2%	
	23	1	**24**
Encouraging students to seek support from other team members	100.0%	0.0%	
	24	0	**24**

Most mentors (67% - 92%) also used each strategy to support students' STEM educational and career pathways (Table 25). For example, 67% of mentors reported recommending extracurricular programs that align with students' goals, 79% discussed STEM career opportunities with the DoD or other government agencies, 83% recommended AEOPs that aligned with students' goals, and 92% discussed STEM career opportunities in private industry or academia. Mentors reported use of strategies in this category and all others increased from the prior year's evaluation findings.

Table 25. Mentors Using Strategies to Support Student STEM Educational and Career Pathways (n=24)

	Yes - I used this strategy	No - I did not use this strategy	Response Total
Asking my student(s) about their educational and/or career goals	91.7%	8.3%	
	22	2	**24**
Recommending extracurricular programs that align with students' goals	66.7%	33.3%	
	16	8	**24**
Recommending Army Educational Outreach Programs that align with students' goals	83.3%	16.7%	
	20	4	**24**
Providing guidance about educational pathways that will prepare my student(s) for a STEM career	91.7%	8.3%	
	22	2	**24**
Discussing STEM career opportunities within the DoD or other government agencies	79.2%	20.8%	
	19	5	**24**
Discussing STEM career opportunities in private industry or academia	91.7%	8.3%	
	22	2	**24**
Discussing the economic, political, ethical, and/or social context of a STEM career	66.7%	33.3%	
	16	8	**24**
Recommending student and professional organizations in STEM to my student(s)	70.8%	29.2%	
	17	7	**24**
Helping students build a professional network in a STEM field	79.2%	20.8%	
	19	5	**24**
Helping my student(s) with their resume, application, personal statement, and/or interview preparations	66.7%	33.3%	
	16	8	**24**

Because a goal of the AEOP is to create a pipeline of AEOPs, mentors were asked which other programs they explicitly discussed with apprentices (Table 26). Half of mentors reported having discussed AEOP generally with their apprentices, but without reference to any specific programs. The most frequently discussed programs were HSAP (67%) and URAP (50%). A third of mentors (33%) discussed REAP with their apprentices, and a quarter (25%) discussed SMART. It is noteworthy, however that most mentors did not discuss other programs such as JSHS (88%), SEAP (88%), and CQL (92%), for which apprentices are or will soon be eligible.

Table 26. Mentors Explicitly Discussing AEOPs with Apprentices (n=24)

	Yes - I discussed this program with my student(s)	No - I did not discuss this program with my student(s)	Response Total
UNITE	8.3%	91.7%	
	2	22	**24**
Junior Science & Humanities Symposium (JSHS)	12.5%	87.5%	
	3	21	**24**
Science & Engineering Apprenticeship Program (SEAP)	12.5%	87.5%	
	3	21	**24**
Research & Engineering Apprenticeship Program (REAP)	33.3%	66.7%	
	8	16	**24**
High School Apprenticeship Program (HSAP)	66.7%	33.3%	
	16	8	**24**
College Qualified Leaders (CQL)	8.3%	91.7%	
	2	22	**24**
GEMS Near Peer Mentor Program	12.5%	87.5%	
	3	21	**24**
Undergraduate Research Apprenticeship Program (URAP)	50.0%	50.0%	
	12	12	**24**
Science Mathematics, and Research for Transformation (SMART) College Scholarship	25.0%	75.0%	
	6	18	**24**
National Defense Science & Engineering Graduate (NDSEG) Fellowship	25.0%	75.0%	
	6	18	**24**
I discussed AEOP with my student(s) but did not discuss any specific program	50.0%	50.0%	
	12	12	**24**

Mentors were also asked to rate the usefulness of various resources for exposing apprentices to AEOPs (Table 27). All mentors reported that participation in HSAP was either somewhat or very much useful for this purpose. The HSAP program administrator or site coordinator (92%) and AEOP website (83%) were also reported to be at least somewhat useful resources by mentors. Many mentors, however, had not experienced AEOP social media (63%) and invited speakers (54%).

Table 27. Useful Resources for Exposing Apprentices to AEOPs (n=24)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Army Research Office (ARO) website	25.0%	4.2%	8.3%	33.3%	29.2%	
	6	1	2	8	7	**24**
Army Educational Outreach Program (AEOP) website	4.2%	0.0%	12.5%	33.3%	50.0%	
	1	0	3	8	12	**24**
AEOP on Facebook, Twitter, Pinterest or other social media	62.5%	4.2%	8.3%	12.5%	12.5%	
	15	1	2	3	3	**24**
AEOP brochure	29.2%	0.0%	12.5%	33.3%	25.0%	
	7	0	3	8	6	**24**
HSAP Program administrator or site coordinator	4.2%	0.0%	4.2%	29.2%	62.5%	
	1	0	1	7	15	**24**
Invited speakers or "career" events	54.2%	4.2%	4.2%	25.0%	12.5%	
	13	1	1	6	3	**24**
Participation in HSAP	0.0%	0.0%	0.0%	12.5%	87.5%	
	0	0	0	3	21	**24**

Mentors were also asked to report on the usefulness of these resources for exposing apprentices to DoD STEM careers (Table 28). Again, all mentors reported that participation in HSAP was either somewhat or very much useful for this purpose. Similarly, the HSAP site coordinator (83%) and AEOP website (79%) were reported to be at least somewhat useful for exposing apprentices to DoD STEM careers. Many mentors had not experienced resources such as AEOP on social media (63%) and invited speakers (49%).

Table 28. Usefulness of Resources for Exposing Apprentices to DoD STEM Careers (n=24)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total

Army Research Office (ARO) website	29.2%	8.3%	4.2%	25.0%	33.3%	
	7	2	1	6	8	**24**
Army Educational Outreach Program (AEOP) website	4.2%	0.0%	16.7%	33.3%	45.8%	
	1	0	4	8	11	**24**
AEOP on Facebook, Twitter, Pinterest or other social media	62.5%	0.0%	8.3%	12.5%	16.7%	
	15	0	2	3	4	**24**
AEOP brochure	25.0%	0.0%	16.7%	33.3%	25.0%	
	6	0	4	8	6	**24**
HSAP Program administrator or site coordinator	8.3%	4.2%	4.2%	29.2%	54.2%	
	2	1	1	7	13	**24**
Invited speakers or "career" events	45.8%	4.2%	8.3%	20.8%	20.8%	
	11	1	2	5	5	**24**
Participation in HSAP	0.0%	0.0%	0.0%	12.5%	87.5%	
	0	0	0	3	21	**24**

Satisfaction with HSAP

Apprentices were asked about their satisfaction with a number of features of the HSAP program (Table 29). Overall, apprentices reported high levels of satisfaction, with two-thirds or more reporting being somewhat or very much satisfied with all program features. For example, large majorities of apprentices were somewhat or very much satisfied with the amount of stipend pay (93%), communication with host site organizers (90%), and physical locations of program activities (90%). Few apprentices expressed dissatisfaction with any program features, although 4 apprentices (13%) reported being "not at all" satisfied with the variety of STEM topics available to them and 4 apprentices (13%) were not satisfied with the timeliness of stipend payments.

Table 29. Apprentice Satisfaction with HSAP Program Features (n=31)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Applying or registering for the program	0.0%	0.0%	12.9%	32.3%	54.8%	
	0	0	4	10	17	**31**

Other administrative tasks (in-processing, network access, etc.)	0.0%	3.2%	12.9%	35.5%	48.4%	
	0	1	4	11	15	**31**
Communicating with your host site organizers	0.0%	0.0%	9.7%	32.3%	58.1%	
	0	0	3	10	18	**31**
The physical location(s) of Apprenticeship Program activities	0.0%	0.0%	9.7%	22.6%	67.7%	
	0	0	3	7	21	**31**
The variety of STEM topics available to you in the Apprenticeship Program	3.2%	12.9%	19.4%	19.4%	45.2%	
	1	4	6	6	14	**31**
Teaching or mentoring provided during Apprenticeship Program activities	0.0%	3.2%	9.7%	12.9%	74.2%	
	0	1	3	4	23	**31**
Amount of stipends (payment)	3.2%	0.0%	3.2%	19.4%	74.2%	
	1	0	1	6	23	**31**
Timeliness of payment of stipend	6.5%	12.9%	12.9%	9.7%	58.1%	
	2	4	4	3	18	**31**
Research abstract preparation requirements	0.0%	3.2%	16.1%	16.1%	64.5%	
	0	1	5	5	20	**31**

Since access to mentors is a key component of any apprenticeship program, apprentices were asked to report on the availability of their mentors. HSAP apprentices reported high levels of mentor availability with approximately three-quarters indicating their mentor was either available all or more than half of the time (Table 30).

Table 30. Apprentice Reports of Availability of Mentors (n=31)

Choice	Response Percent	Response Total
I did not have a mentor	0.00 %	0
The mentor was never available	0.00 %	0
The mentor was available less than half of the time	12.90 %	4

The mentor was available about half of the time of my project	9.68 %	3
The mentor was available more than half of the time	19.35 %	6
The mentor was always available	58.06 %	18

Apprentices were asked about their satisfaction with various features of their HSAP experience relating to their mentors and their research experiences (Table 31). The overall responses were very positive with 87% -100% reporting being somewhat or very much satisfied with all items in this section. For example, all apprentices (100%) were at least somewhat satisfied with their working relationship with their team or group, 97% were at least somewhat satisfied with their research experience overall, and 90% were at least somewhat satisfied with their working relationships with their mentors.

Table 31. Apprentice Satisfaction with Their Experience (n=31)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
My working relationship with my mentor	3.2%	0.0%	6.5%	16.1%	74.2%	
	1	0	2	5	23	**31**
My working relationship with the group or team	0.0%	0.0%	0.0%	6.5%	93.5%	
	0	0	0	2	29	**31**
The amount of time I spent doing meaningful research	0.0%	3.2%	6.5%	22.6%	67.7%	
	0	1	2	7	21	**31**
The amount of time I spent with my research mentor	3.2%	0.0%	9.7%	25.8%	61.3%	
	1	0	3	8	19	**31**
The research experience overall	0.0%	0.0%	3.2%	12.9%	83.9%	
	0	0	1	4	26	**31**

The questionnaire included open-ended items asking apprentices to comment about their satisfaction with their HSAP experiences. When asked about their overall satisfaction with HSAP, all 29 apprentices who provided a response had something positive to say. Comments focused on the value of the learning and career exposure apprentices had experienced and their experiences with their mentors. For example,

> *I am extremely satisfied with my experience with [HSAP]. I truly enjoyed doing engaging and extensive research in the field of thermodynamics. Working with my mentor and my peer collaborator was a great opportunity and I am happy to say that I have gained a lot of knowledge*

and many skills throughout my journey... I hope to participate in another AEOP program, such as URAP or CQL. (HSAP Apprentice)

My experience at [the lab] was the most in-depth learning experience I ever had. I was not only able to learn a variety of technical and communication skills, but also [was involved] in daily hands-on research. From testing minuscule pressure sensors in the lab, running simulations, processing data, and 3D design, I was constantly figuring out new things and enjoyed every second of it! This opportunity exposed me to the advanced world of optics and utilizing nanotechnology to enhance the quality of life. In addition, I am very impressed by every single hard-working researcher in our group. Each of them contributed to my learning experience and were always willing to address any questions I had. I am especially thankful for my mentor, who worked closely with every day and helped me discover all the theories behind our optical pressure sensor research project. He ensured that I always had the opportunity to involve myself in cutting-edge research and allowed me to make the most of my HSAP experience. I was exposed to areas of the engineering world, such as resonances, semiconductor fabrication process, and so much more, that I never knew existed. I am endlessly grateful for AEOP for this eye-opening opportunity, and I am confident that this experience will lead me to unimaginable paths and direct my future for the better [HSAP Apprentice]

I was scared going into the HSAP. I had no experience and no previous knowledge about an official work place going into the program. However, my mentor and those in my lab helped me to overcome the fear, become comfortable, and start to learn about everything. This apprenticeship encouraged me to keep pursuing my dream of being a chemical engineer, but also led me to want biochemistry as my minor. The experience and research was everything I could ask for, so I can't wait to apply to more apprenticeships/internships whether it be through AEOP or a different program in order to gain even more experience in the STEM field. I'm extremely satisfied and content with my decision to apply and do my best here, and can't wait to continue my STEM career. (HSAP Apprentice)

Five of the apprentices had positive comments but also offered some caveats. These caveats focused on timeliness of stipend payments and communication with the program and their mentors. For example,

Overall, I'm very satisfied with the Apprenticeship Program and my experience with it. I feel much more prepared for a career in STEM research than I was before this program…However there are a few things I wasn't entirely satisfied with. I wish my mentor had been clearer going in as to what he expected from me in terms of lab reports and background knowledge --I feel like I wasted a lot of time at the beginning of the program figuring out what resources to use to learn this stuff when I could have easily done that during the school year in preparation for the program. I felt like I didn't have a lot of direction from my mentor until the second half of the program, when things were really getting down to the wire: this was less because he didn't care, and more of he was

spread very thin across many projects which he cared a lot about. In addition, I was not paid until the last two weeks of my participation in the program. Fortunately for me, I had some savings to fall back on, but this could feasibly be an issue for future applicants who are relying on the stipends as a source of income for living. (HSAP Apprentice)

Apprentices were asked in both an open-ended questionnaire item and in interviews about the benefits of HSAP. When responding to the questionnaire items asking them to list three benefits of HSAP, the 31 apprentices who provided responses focused on the STEM learning and skills they experienced in HSAP (mentioned in 25 responses). Another 18 responses included comments about the benefit of the research experience, and 14 comments noted the benefit of the career information apprentices received.

Apprentices participating in interviews echoed these themes and commented on a variety of benefits including workplace skills and the opportunity to collaborate. For example,

I think the biggest benefit for sure would definitely be getting greater knowledge base in some areas that I was interested in. Just knowing what more careers and various subjects would be like, and getting to work with people who have such vast knowledge in the areas that I was interested in. (HSAP Apprentice)

The most valuable experience that I've gained is probably learning to work with other researchers. I was working on research projects, mostly independently with a little bit of collaboration with my mentor.
Throughout this program I've been working a lot more with other students of my age, and a little bit older. That probably was the most unique experience that I gained here. (HSAP Apprentice)

Apprentices were also asked to list three ways the program could be improved in the future. The 31 apprentices who responded offered a wide variety of improvements. The most frequently mentioned improvements included improvements to communication from the program such as information about program requirements (mentioned in 9 comments), ensuring the timeliness of stipend payments (mentioned in 7 comments), providing a larger choice of disciplinary areas or projects (mentioned in 6 comments), offering a longer program (mentioned in 5 comments), providing examples of abstracts, posters, and papers (mentioned in 5 comments), and providing more locations and including more students in HSAP (mentioned in 5 comments).

Mentors were also asked about their satisfaction with various HSAP program features (Table 32). Similar to the apprentice responses, large majorities of mentors were satisfied with features of HSAP, with 80% or more indicating they were at least somewhat satisfied with all features they had experienced (42% indicated they had not experienced communicating with AAS). Nearly all mentors were at least somewhat satisfied with communicating with ARO (96%) and the research abstract preparation requirements (92%), while 88% were at least somewhat satisfied with their communication with HSAP organizers and 83% with the support for instruction or mentorship. Few mentors indicated that they were "not at all"

satisfied with any HSAP features, although 3 mentors (12%) indicated that they were not satisfied with stipend payments.

Table 32. Mentor Satisfaction with HSAP Program Features (n=24)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Application or registration process	4.2%	4.2%	4.2%	33.3%	54.2%	
	1	1	1	8	13	**24**
Other administrative tasks (in-processing, network access, etc.)	12.5%	8.3%	0.0%	33.3%	45.8%	
	3	2	0	8	11	**24**
Communicating with Army Research Office (ARO)	0.0%	0.0%	4.2%	20.8%	75.0%	
	0	0	1	5	18	**24**
Communicating with HSAP organizers	8.3%	0.0%	4.2%	20.8%	66.7%	
	2	0	1	5	16	**24**
Support for instruction or mentorship during program activities	8.3%	0.0%	8.3%	25.0%	58.3%	
	2	0	2	6	14	**24**
Stipends (payment)	4.2%	12.5%	4.2%	8.3%	70.8%	
	1	3	1	2	17	**24**
Research abstract preparation requirements	0.0%	0.0%	8.3%	41.7%	50.0%	
	0	0	2	10	12	**24**
Communicating with Academy of Applied Science (AAS)	41.7%	4.2%	4.2%	12.5%	37.5%	
	10	1	1	3	9	**24**

Mentors also responded to an open-ended questionnaire item asking about their overall satisfaction with the program. Of the 16 mentors who provided a response, all had something positive to say, focusing on communication with the program, the positive impact on students, and their relationships with their apprentices. For example,

> *Absolutely phenomenal getting to work with someone in high school and watch them develop over the summer-- growing professionally and gaining interest in STEM through contributing to actual research. They blew away my expectations and we're hoping she applied again next year, as we would love to have her again.* (HSAP Mentor)

I am very happy with the three excellent HSAP students worked in my lab not only for the work they have done (two manuscripts in preparation with them as co-authors), but also their passions and hard works in learning. I could see the changes in them within this short 8 weeks of lab experience and all three will pursue STEM in college (Physics, Engineering and pre-med). (HSAP Mentor)

Overall, I was very pleased. The high school apprentices were smart, curious, and were a great fit with the college interns. Much collaborative learning happened across all levels from advanced college students to early-year college students to the high school apprentices. Everyone treated each other with respect and good teamwork occurred throughout the 2-month program. (HSAP Mentor)

One mentor responded positively, but added caveats focusing on streamlining administrative details, increasing program outreach, and providing more connections to DoD researchers:

Overall, I am very satisfied with the HSAP program. To improve the program, I would recommend that we conduct as many administrative opportunities for the program/surveys/other prior to program start so that the students can focus on conducting research. I don't know how, but [I] believe we need to do a better job of communicating to our local high schools about opportunities within this program, especially for minority and underrepresented students. Perhaps a webinar/opportunity to Skype with Army research professionals in their laboratories explaining some of the work that they do, or having videos available for the students to look at that would help motivate them for careers within DOD as well as STEM and research would be very helpful.

Mentors were asked to list three program strengths in another open-ended questionnaire item. The 19 mentors who responded focused on apprentices' research opportunities and laboratory experience (mentioned in 10 comments), the education and career information apprentices receive (mentioned in 7 comments), and the opportunity for apprentices to work in research teams (mentioned in 7 comments).

Mentors participating in interviews also noted that HSAP provides benefits for them personally and for their work. Mentor comments focused on the satisfaction associated with watching their apprentices grow and learn, the research assistance the apprentices provided in their labs, and the opportunities for their graduate students to act as mentors and gain teaching experience. For example,

I'm able to build a tiered system where everybody has a little bit of an engagement in the mentoring process. When you do that, it makes you think about what you're doing. You have to pay attention to how you're behaving because now you're a role model for somebody, etc. The value for our laboratory, in that sense, I think is probably the best part of the program. (HSAP Mentor)

Mentors were also asked in an open-ended questionnaire item to list three improvements for HSAP. The 18 mentors who responded provided a wide variety of suggestions for improvement. One of the most frequently mentioned improvements focused on communication from the program (mentioned in 5 comments), including communicating program requirements more effectively, communicating more with high schools, providing brochures designed especially for high school students, and providing apprentices with more information on DoD careers. Another 4 comments focused on providing apprentices with opportunities to present their research, 3 comments on improving administrative details (e.g., accepting students earlier, completing administrative work before the start of the apprenticeship, and providing mentors access to apprentices' application materials), and 3 comments focused on providing more opportunities for apprentices to interact with one another.

Findings from the Actionable Program Evaluation indicate that HSAP actively engages apprentices in authentic STEM experiences in ways not typically available to them in high school. Findings also indicate that mentors use a variety of evidence-based mentoring techniques, employing numerous strategies to enhance students' HSAP experiences. Both apprentices and mentors reported high levels of satisfaction with the program, and appreciated the unique opportunities for STEM learning in a laboratory setting that HSAP provides.

7

7 | Outcomes Evaluation

The evaluation of HSAP included measurement of several outcomes related to AEOP and program objectives, including impacts on apprentices' STEM knowledge and skills, STEM identities and confidence, interest in and intent for future STEM engagement, attitudes toward research, and knowledge of and interest in participating in additional AEOP opportunities.[6] STEM competencies include foundational knowledge, skills, and abilities in STEM, coupled with the confidence to apply them appropriately. These competencies are important not only for those engaging in STEM enterprises, but also for all members of society as critical consumers of information and effective decision makers in a world that is heavily reliant on STEM. The evaluation of HSAP included apprentices' self-reported gains in STEM competencies and engagement in opportunities intended to develop skills such as collaboration, teamwork, and communication that are considered to be critical STEM skills in the 21st century.

STEM Knowledge and Skills

Apprentices were asked to rate the impact HSAP had on various aspects of their STEM knowledge (Table 33). All students reported some level of gain in each area, and a large majority (90%-100%) reported medium or large gains in each area of their STEM knowledge. For example, all students reported medium or large gains in their in-depth knowledge of STEM topics and 97% in their knowledge of how scientists and engineers work

[6] 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.

on problems in STEM. These items were combined into a composite variable[7] to test for differential impacts across subgroups of apprentices. There were no significant differences in STEM knowledge impacts by gender or race/ethnicity.

Table 33. Apprentice Report of Impacts on STEM Knowledge (n=31)

	No gain	Small gain	Medium gain	Large gain	Response Total
In depth knowledge of a STEM topic(s)	0.0%	0.0%	35.5%	64.5%	
	0	0	11	20	**31**
Knowledge of research conducted in a STEM topic or field	0.0%	6.5%	19.4%	74.2%	
	0	2	6	23	**31**
Knowledge of research processes, ethics, and rules for conduct in STEM	0.0%	6.5%	35.5%	58.1%	
	0	2	11	18	**31**
Knowledge of how scientists and engineers work on real problems in STEM	0.0%	3.2%	22.6%	74.2%	
	0	1	7	23	**31**
Knowledge of what everyday research work is like in STEM	0.0%	9.7%	16.1%	74.2%	
	0	3	5	23	**31**

Apprentices were also asked to rate the impact of their HSAP experiences on their STEM competencies (Table 34). A majority of apprentices (60% - 90%) reported medium or large gains on all items. For example, 90% of apprentices reported medium or large gains in their ability to communicate about their experiments in different ways and 87% reported at least medium gains in identifying the strengths and limitations of data, interpretations, or arguments presented in technical or scientific texts. The STEM competencies Items were combined into a composite variable[8] to test for differential impacts across subgroups of apprentices. No significant differences were found between males and females, or between minority and non-minority apprentices in terms of HSAP impact on their STEM competencies.

[7]The Cronbach's alpha reliability for these 5 STEM Knowledge items was 0.885.

[8] The Cronbach's alpha reliability for these 10 STEM Competency items was 0.932.

Table 34. Apprentice Report of Gains in STEM Competencies (n=31)

	No gain	Small gain	Medium gain	Large gain	Response Total
Asking a question that can be answered with one or more scientific experiments	6.5% 2	16.1% 5	35.5% 11	41.9% 13	**31**
Using knowledge and creativity to suggest a testable explanation (hypothesis) for an observation	12.9% 4	12.9% 4	32.3% 10	41.9% 13	**31**
Considering different interpretations of data when deciding how the data answer a question	3.2% 1	22.6% 7	25.8% 8	48.4% 15	**31**
Supporting an explanation for an observation with data from experiments	6.5% 2	12.9% 4	25.8% 8	54.8% 17	**31**
Supporting an explanation with relevant scientific, mathematical, and/or engineering knowledge	6.5% 2	9.7% 3	38.7% 12	45.2% 14	**31**
Identifying the strengths and limitations of explanations in terms of how well they describe or predict observations	12.9% 4	9.7% 3	32.3% 10	45.2% 14	**31**
Defending an argument that conveys how an explanation best describes an observation	12.9% 4	25.8% 8	32.3% 10	29.0% 9	**31**
Identifying the strengths and limitations of data, interpretations, or arguments presented in technical or scientific texts	6.5% 2	6.5% 2	41.9% 13	45.2% 14	**31**
Integrating information from technical or scientific texts and other media to support your explanation of an observation	3.2% 1	9.7% 3	22.6% 7	64.5% 20	**31**
Communicating about your experiments and explanations in different ways (through talking, writing, graphics, or mathematics)	6.5% 2	3.2% 1	32.3% 10	58.1% 18	**31**

Apprentices were asked to rate the impact of HSAP on their "21st Century Skills" – those skills that are necessary across a wide variety of fields (Table 35). A large majority (87% - 97%) of apprentices reported

medium to large gains on all items associated with their 21st Century Skills. For example, 97% of apprentices reported medium or large gains in their ability to communicate effectively with others and 94% in setting goals and reflecting on performance and including others' perspectives when making decisions. The 21st Century Skills items were combined into a composite variable[9] to test for differential impacts across subgroups of apprentices. No significant differences were found in terms of 21st Century Skills by gender or race/ethnicity.

Table 35. Apprentice Report of Impacts on 21st Century Skills (n=31)

	No gain	Small gain	Medium gain	Large gain	Response Total
Learning to work independently	9.7%	3.2%	25.8%	61.3%	
	3	1	8	19	**31**
Setting goals and reflecting on performance	3.2%	3.2%	35.5%	58.1%	
	1	1	11	18	**31**
Sticking with a task until it is finished	3.2%	9.7%	19.4%	67.7%	
	1	3	6	21	**31**
Making changes when things do not go as planned	3.2%	9.7%	16.1%	71.0%	
	1	3	5	22	**31**
Working well with people from all backgrounds	3.2%	9.7%	12.9%	74.2%	
	1	3	4	23	**31**
Including others' perspectives when making decisions	3.2%	3.2%	22.6%	71.0%	
	1	1	7	22	**31**
Communicating effectively with others	3.2%	0.0%	29.0%	67.7%	
	1	0	9	21	**31**
Viewing failure as an opportunity to learn	3.2%	9.7%	16.1%	71.0%	
	1	3	5	22	**31**

21st Century Skills Assessment

A new component of the HSAP evaluation in FY17 was a pilot of the 21st Century Skills Assessment (Johnson & Sondergeld, 2016). Mentors assessed each participant in a pre/post manner. The first

[9] The Cronbach's alpha reliability for these 8 21st Century Skills items was 0.923.

assessment was completed in the first days of the program (pre). 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 Unite program. The assessment tool can be found in the Appendix (Section 3 of this report). 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 in the pilot to assess their participants in each of the domains that they felt applied to the work apprentices had completed with them over the course of the program. As a result, between 4 and 19 apprentices were assessed for 24 skills related to each of the six areas. Table 36 presents an overall summary of the findings for each of the six domains of 21st Century Skills. These are presented graphically in Figure 1. Table 37 presents findings for each of the 24 specific skills associated with the six areas of 21st Century Skills.

Significant skills increase occurred from pre-post (p<.05) in all skill sets except for Communication, Collaboration, Social, and Cross-Cultural skills which had a higher than average baseline at the pre-observation (see Table 37). All other skill sets had similar levels of growth (0.31-0.35). Figure 1 shows that, on average, students were rated slightly above the Progressing level at the beginning of their apprenticeships and increased to an approaching Demonstrates Mastery level (approximately 2.50) or higher by the end of their program.

Table 36. Overall 21st Century Skill Set Assessment Pre-Post Results

Skill Set	*n*	Observation Time		Pre-Post Change	*t*-stat
		Pre - *M*(*SD*)	Post - *M*(*SD*)		
Creativity & Innovation	19	2.22(.47)	2.53(.49)	+0.31	1.83*
Critical Thinking & Problem Solving	19	2.21(.42)	2.56(.43)	+0.35	2.71**
Communication, Collaboration, Social, & Cross-Cultural	19	2.37(.55)	2.61(.39)	+0.25	1.63
Information, Media, & Technological Literacy	19	2.27(.48)	2.62(.37)	+0.35	2.50*
Flexibility, Adaptability, Initiative, & Self-Direction	19	2.26(.46)	2.62(.34)	+0.35	2.75**
Productivity, Accountability, Leadership, & Responsibility	18	2.13(.54)	2.44(.45)	+0.31	1.93*

NOTE. Statistical significance levels for one-tailed tests provided in table by asterisks with *p<.05, **p<.01, ***p<.001

Figure 1. 21st Century Skills Assessment Pre-Post Comparison with Criteria Indicators

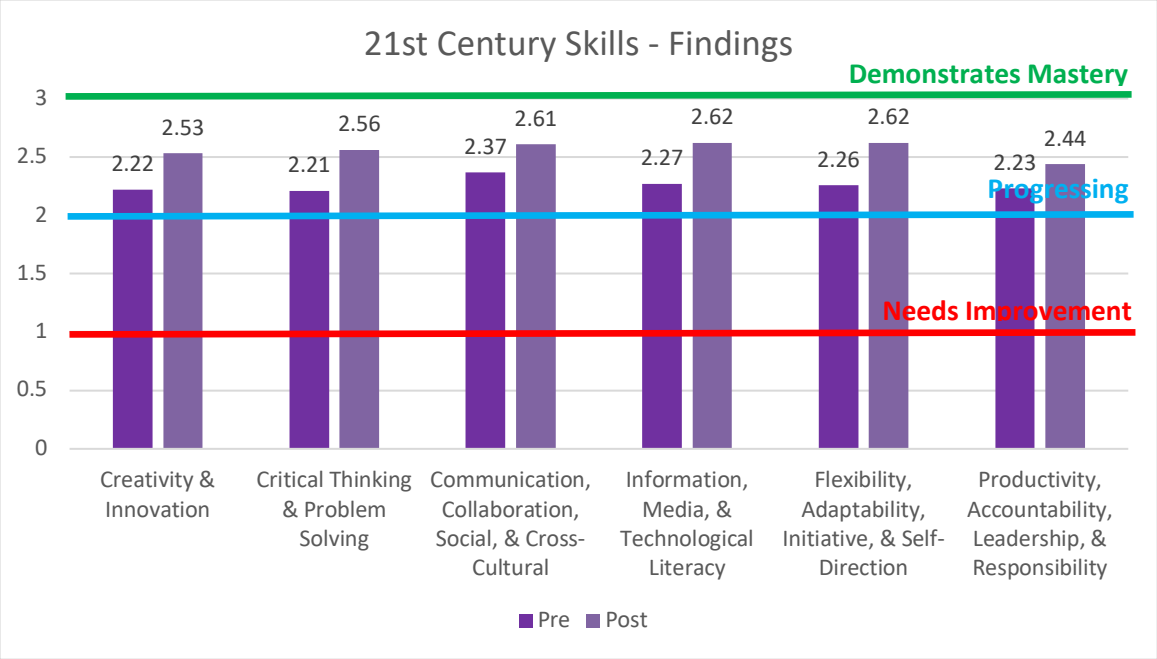


Table 37 shows findings from specific skills associated with overall skill sets. All 24 specific skills observed increased from pre-post observation (100%). Approximately half (54%) of the 24 specific skills observed showed significant increases from pre-post observation. The 21st Century Skills areas with greatest improvement over time were associated with independence – being a self-directed learner, managing goals/time, and making judgments/decisions.

Table 37. Overall 21st Century Skill Set Observation Pre-Post Results

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	19	2.16(.50)	2.42(.51)	+0.26	1.76*
Work creatively with others	18	2.22(.65)	2.67(.49)	+0.44	2.05*
Implement innovations	15	2.27(.46)	2.60(.63)	+0.33	1.58
Critical Thinking & Problem Solving					
Reason effectively	18	2.33(.49)	2.67(.59)	+0.33	1.84*
Use systems thinking	12	2.25(.62)	2.50(.67)	+0.25	1.00
Make judgments and decisions	18	2.11(.47)	2.56(.51)	+0.44	3.06**
Solve problems	17	2.24(.66)	2.59(.51)	+0.35	1.69
Communication, Collaboration, Social, & Cross-Cultural					
Communicate clearly	19	2.42(.61)	2.68(.48)	+0.26	2.42
Communicate with others	16	2.25(.77)	2.56(.51)	+0.31	1.32

Interact effectively with others	17	2.29(.47)	2.64(.49)	+0.35	2.40*
Information, Media, & Technological Literacy					
Access and evaluate information	18	2.06(.73)	2.50(.51)	+0.44	2.41*
Use and manage information	17	2.18(.53)	2.59(.51)	+0.41	2.14*
Analyze media	9	2.22(.44)	2.78(.44)	+0.56	2.29*
Create media products	4	2.25(.50)	2.75(.50)	+0.50	1.73
Apply technology effectively	18	2.56(.51)	2.61(.50)	+0.06	0.37
Flexibility, Adaptability, Initiative, & Self-Direction					
Adapt to change	11	2.27(.47)	2.64(.50)	+0.36	1.79*
Be flexible	15	2.33(.62)	2.47(.52)	+0.13	0.62
Manage goals and time	17	2.29(.47)	2.82(.39)	+0.53	3.50**
Work independently	16	2.31(.48)	2.63(.50)	+0.31	1.78*
Be a self-directed learner	16	1.94(.68)	2.50(.52)	+0.56	3.09**
Productivity, Accountability, Leadership, & Responsibility					
Manage projects	14	2.07(.62)	2.43(.51)	+0.36	1.59
Produce results	12	2.33(.49)	2.67(.49)	+0.33	2.35*
Guide and lead others	11	1.91(.70)	2.18(.60)	+0.27	1.15
Be responsible to others	15	2.27(.46)	2.40(.63)	+0.13	0.56

NOTE. Statistical significance levels for one-tailed tests provided in table by asterisks with *$p<.05$, **$p<.01$, ***$p<.001$

STEM Identity and Confidence

Since STEM identity, or seeing oneself as capable of succeeding in STEM, has been linked to future interest and participation in STEM as a field of study and career choice,[10] HSAP and other programs in the AEOP portfolio emphasize supporting participants' STEM identities. Because of this, the apprentice survey included a series of items intended to measure HSAP's impact on apprentices' STEM identities and confidence (Table 38). Apprentices reported that HSAP had positive impacts in all areas of STEM identity with 84% - 97% of apprentices reporting medium to large gains on all STEM identity items. For example, nearly all apprentices (97%) reported medium or large gains in their desire to build relationships with mentors in STEM, and 94% reported similar gains in their decisions on a path to pursue a career in STEM.

Table 38. Apprentice Report of Impacts on STEM Identity (n=31)

	No gain	Small gain	Medium gain	Large gain	Response Total

[10] 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.

Interest in a new STEM topic	3.2%	6.5%	35.5%	54.8%	
	1	2	11	17	**31**
Deciding on a path to pursue a STEM career	3.2%	3.2%	48.4%	45.2%	
	1	1	15	14	**31**
Sense of accomplishing something in STEM	0.0%	12.9%	22.6%	64.5%	
	0	4	7	20	**31**
Feeling prepared for more challenging STEM activities	0.0%	9.7%	16.1%	74.2%	
	0	3	5	23	**31**
Confidence to try out new ideas or procedures on my own in a STEM	6.5%	9.7%	16.1%	67.7%	
	2	3	5	21	**31**
Patience for the slow pace of STEM research	6.5%	9.7%	25.8%	58.1%	
	2	3	8	18	**31**
Desire to build relationships with mentors who work in STEM	0.0%	3.2%	22.6%	74.2%	
	0	1	7	23	**31**
Connecting a STEM topic or field to my personal values	3.2%	9.7%	22.6%	64.5%	
	1	3	7	20	**31**

A composite variable was created from the STEM Identity items,[11] and there were no significant differences in impact based on gender or on race/ethnicity.

Interest and Future Engagement in STEM

Another key goal of the AEOP is to develop a STEM-literate citizenry. In order to examine the impact of HSAP on apprentices' interest in future engagement in STEM, the questionnaire asked them to reflect on whether the likelihood of their engaging in STEM activities outside of typical school activities changed as a result of their HSAP experiences (Table 39). More than half of apprentices reported being more likely or much more likely to engage in all activities listed as a result of their participation in HSAP. Apprentices reported being particularly more likely to work on a STEM project or experiment at a university/professional setting (90%) after participating in HSAP. A composite score was created from these items,[12] and no statistically significant differences were found by gender or race/ethnicity in terms of future engagement in STEM.

[11] The Cronbach's alpha reliability for these 8 STEM Identity items was 0.883.
[12] These 10 Likelihood to Engage items had a Cronbach's alpha reliability of 0.833.

In order to further understand how HSAP influenced apprentices' intentions to engage in STEM in the future, they were also asked to report on how interested they were in participating in AEOPs in the future (Table 40). More than half reported being interested in URAP (74% somewhat or very much interested) and SMART (52% somewhat or very much interested). Nearly half or more reported having never heard of AEOPs such as CQL (65%), GEMS Near Peer Mentors (52%), and the NDSEG Fellowship (48%).

Apprentices were also asked to rate the impact of various resources on their awareness of AEOPs (Table 41) in order to understand which resources are most effective in informing participants about AEOPs. Apprentice reports about the impact of HSAP and AEOP resources on their awareness of AEOPs (somewhat or very much impactful) was variable. For example, 91% reported that participating in HSAP was at least somewhat impactful and 74% that their mentors were at least a little impactful on their awareness of AEOPs. Less than half of apprentices (42%) rated the AEOP brochure as at least somewhat useful, and only 3% reported that AEOP on social media was at least somewhat useful. More than half of apprentices (68%) reported not having experienced AEOP on social media, 39% had not experienced the AEOP brochure, and 33% had not experienced presentations or information shared through the apprenticeship program.

Table 39. Change in Likelihood Apprentices Will Engage in STEM Activities Outside of School (n=31)

	Much less likely	Less likely	About the same before and after	More likely	Much more likely	Response Total
Watch or read non-fiction STEM	0.0%	0.0%	45.2%	25.8%	29.0%	
	0	0	14	8	9	**31**
Tinker (play) with a mechanical or electrical device	0.0%	3.2%	41.9%	35.5%	19.4%	
	0	1	13	11	6	**31**
Work on solving mathematical or scientific puzzles	0.0%	0.0%	45.2%	25.8%	29.0%	
	0	0	14	8	9	**31**
Use a computer to design or program something	0.0%	3.2%	16.1%	38.7%	41.9%	
	0	1	5	12	13	**31**
Talk with friends or family about STEM	0.0%	0.0%	22.6%	29.0%	48.4%	
	0	0	7	9	15	**31**
	0.0%	3.2%	29.0%	35.5%	32.3%	

Mentor or teach other students about STEM	0	1	9	11	10	**31**
Help with a community service project related to STEM	0.0%	0.0%	22.6%	35.5%	41.9%	
	0	0	7	11	13	**31**
Participate in a STEM camp, club, or competition	0.0%	0.0%	25.8%	45.2%	29.0%	
	0	0	8	14	9	**31**
Take an elective (not required) STEM class	0.0%	0.0%	35.5%	19.4%	45.2%	
	0	0	11	6	14	**31**
Work on a STEM project or experiment in a university or professional setting	0.0%	0.0%	9.7%	25.8%	64.5%	
	0	0	3	8	20	**31**

Table 40. Apprentice Interest in Future AEOP Programs (n=31)

	I've never heard of this program	Not at all	A little	Somewhat	Very much	Response Total
College - College Qualified Leaders (CQL)	64.5%	6.5%	9.7%	6.5%	12.9%	
	20	2	3	2	4	**31**
College - Undergraduate Research Apprenticeship Program (URAP)	9.7%	3.2%	12.9%	19.4%	54.8%	
	3	1	4	6	17	**31**
College - Science Mathematics, and Research for Transformation (SMART) College Scholarship	38.7%	3.2%	6.5%	22.6%	29.0%	
	12	1	2	7	9	**31**
College - National Defense Science & Engineering Graduate (NDSEG) Fellowship	48.4%	9.7%	16.1%	6.5%	19.4%	
	15	3	5	2	6	**31**
High School and College - GEMS Near Peer Mentor Program	51.6%	9.7%	9.7%	6.5%	22.6%	
	16	3	3	2	7	**31**

Table 41. Impact of Resources on Apprentice Awareness of AEOPs (n=31)

	Did not experience	Not at all	A little	Somewhat	Very much	Response Total
Army Educational Outreach Program (AEOP) website	6.5%	3.2%	32.3%	19.4%	38.7%	
	2	1	10	6	12	**31**
AEOP on Facebook, Twitter, Pinterest or other social media	67.7%	16.1%	12.9%	3.2%	0.0%	
	21	5	4	1	0	**31**
AEOP brochure	29.0%	9.7%	19.4%	22.6%	19.4%	
	9	3	6	7	6	**31**
My Apprenticeship Mentor	0.0%	9.7%	16.1%	12.9%	61.3%	
	0	3	5	4	19	**31**
Presentations or information shared through the Apprenticeship Program	25.8%	6.5%	16.1%	25.8%	25.8%	
	8	2	5	8	8	**31**
Participation in the Apprenticeship Program	6.5%	3.2%	6.5%	19.4%	64.5%	
	2	1	2	6	20	**31**

Attitudes toward DoD Research

Apprentice attitudes about the importance of DoD research are an important prerequisite to their continued interest in the field and potential involvement in the future. In order to gauge apprentices' attitudes in this area, the apprentice questionnaire asked apprentices about their opinions of what DoD researchers do and the value of DoD research (Table 42). No apprentices disagreed with any of the items, and a large majority agreed or strongly agreed with all statements. For example, 97% of apprentices agreed or strongly agreed that DoD researchers advance science and engineering fields and that DoD researchers develop new, cutting edge technologies.

Table 42. Apprentice Opinions of DoD Researchers and Research (n=31)

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Response Total
DoD researchers advance science and engineering fields	0.0%	0.0%	3.2%	41.9%	54.8%	
	0	0	1	13	17	**31**

DoD researchers develop new, cutting edge technologies	0.0%	0.0%	3.2%	48.4%	48.4%	
	0	0	1	15	15	**31**
DoD researchers solve real-world problems	0.0%	0.0%	6.5%	35.5%	58.1%	
	0	0	2	11	18	**31**
DoD research is valuable to society	0.0%	0.0%	6.5%	38.7%	54.8%	
	0	0	2	12	17	**31**

Education and Career Aspirations

To determine the impact of HSAP on apprentice educational aspirations, apprentices were asked to report on their aspirations after participating in HSAP (Table 43). All but one apprentice (97%) reported they aspired to, at a minimum, finish college (get a Bachelor's degree). And a large majority (84%) reported they aspired to obtain some sort of advanced degree (Master's or higher).

Table 43. Apprentice Education Aspirations After HSAP (n=31)

Choice	Response Percent	Response Total
Go to a trade or vocational school	0.00 %	0
Go to college for a little while	3.23 %	1
Finish college (get a Bachelor's degree)	6.45 %	2
Get more education after college	6.45 %	2
Get a master's degree	35.48 %	11
Get a Ph.D.	38.71 %	12
Get a medical-related degree (M.D.), veterinary degree (D.V.M), or dental degree (D.D.S)	0.00 %	0
Get a combined M.D. / Ph.D.	6.45 %	2
Get another professional degree (law, business, etc.)	3.23 %	1

Overall Impact

Finally, apprentices were asked to report on the overall impacts of participating in HSAP (Table 45). Over two-thirds of apprentices (74% - 100%) reported that HSAP impacted them in each area listed. For example, all or nearly all apprentices agreed that HSAP impacted their confidence in STEM

knowledge, skills, and abilities (100%), their appreciation and awareness of DoD STEM research (97%), and their awareness of and interest in other AEOPs (97%). These items were combined into a composite variable[13] to test for differences among subgroups of students; no significant differences were found by gender or race/ethnicity.

Table 45. Apprentice Opinions of HSAP Impacts (n=31)

	Disagree - This did not happen	Disagree - This happened but not because of HSAP	Agree - HSAP contributed	Agree - HSAP was primary reason	Response Total
I am more confident in my STEM knowledge, skills, and abilities	0.0% 0	0.0% 0	54.8% 17	45.2% 14	31
I am more interested in participating in STEM activities outside of school requirements	0.0% 0	9.7% 3	64.5% 20	25.8% 8	31
I am more aware of other AEOPs	3.2% 1	0.0% 0	35.5% 11	61.3% 19	31
I am more interested in participating in other AEOPs	0.0% 0	3.2% 1	45.2% 14	51.6% 16	31
I am more interested in taking STEM classes in school	0.0% 0	25.8% 8	58.1% 18	16.1% 5	31
I am more interested in earning a STEM degree	0.0% 0	19.4% 6	64.5% 20	16.1% 5	31
I am more interested in pursuing a career in STEM	0.0% 0	19.4% 6	64.5% 20	16.1% 5	31
I am more aware of Army or DoD STEM research and careers	3.2% 1	0.0% 0	48.4% 15	48.4% 15	31

[13] The Cronbach's alpha reliability for the 10 Overall Impact items was 0.809.

I have a greater appreciation of Army or DoD STEM research	3.2%	0.0%	41.9%	54.8%	
	1	0	13	17	31
I am more interested in pursuing a STEM career with the Army or DoD	16.1%	16.1%	45.2%	22.6%	
	5	5	14	7	31

Findings from the outcomes evaluation indicate that HSAP apprentices experienced growth in their STEM knowledge and skills as a result of participating in HSAP and were positively impacted by their apprenticeship experiences in a variety of ways. Apprentices reported gains in their 21st Century Skills as a result of HSAP, and mentors also observed gains in these skill sets over the course of apprentices' HSAP experiences. Moreover, apprentices grew in terms of their STEM identities and confidence as a result of participating in HSAP and reported increased likelihood of participating in a number of STEM-related activities after their apprenticeships. Although many apprentices had not heard of other AEOPs, they reported being interested in participating in AEOPs in the future. Apprentices had positive opinions about DoD research and researchers and overall had educational aspirations that would prepare them for STEM careers in the future.

8 | Findings and Recommendations

Summary of Findings

The 2017 evaluation of HSAP collected data about participants; participants' perceptions of program processes, resources, and activities; and indicators of achievement in outcomes related to AEOP and program objectives. A summary of findings is provided in Table 46.

Table 46. 2017 HSAP Evaluation Findings

Participant Profiles	
HSAP continues to receive increasing numbers of applications, however enrollment in 2017 declined and failed to meet program objectives.	The increasing number of applications HSAP has received over the past 3 years (267 in FY15; 363 in FY16; and 629 in FY17) suggests that the program has been successful in its outreach to high schools.
	A total of 54 apprentices participated in 2017. This is a decrease of 20% compared to 2016 when 65 apprentices were enrolled. Enrollment failed to meet the program's 2017 goal of 70 apprentices.
HSAP continues to serve students from groups traditionally underrepresented and underserved in STEM.	Over half of apprentices (60%) were female, a group underrepresented in some STEM fields. This represents an increase in participation of females compared to 2016 when only 49% of participants were female.
	HSAP served students from a variety of races and ethnicities, although the most commonly reported races/ethnicities were White (42%) and Asian (25%) (not groups traditionally underrepresented and underserved), a slight increase compared to 2016 when 37% of apprentices were White and 20% were Asian.
	Twenty of the 36 HSAP sites were Historically Black Colleges and Universities or Minority Serving Institutions (HBCU/MIs). As in 2016, 15% of apprentices identified themselves as Black or African American, a group traditionally underserved and underrepresented in STEM. A slightly smaller percentage of apprentices (14%) identified as Hispanic or Latino (also a group traditionally underserved and underrepresented in STEM) than in 2016 (18%).
	A small percentage (17%) of apprentices reported that they receive free or reduced-price school lunches, a commonly used indicator of low-income status. Three-quarters (75%) reported that they do not receive free or reduced-price school lunches.

Actionable Program Evaluation	
HSAP apprentices learned about AEOP most frequently through their schools and through personal contacts, and were motivated to participate by the learning opportunities	The most common sources of information about AEOP were related to apprentices' schools and personal contacts. School sources of information included school or university newsletters, emails, or websites (38%) and someone who works at the school or university apprentices attend (34%). Nearly half of participants (48%) reported learning about AEOP through personal contacts (past participant – 17%; friend – 17%; or family member – 14%).
	The most frequently reported motivators for apprentices to participate in HSAP were related to learning opportunities, including the desire to learn something new or interesting (100%), interest in STEM (100%), and desire to expand laboratory skills (93%). Likewise, 86% of students reported that they were motivated by the opportunity to learn in ways not possible in school and 86% by the opportunity to use advanced laboratory technology.
HSAP apprentices learned about STEM careers both in general and to a lesser extent within the DoD, during their apprenticeships.	More than half (61%) of apprentices reported learning about three or more STEM jobs and careers in general and almost all (91%) reported learning about at least one. Fewer apprentices reported learning about STEM jobs and careers within the DoD, with 42% of responding apprentices reporting learning about three or more and 71% reporting learning about at least one. Over a quarter (29%) of apprentices had not learned about any DoD STEM jobs and careers.
	Apprentices identified a variety of resources that impacted their learning about DoD STEM careers. Most (81%) reported that simply participating in HSAP was at least somewhat impactful. Over two-thirds (65%) of apprentices indicated their mentors and the AEOP website were at least somewhat useful for impacting their awareness of DoD STEM careers. Most (71%) had not experienced AEOP on social media and over a quarter (26%) had not experienced the AEOP brochure.
	All mentors reported that participation in HSAP was either somewhat or very much useful for apprentices' awareness of DoD STEM careers. Similarly, the HSAP site coordinator (83%) and AEOP website (79%) were reported to be at least somewhat useful for exposing apprentices to DoD STEM careers. Many mentors had not experienced resources such as AEOP on social media (63%) and invited speakers (49%).
	All but 1 apprentice (97%) reported that HSAP positively impacted their awareness of DoD STEM research and careers.
HSAP apprentices engaged in a variety of STEM practices on a regular basis during their apprenticeships and reported	Approximately half or more of apprentices reported engaging in all STEM practices about which they were asked either weekly or daily while in HSAP. For example, 97% reported interacting with STEM researchers weekly or daily, 90% reported working with a STEM researcher on a real-world STEM

significantly higher levels of engagement in these practices in HSAP as compared to their typical school experiences.	problem weekly or daily, and 90% reported working collaboratively as part of a team weekly or daily.
	In order to understand how the HSAP experience compared with apprentices' typical school experiences, apprentices were asked how frequently they engaged in the same activities in school. Apprentices reported significantly higher STEM engagement in HSAP as compared to in school (effect size is large with d = 2.07).
HSAP mentors were accessible to students and used strategies associated with all areas of effective mentoring	HSAP apprentices reported high levels of mentor availability with approximately three-quarters indicating their mentor was either available all or more than half of the time. No apprentices reported not having access to their mentor.
	Large majorities of mentors (79% - 96%) reported using each strategy associated with establishing the relevance of learning activities. For example, nearly all (96%) reported becoming familiar with student backgrounds and interests, giving student real-life problems to investigate, and encouraging students to suggest new readings, activities, or projects.
	Most mentors (67% - 100%) reported using each strategy associated with supporting the diverse needs of students as learners. For example, all mentors reported using a variety of teaching and/or mentoring activities to meet the needs of students, and nearly all (96%) reported identifying students' learning styles at the start of HSAP.
	Large majorities of mentors (88% - 100%) reported using each strategy associated with supporting student development of collaboration and interpersonal skills. For example, all mentors reported listening to students with an open mind, having students exchange ideas with others whose backgrounds or viewpoints are different from their own, and having students work on collaborative activities as a member of a team.
	Large majorities of mentors (83%-100%) reported using each strategy associated with supporting student engagement in authentic STEM activities. For example, all mentors reported supervising their students while they practiced STEM research skills. Nearly all (96%) encouraged students to work collaboratively and demonstrated laboratory/field techniques, procedures, and tools for students.
	Most mentors (67% - 92%) reported using each strategy associated with supporting students' STEM educational and career pathways. For example, 67% of mentors reported recommending extracurricular programs that align with students' goals, 79% discussed STEM career opportunities with the DoD or other government agencies, 83% recommended AEOPs that aligned with students' goals, and 92% discussed STEM career opportunities in private industry or academia.

Apprentices and mentors reported high levels of satisfaction with their HSAP experiences and offered a variety of suggestions for program improvement.	Apprentices reported high levels of satisfaction with HSAP program features, with two-thirds or more reporting being somewhat or very much satisfied with all program features about which they were asked. For example, large majorities of apprentices were somewhat or very much satisfied with the amount of stipend pay (93%), communication with host site organizers (90%), and physical locations of program activities (90%). Few apprentices expressed dissatisfaction with any program features, although 4 apprentices (13%) reported being "not at all" satisfied with the variety of STEM topics available to them and 4 apprentices (13%) were not satisfied with the timeliness of stipend payments.
	Apprentices were satisfied with features of their HSAP experience relating to their mentors and their research experiences (87% - 100% somewhat or very much satisfied with all items). For example, all apprentices (100%) were at least somewhat satisfied with their working relationship with their team or group, 97% were at least somewhat satisfied with their research experience overall, and 90% were at least somewhat satisfied with their working relationships with their mentors.
	Apprentices' most frequently mentioned areas of improvements included improvements to communication from the program (e.g. information about program requirements); ensuring the timeliness of stipend payments; providing a larger choice of disciplinary areas or projects; offering a longer program; providing examples of abstracts, posters, and papers; and expanding HSAP to provide more locations and include more students.
	Large majorities of mentors were satisfied with features of HSAP, with 79% or more indicating they were at least somewhat satisfied with all features they had experienced. For example, nearly all mentors were at least somewhat satisfied with communicating with ARO (96%) and the research abstract preparation requirements (92%), while 88% were at least somewhat satisfied with their communication with HSAP organizers and 83% with the support for instruction or mentorship.
	Mentors offered a variety of suggestions for program improvement. One of the most frequently mentioned improvements focused on communication from the program, including communicating program requirements more effectively, communicating more with high schools, providing brochures designed especially for high school students, and providing apprentices with more information on DoD careers. Mentors also encouraged the program to provide apprentices with opportunities to present their research, to streamline or improve administrative details (e.g., accepting students earlier, completing administrative work before the start of the apprenticeship, and providing mentors access to apprentices' application materials), and to provide more opportunities for apprentices to interact with one another.
Outcomes Evaluation	

HSAP had a positive impact on apprentices' STEM knowledge and competencies	All students reported some level of gain in each area of STEM knowledge, and a large majority (90%-100%) reported medium or large gains in each area of their STEM knowledge. For example, all students reported medium or large gains in their in-depth knowledge of STEM topics and 97% in their knowledge of how scientists and engineers work on problems in STEM.
	A majority of apprentices (60% - 90%) reported medium or large gains on all items related to their STEM competencies. For example, 90% of apprentices reported medium or large gains in their ability to communicate about their experiments in different ways and 87% reported at least medium gains in identifying the strengths and limitations of data, interpretations, or arguments presented in technical or scientific texts.
Apprentices demonstrated observable gains in their 21st Century Skills during their HSAP experiences and self-reported growth in these skills.	HSAP apprentices demonstrated significant gains in their 21st Century Skills on the four-point scale as assessed by their mentors in the domains of Creativity & Innovation (0.31 gain), Critical Thinking and Problem Solving (0.35 gain), Flexibility, Adaptability, Initiative, & Self-Direction (0.35 gain), and Productivity, Accountability, Leadership, & Responsibility (0.31 gain).
	A large majority (87% - 97%) of apprentices reported medium to large gains on all items associated with their 21st Century Skills. For example, 97% of apprentices reported medium or large gains in their ability to communicate effectively with others and 94% in setting goals and reflecting on performance and including others' perspectives when making decisions.
HSAP apprentices experienced growth in their STEM identities and confidence as a result of their apprenticeship experiences.	Apprentices reported that HSAP had positive impacts in all areas of STEM identity with 84% - 97% of apprentices reporting medium to large gains on all STEM identity items. For example, nearly all apprentices (97%) reported medium or large gains in their desire to build relationships with mentors in STEM, and 94% reported similar gains in their decisions on a path to pursue a career in STEM.
	All apprentices (100%) credited HSAP with their increased confidence in their STEM knowledge, skills, and abilities.
HSAP apprentices were more likely to engage in STEM activities outside of regular school activities as a result of their apprenticeship experiences.	A large majority of apprentices (91%) reported that participating in HSAP contributed to their interested in participating in STEM activities outside of school.
	More than half of apprentices reported being more likely or much more likely to engage in all activities about which they were asked as a result of their participation in HSAP. Apprentices reported being particularly more likely to work on a STEM project or experiment at a university/professional setting (90%), and over three –quarters (77%) were more likely to talk with family or friends about STEM after participating in HSAP.
HSAP apprentices expressed increased interest in participating in other AEOPs	Nearly all (97%) of apprentices indicated that they were more aware of other AEOPs as a result of HSAP and credited HSAP with their increased interest in participating in AEOPs in the future. More than half of apprentices reported

in the future, although many had not heard of AEOPs for which they currently are or will soon be eligible.	being interested in URAP (74% somewhat or very much interested) and SMART (52% somewhat or very much interested).
	Substantial proportions of apprentices reported having never heard of AEOPs such as CQL (65%), GEMS Near Peer Mentors (52%), and the NDSEG Fellowship (48%).
HSAP participation and mentors were the most impactful resources for apprentices to learn about AEOPs, however few mentors discussed specific AEOPs with their apprentices.	Apprentice reports about the impact of HSAP and AEOP resources on their awareness of AEOPs (somewhat or very much impactful) was variable. For example, 91% reported that participating in HSAP was at least somewhat impactful and 74% that their mentors were at least a little impactful on their awareness of AEOPs. Less than half of apprentices (42%) rated the AEOP brochure as at least somewhat useful, and only 3% reported that AEOP on social media was at least somewhat useful.
	More than half of apprentices (68%) reported not having experienced AEOP on social media, 39% had not experienced the AEOP brochure, and 33% had not experienced presentations or information shared through the apprenticeship program.
	All mentors reported that participation in HSAP was either somewhat or very much useful for informing apprentices about AEOPs. Mentors also reported that the HSAP program administrator or site coordinator (92%) and AEOP website (83%) were at least somewhat useful for informing apprentices about AEOPs.
	Half of mentors reported having discussed AEOP generally with their apprentices, but without reference to any specific programs. The most frequently discussed programs were HSAP (67%) and URAP (50%). A third of mentors (33%) discussed REAP with their apprentices, and a quarter (25%) discussed SMART. It is noteworthy, however that most mentors did not discuss other programs such as JSHS (88%), SEAP (88%), and CQL (92%), for which apprentices are or will soon be eligible.
HSAP apprentices had positive opinions about DoD research and DoD researchers.	All but 1 apprentice (97%) reported being more aware of and having a greater appreciation for Army or DoD STEM research as a result of participating in HSAP.
	A large majority of apprentices (94% - 97%) agreed or strongly agreed with a series of statements about DoD research and researchers. For example, 97% of apprentices agreed or strongly agreed that DoD researchers advance science and engineering fields and that DoD researchers develop new, cutting edge technologies.
HSAP positively impacted apprentices' STEM	After participating in HSAP, all but one apprentice (97%) reported they aspired to, at a minimum, finish college (get a Bachelor's degree). And a large majority (84%) reported they aspired to obtain some sort of advanced degree (Master's or higher).

educational and career aspirations.	Over three-quarters of apprentices (81%) reported being more interested earning a STEM degree and in pursuing a career in STEM as a result of participating in HSAP. Over two-thirds (68%) of apprentices were more interested in pursuing a STEM career with the Army or DoD as a result of participating in HSAP.

Responsiveness to FY17 Evaluation Recommendations

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

FY16 Finding: AEOP objectives include expanding participation of historically underrepresented and underserved populations. Between 2014 and 2016, HSAP has engaged more apprentices who identify with a typically underrepresented group in STEM, which is a positive trend. Additionally, it is positive that the HBCU/MI sites increased from 2 in 2014 to 7 in 2015 to 16 in 2016. HSAP should explore how to accommodate more participants in coming years – as the 18% placement rate indicates a much larger interest and need than is currently being accommodated.

HSAP FY17 Efforts and Outcomes: ARO and AAS identified and targeted nearby high schools and organizations that have traditionally underserved and underrepresented populations in STEM, then directly sent emails advertising the HSAP program to those locations. The Total Title I School participation for HSAP in FY16 was 17%, in FY17 it increased to 28%. The HBCU/MSI in FY16 was 52% for HSAP and there was an increase to 56% for HSAP in FY17.

FY16 Finding: Similar to past years in HSAP, recruitment of apprentices is largely accomplished with personal interactions, either by knowing someone at the university or someone who works at HSAP. As a result, the ability of HSAP to recruit underserved or underrepresented populations of students depends upon the diversity of the high schools in which recruitment takes place. Thus, HSAP may want to emphasize recruiting a more diverse pool of mentors and apprentices, perhaps specifically targeting more urban schools or schools who receive Title 1 funding. AAS and ARO should work with AEOP SOI awardees and identify possible overlaps where we can leverage our strategic outreach partners' reach and network A focused and strategic plan to engage a more diverse pool of apprentices could ultimately improve the diversity of the STEM pipeline, based on the large impact that HSAP has on STEM knowledge, skills, and identity.

HSAP FY17 Efforts and Outcomes: Although HBCU/MSI and Title I school participation increased in FY17, diversity among students continues to be low. It is anticipated that diversity among students will continue to increase as the current approach to reach out to Title I high schools and HBCU/MSI has proven successful.

FY16 Finding: HSAP is very effective in offering apprentices authentic opportunities to engage in STEM professional activities, and for mentors to build the next generation of STEM professionals. Mentors are particularly skilled in being able to engage high school students in their laboratory by giving them meaningful learning experiences and asking them to report on their work to graduate students and STEM professionals. Most of the apprentices had not heard of the range of AEOP programs (78% had not hear of UNITE, 86% had not heard of CQL, and 79% had not heard of GEMS Near Peer). Although mentors are particularly skilled in their area of expertise, mentors should be better prepared by the program to provide information and resources on the array of AEOP opportunities. AAS/ARO should work with the Battelle and the CAM to develop materials and training/onboarding that could be used with mentors each year to target this area of need.

HSAP FY17 Efforts and Outcomes: In addition to ongoing mentor communication, in FY17, a Meet & Greet was developed and implemented at several universities where students and mentors came together to talk about their experiences and learn about other AEOP programs. We will expand this effort in FY18. We also assisted the CAM's office to create DoD Career webinars for students and mentors to learn about DoD careers.

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

No recommendations were provided in FY16 in this area.

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

FY16 Finding: HSAP mentors were effective in FY16 at informing apprentices about DoD STEM jobs/careers, as 97% of respondents reported hearing about one STEM career and 50% reported hearing about 5 or more, which is increased greatly from 2015. However, there was little overall impact of the program and mentors on apprentice awareness of DoD STEM careers, as only 68% of HSAP apprentices felt that their participation in the program impacted their awareness and 64% felt that their mentors impacted their awareness. Apprentices reported not utilizing the AAS website (83%), It Starts Here! Magazine (83%), social media outlets (72%), Invited speakers (61%), and the ARO website (53%). This lack of awareness/utilization is a potential barrier for communicating about Army/DoD STEM research and careers and the AEOP portfolio overall. In an effort to increase and standardize the information provided to apprentices, it would be beneficial to create a resource that profiles Army STEM interests and the education, on-the-job training, and related research activities of Army careers. Such a resource could not only start the conversation about Army STEM careers and motivate further exploration beyond the resource itself, but could be used to train the mentors to learn more about specific Army/DoD STEM research and careers. The application to be a HSAP site or a mentor could ask for their plan to explicitly discuss these resources (e.g., Army and directorate STEM career webpages, online magazines, federal application guidelines), thus developing a network of ongoing opportunities for the apprentices. Again, some type of onboarding/training for mentors – even virtual – would help to support progress in this area for HSAP.

HSAP FY17 Efforts and Outcomes: AEOP objectives identified that there was a lack of awareness of DoD STEM careers in FY16. In FY17, promotional materials, as well as a webinar was developed to help engage the apprentices in learning more about DoD STEM careers.

FY16 Finding: Participation in the HSAP evaluation improved for apprentices but less than desirable for mentors. Very few mentors (12%) and apprentices (55%) completed the evaluation survey. The program leadership reported the decrease in participants was greatly due to the use of Constant Contacts for the majority of marketing/promotion, instead of more personal approaches to participation in the evaluation survey. It is recommended that the program use a more personal approach to recruiting participation in the evaluation survey. This strategy worked well for recruiting participants in the evaluation interviews in FY16. A recommendation for the FY17 years and beyond would be for the HSAP program mentors to provide time for apprentices to complete the survey during their apprenticeship meeting time. This will provide a more accurate measure to gauge how effective HSAP activities and communications are in growing awareness of AEOPs.

HSAP FY17 Efforts and Outcomes: Under the umbrella of all the apprenticeships, and in a coordinated effort, all apprenticeships issue ongoing communication (links to evaluation, abstracts, 21st century skills, poster tips, etc.) throughout the summer to all participants. This is done by each IPA for a more personal touch. It also allows instant feedback from participants. A less personal approach, Constant Contact, was used last year for two of the apprenticeships which deemed unreliable.

Recommendations for FY18 Program Improvement/Growth

Evaluation findings indicate that FY17 was a successful year for the HSAP program. The number of applications for HSAP apprenticeship slots increased considerably in FY17 (629 compared to 363 in FY16) indicating the demand for the program is high. More than 60% of apprentices who participated were female. HSAP participants reported significantly higher engagement in STEM during HSAP than in school. All apprentices reported having access to their mentors. STEM knowledge and competencies increased for a large majority of participants and mentor assessed 21st Century Skills increased overall for HSAP apprentices. All participants reported increased confidence in STEM knowledge, skills, and abilities as a result of HSAP. While the successes for HSAP detailed above are commendable, there are some areas that remain with potential for growth and/or improvement. The evaluation team therefore offers the following recommendations for FY18 and beyond.

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

1. Despite considerable growth in interest in HSAP, evidenced by the nearly 50% increase in applications for FY17, there was a 20% decrease in the actual number of participants in FY17. HSAP failed to meet their enrollment goal of 70 apprentices as a result. HSAP should focus on growing infrastructure to support more potential participation in FY18.

2. The demographics of actual participants in HSAP reveal the program has more work to do to reach a greater percentage of underrepresented students. It is commendable that HSAP has been able to accommodate a majority of female apprentices. However, White and Asian groups are the majority in participants (42% and 25% respectively). This is a slight increase from FY16 in fact, while the percentage of African American students has remained at 15% and Hispanic/Latino apprentices held at 14%. HSAP should invest resources in FY18 to target underrepresented groups more strategically to recruit more diverse participation for the program.

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

In FY17, HSAP apprentices and mentors both echoed findings that have been prevalent across the AEOP portfolio. Only a very few number of participants and mentors are accessing and/or utilizing AEOP social media, including the website. In regards to HSAP, 63% of mentors and 71% of apprentices did not experience AEOP social media at all. Therefore, the evaluation team recommends that HSAP work with the consortium members to determine a plan for the future utilization and marketing of AEOP social media and the website.

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

1. The FY17 evaluation findings indicate collective desire of the apprentices and mentors to improve communication across the program. This includes improving the delivery of information from the program leadership to the mentors and site directors, as well as information (program requirements, stipend payments, that is transmitted between AAS/ARO and the apprentices directly. It is recommended that AAS and ARO take steps to examine communication channels and determine how communication can be improved for HSAP.

2. HSAP made progress in growing apprentice awareness of AEOPs, as 97% indicated that they had learned about AEOPs during the program. 74% indicated they were interested in URAP. However, HSAP participants were not made cognizant of some applicable AEOP opportunities during the program in FY17. In fact, 65% of HSAP apprentices had not heard of CQL, and 42% had not heard of the NDSEG Fellowship. Mentors reported that they did not discuss other AEOPs with their apprentices including: JSHS (88%), SEAP (88%), and CQL (92%). It is strongly recommended that HSAP work with their staff and the consortium to develop a plan for marketing and informing participants frequently about other AEOP opportunities and resources.