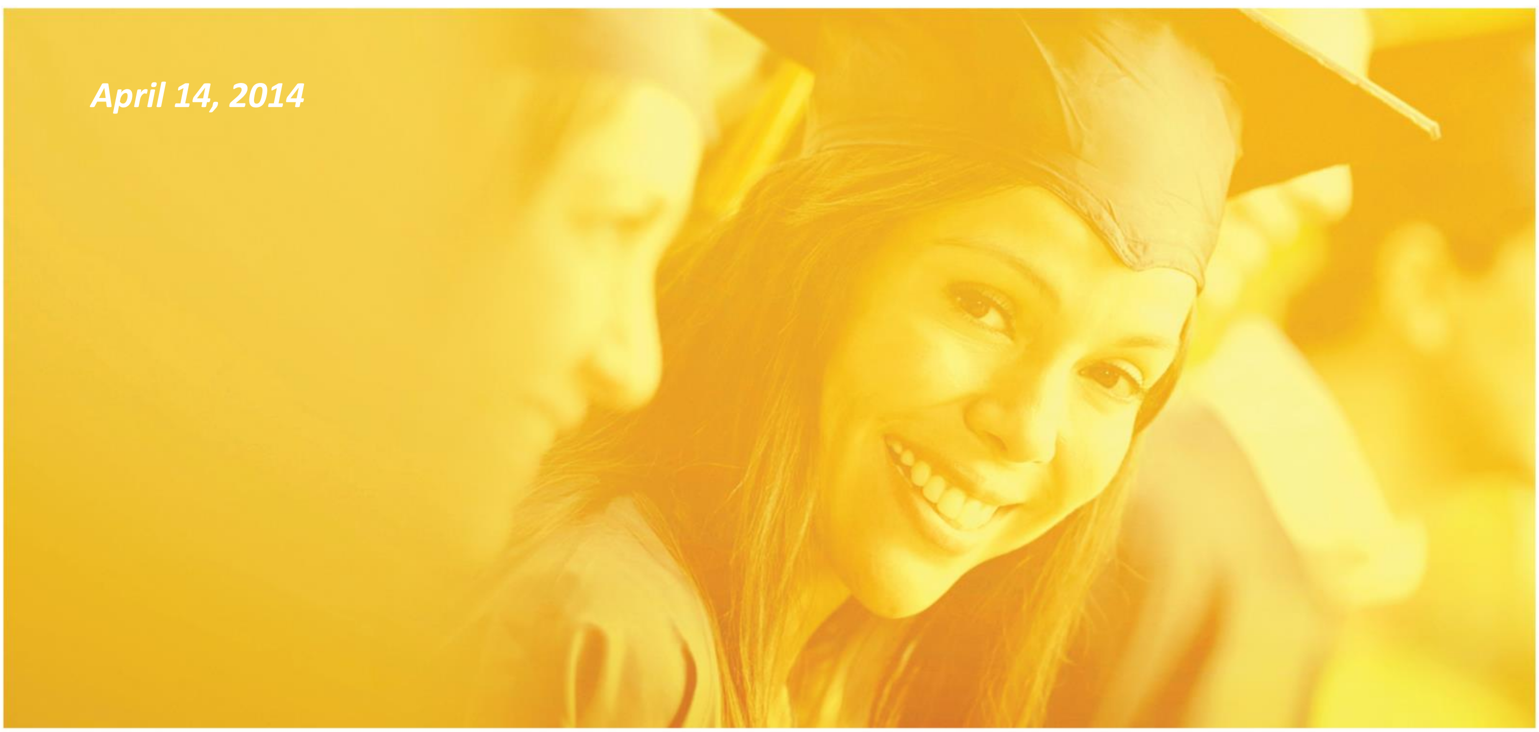
# Army Educational Outreach Program

## 2013 Portfolio Evaluation Report

ARMY EDUCATIONAL OUTREACH PROGRAM



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## U.S. Army Contacts

**Jeffrey Singleton**
Director, Basic Research and Educational Outreach
Office of the Assistant Secretary of the Army
Acquisition, Logistics, and Technology
(703) 617-0315
Jeffrey.d.singleton.civ@mail.mil

**Andrea Simmons-Worthen**
Army Educational Outreach Program Director on behalf of the Office of the Deputy
Secretary of the Army for Research and Technology
(703) 617-0202
andrea.e.simmons.ctr@mail.mil

## AEOP Cooperative Agreement Managers

**Louie Lopez**
AEOP Cooperative Agreement Manager
U.S. Army Research, Development, and Engineering Command (RDECOM)
(410) 278-9858
louie.r.lopez.civ@mail.mil

**Jennifer Carroll**
AEOP Deputy Cooperative Agreement Manager
U.S. Army Research, Development, and Engineering Command (RDECOM)
(410) 306-0009
jennifer.j.carroll2.civ@mail.mil

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## Virginia Tech Evaluation Contacts

**Rebecca Kruse, Ph.D.**
Evaluation Director, AEOP CA
Virginia Tech
(703) 336-7922
rkruse75@vt.edu

**Donna Augustine Burnette**
Program Director, AEOP CA
Virginia Tech
(540) 315-5807
donna.augustine@vt.edu

## Virginia Tech Principal Investigators

**Susan Short, Ph.D.**
Associate Vice President for Engagement
Virginia Tech
(540) 231-9497
sshort@vt.edu

**Scott Weimer**
Director of Continuing and Professional Education
Virginia Tech
(540) 231-7887
weimers@vt.edu

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## Executive Summary

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 them 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 priorities and objectives toward STEM literate citizenry, STEM savvy educators, and sustainable infrastructure.

### AEOP Priorities

**Priority 1: STEM Literate Citizenry.**

- Broaden, deepen, and diversify the pool of STEM talent in support of our defense industry base.

**Priority 2: STEM Savvy Educators.**

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

**Priority 3: Sustainable Infrastructure**.

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

| Table 1. 2013 AEOP Participation Numbers | | |
|---|---|---|
| CQL | College Qualified Leaders | 260 |
| eCM | eCYBERMISSION | 21,345 |
| GEMS | Gains in the Education of Mathematics & Science | 2,107 |
| HSAP | High School Apprenticeship Program | 29 |
| JSHS | Junior Science & Humanities Symposium | 7,600 |
| JSS | Junior Solar Sprint | 140 |
| REAP | Research & Engineering Apprenticeship Program | 101 |
| SEAP | Science & Engineering Apprentice Program | 101 |
| STPI | STEM Teacher Program Initiatives | 43 |
| UNITE | UNITE | 188 |
| URAP | Undergraduate Research Apprenticeship Program | 61 |
| WPBDC | West Point Bridge Design Competition | 9,500 |
| | **Total 2013 AEOP Participants** | **41,475** |

In 2013, the AEOP had **41,475** unique program participants. The discrepancy in the number of AEOP participants previously reported (66,484) was discovered through AEOP's evaluation efforts that the West Point Bridge Design Competition allowed participants to submit multiple entries to the bridge contest.

The 2013 AEOP portfolio was evaluated by Virginia Tech, the Lead Organization (LO) of the AEOP CA. The LO conducted evaluations for GEMS, UNITE, SEAP, CQL, REAP, HSAP, URAP, JSS, JSHS, and STPI programs. David Heil & Associates conducted the evaluation for eCM. WPBDC was not evaluated with the AEOP CA portfolio in 2013.

Most AEOP program evaluations utilized participant questionnaires, as well as focus groups or interviews with participants and adults who led educational activities or supervised research projects (herein called mentors). Features unique to the assessment of certain programs or program types include the following:

- GEMS and UNITE assessment involved pre-program and post-program student questionnaires to enable the measurement of participant growth through the program;
- Apprenticeship program (SEAP, CQL, REAP, HSAP, and URAP) assessment incorporated questionnaires and rubrics used by mentors to describe their mentoring activities and measure participant knowledge and ability levels;
- JSS assessment provided baseline analysis of feasibility and level of use of online resources, using website analytics and questionnaires for event host and teachers who registered at the JSS website;
- JSHS assessment included questionnaires for both regional and national participants, as well as regional directors, and national judges;
- STPI assessment focused on its 2013 STEM Teacher Academy (STA) and included post-STA and 9-month post-STA questionnaires for 2013 and 2012 STA participants, respectively; and
- eCM assessment included alumni/past winner outcomes and of 2013 program resources, activities, and participant outcomes. The 2013 evaluation is discussed here.

This report summarizes the 2013 evaluation of the AEOP portfolio. Eleven individual program evaluation reports are available under a separate cover. The executive summaries for these ten reports are attached as appendices of this document. This report includes a program overview, evaluation and assessment strategy, study sample, and evaluation findings. The final section offers evidence-based recommendations intended to inform decision-making regarding future program development.

## Summary of Findings

The 2013 AEOP evaluations collected data about participants, their perceptions of program processes, resources, and activities, and indicators of achievement related to outcomes aligned with AEOP and program objectives. A summary of findings is provided in Table 2.

| Table 2. Summary of Findings | |
|---|---|
| **Priority 1: STEM Literate Citizenry**<br>*Broaden, deepen, and diversify the pool of STEM talent in support of our Defense Industry Base.* | • **Finding #1: AEOP provided outreach to 41,312 students through its comprehensive portfolio of programs, yet considerable unmet need exists in many AEOP programs. Across the AEOP participants, mentors, and event directors call for expansion of DoD's unique and effective outreach programs that develop the Nation's future STEM talent.**<br>• **Finding #2: AEOP provided outreach to participants from underserved and underrepresented groups, but some programs were more effective at this than others. Even the strongest pipelines have limited success retaining underserved and underrepresented populations.**<br>• **Finding #3: AEOP provided participants with frequent exposure to real-world, hands-on, and collaborative STEM activities, which are less frequently available in their regular schools. Balancing hands-on *and* minds-on STEM activities is a promising practice that may produce greater student affective and achievement outcomes than hands-on activities alone.**<br>• **Finding #4: AEOP participants and their mentors perceived that AEOP experiences improved their STEM-specific and transferrable competencies and confidence. Improvements in confidence related to hands-on skills and abilities are consistent with the frequency with which participants reported engaging in related activities during the program, further supporting the recommendation to balance hands-on and minds-on STEM activities in program activities.**<br>• **Finding #5: AEOP expanded the number of participants engaged in ongoing DoD research, and exposed many others to DoD STEM interests. These efforts serve to improve participants' understanding of and attitudes toward DoD STEM research and researchers.**<br>• **Finding #6: AEOP exposed participants to Army and DoD STEM careers, but some elements were more effective at this than others. Direct engagement with Army and DoD STEM researchers and/or facilities during program activities are the most promising practices. Across AEOP mentors call for comprehensive resources that will improve their awareness of exciting Army and DoD STEM research and careers and that better support their efforts to encourage participants to consider careers with the DoD.**<br>• **Finding #7: AEOP served both to sustain existing STEM educational and career aspirations of its participants and to inspire new achievement, including intentions to pursue DoD STEM careers. AEOP has the potential to serves a critical need in providing authentic STEM experiences that both inspire and sustain participants' interest in STEM fields and that provide exciting and obtainable STEM career options to medical fields.** |

| | |
|---|---|
| **Priority 2: STEM Savvy Educators**<br>*Support and empower educators with unique Army research and technology resources.* | • **Finding #1:** AEOP efforts to expand and reward teacher engagement were successful. "Boots on the ground" efforts to establish relationships with schools and teachers, and incentives for teachers, especially those that assist teachers in supporting their students' engagement in AEOP, are promising practices for further expanding teacher participation. Several AEOP programs have untapped potential to engage greater numbers of teachers in their programs.<br>• **Finding #2:** AEOP provided professional development to teachers through direct instruction from Army scientists and engineers (S&Es). Teachers' translation of their learning from the STEM Teachers Academy (STA) to the classroom and school may depend on the relevance of content to teachers' contexts and the structure of STA professional development model. Alternative models are needed to establish national reach, including teachers and schools serving underserved and underrepresented populations.<br>• **Finding #3:** AEOP online resources supported teachers in program engagement and classroom integration, but certain resources are underutilized. Underutilization may result from a lack of awareness or lack of understanding of how they may be best utilized to support participant engagement and/or classroom integration.<br>• **Finding #4:** AEOP expanded efforts to recruit, prepare, and study the experiences of S&E mentors, including tracking the development and impact of GEMS near-pear mentors, HSAP/URAP graduate mentoring fellows, and JSHS national judges. S&Es contribute valuable perspective pertaining to Priority 1 and Priority 2 objectives that informed many if not all 2013 evaluation recommendations; data collection about and from S&Es should be expanded and standardized in future evaluation. |
| **Priority 3: Sustainable Infrastructure**<br>*Develop and implement a cohesive, coordinated, and sustainable STEM education outreach infrastructure across the Army.* | • **Finding #1:** AEOP evaluation efforts expanded in 2013 with the evaluation of eleven programs, increased focus on AEOP Priority 2 objectives, and shifts toward common program metrics that align with AEOP's guiding framework. Future evaluation efforts are informed by and strive to adhere to Federal guidance and best practices for rigorous program evaluation, while attending to AEOP priorities.<br>• **Finding #2:** AEOP marketing, promotion, and branding activities expanded to reach Consortium members, participants, and the public with a unified message about AEOP's pipeline of programs. Data suggest, however, that AEOP- and program-level marketing have less success than sites' marketing efforts at attracting students to and retaining them in the pipeline. Participants' interest in AEOP will benefit from greater emphasis on cross-promotion of elements during program activities. |

## What AEOP participants are saying…

*"I very much enjoyed my [**CQL**] internship at USACIL. I became an "expert" in a specific topic, and was able to present my findings to other colleagues and scientists in the field. I believe the most valuable experience was being able to work under the same conditions as they are overseas and to collaborate with the DNA and latent print analysts."* – CQL Apprentice

*"[He] was well trained, understood the research process and the tools needed to complete the project. He worked well with others and provided some training to existing employees in some of the techniques. I would have hired him full time if I could."* – CQL Mentor

*"**eCYBERMISSION** has increased my confidence and passion that I can excel and contribute towards the STEM fields, and has no doubt increased my desire to attend a STEM-based high school and college."* -eCYBERMISSION Contestant

*"This **GEMS** experience was truly phenomenal experience that helped me decide to pursue a career as, hopefully, an Army research engineer."* – GEMS Student

*"I think [**GEMS**] motivates students in STEM fields because it relates science back to real life. In school they just learn facts and they're not actually able to connect it back to real life… [applying school concepts] is what **GEMS** does."* **–** GEMS Mentor

*"It was satisfying to have grown over these past few weeks from knowing virtually nothing to being able to have a discussion with Ph.D. based on my topic. It is not a usual thing for students like me to have to opportunity to present my work to well-established scientists. Furthermore, I feel very fortunate to have researchers teach me their work and try to show me their passions in their respective fields."* – HSAP Apprentice

"*The **HSAP/URAP** is a great program that is exposing its students to cutting-edge scientific research, which excited them about pursuing careers in science. They become aware of the support and opportunities available through Army/DOD."* – HSAP/URAP Mentor

*"My participation in **JSHS** encouraged other classmates to get involved. Thank you for supporting JSHS in overseas DoDDS schools which do not have the same number of opportunities as statewide students."* – JSHS Contestant

**"***I am so blessed that I had the chance to participate in **JSHS** at the Regional and National levels this year. The experience was absolutely life-changing, and has reaffirmed my interest in majoring in a STEM field in college.***"** – JSHS Contestant

*"Students have an exciting opportunity to apply the scientific concepts they are learning in class to a real-world challenge with **JSS.** Kids develop teamwork and problem-solving abilities, investigate environmental issues, gain hands-on engineering skills, and use principles of science and math to get the fastest, most interesting, and best-crafted vehicle possible."* – JSS Event Host

"*If a genie granted me a wish to spend the summer any way I like, I would use that wish to participate in the **REAP** program again. I leaned things from data software to fundamentals of research. It has given me a leg up on college and has inspired me to pursue my interest in independent experimentation and research. This has been one of the most valuable summers of my high school years. I am grateful for the opportunity and knowledge **REAP** has given me. Thank you."* - REAP Apprentice.

*"It took some time to get her to understand that she was an integral part of the laboratory…The success was, of course, that she actually became one of the research team," - REAP Mentor*

*I'm highly satisfied with the* **SEAP** *research project. It has proven to be a challenging and entertaining learning experience, and I feel that I have grown as a student and researcher as a result of my involvement with the program. The most valuable part of the experience was, by far, the real-world research laboratory experience…"* – SEAP Apprentice

*"*[**SEAP**] *is worthwhile for the mentors, the laboratories, and the students. A lot of these students want to go into STEM industry. These students get the experience that they need to get the jobs that they want – professional development."* - SEAP Mentor

*"*[**STA**] *was one of the best professional opportunities I have ever had in my professional training. I knew of the potential impact upon my learning and thus the learning of my students -- this was my first opportunity to put what was a 'theory' into real life action. Our team consisted of science teachers in 6th, 7th, 8th grade and a math teacher in 6th grade. Powerful Opportunity -- thanks."* – STEM Teacher Academy Teacher (STPI)

*"If it were not for the amazing opportunities opened to me by this* [**UNITE**] *program, I do not think I would have been so knowledgeable about STEM careers and know what I want to do with my life. Now, I am able to say as a rising senior I am ready for the long and significant road ahead."* - UNITE Student

*"After they completed the* [**UNITE**] *program and presented their career aspirations… I thought to myself, 'this is such a diverse group, these people are going to make this world great'. They have such advanced goals for being so young. It was so exciting to hear them explain, you can see the excitement on some of their faces. You could see the passion when they spoke about what they wanted to do."* – UNITE Mentor

*"I've learned that hands-on is very important. When you touch something…that is where you learn. So just writing problems is good for theory but if you want to see what is going on in nature you have to start using instruments and do experiments.* [**URAP**] *gives you that…"* – URAP Apprentice

*"The program was an excellent way to become exposed to and acquainted to research. It was a valuable way to learn how to perform experiments, literature surveys, and academic writing. I have no doubt that it will have a strong influence on the rest of my academic career (I now know substantially more about aero dynamics than I did earlier this summer). I am glad to have been able to participate."* – URAP Apprentice

*"Exposing good laboratory skills and discussion with graduate students made him fully understand what the next step needed to do in STEM research is critically important. I fully believe in this effort, and need to grow to help U.S. training and guidance on students toward STEM.* [**URAP**] *is a building block for U.S. students for international competitiveness in addition to Army/DoD. Overall, I am very excited about the program and looking forward to more opportunity."* – URAP Mentor

## Discussion and Recommendations

1. Across the AEOP there is considerable differential between the number of applicants being considered for AEOP programs and the number of spaces available for participants, indicating significant unmet need. AEOP programs expose interested and talented youth to STEM through engagement opportunities that are unique to the Army and DoD. In light of evidence of program successes, and considering that participants perceive benefit that is beyond what typical school offerings can provide, it is recommended that the Army expand initiatives where possible. It is recommended that the Army expand all programs showing evidence of need.

   The AEOP is purposefully structured to promote a pipeline that offers participants with opportunities for continued exposure to, engagement in STEM pathways that culminate in careers that support the DoD mission. In particular, efforts should be made to ensure that AEOP alumni have the opportunity to advance to the next-level AEOP program that is available to them. Ideally, space in programs would exist for all alumni who are interested and qualified, as well as for new qualified individuals seeking entry to the AEOP pipeline at any given point. This may be impossible for local pipelines (GEMS-SEAP-CQL) to accommodate given the large number of entry-level participants wishing to continue their work at the Army laboratories and the limited positions available to them in the more advanced AEOP opportunities. Where local pipelines cannot accommodate need, cross-promotion of AEOP programs is vital to ensure advancement and retention of talented alumni in the AEOP.

   Further, any expansion of AEOP programs should balance the needs of existing sites and the communities they currently serve with geographic expansion to new sites and communities. To expand the capacity of existing sites, greater investment may be required to expand site administrative staff, physical infrastructure needs, and mentor participation, most notably of S&Es. Programs may benefit from a careful examination of and attention to program- and site-level structures, processes, and resources that both enable and discourage S&Es' participation in programs. Program- and site-level accommodations may be required to further improve S&Es' awareness of programs, feasibility of their participation, and overall motivation to participate. Where appropriate, expansion should include the highly successful partnership models in which S&Es, undergraduate/graduate S&Es-in-training as near-peer mentors, and resource teachers work together to support the translation of complex content into age-appropriate and pedagogically sound activities for youth participants.

2. AEOP objectives include expanding participation of historically underrepresented and underserved populations. While AEOP elements conduct program-level marketing of programs targeting those populations, assessment data suggests that site-level marketing, recruiting, and selection processes have greater influence in determining participants. Data also suggest while most AEOP elements or their sites have some success in recruiting underserved participants to AEOP, there is less success with retaining them in local and AEOP-wide pipelines.

   AEOP programs may benefit from more guidance from Army leadership regarding program- and site-level priorities and processes for maximizing the inclusion and retention of underrepresented and underserved students as appropriate for the individual programs. This guidance may include recommendations for any number of promising marketing practices employed in 2013 programming that targeted recruitment of underserved populations, or those aimed at providing equitable support to ensure successful participation of those populations, and/or more explicit mechanisms for advancement of those participants within AEOP, such as modeled in the UNITE-REAP pipeline. Both UNITE and REAP serve primarily underserved and underrepresented populations. In the UNITE-REAP pipeline, a minimum number of qualified UNITE alumni were invited to and completed a REAP apprenticeship established at the same host site, thus ensuring the advancement of students from underserved populations from one AEOP program to another.

While explicit guidance is encouraged for all individuals who participate in selection processes, such guidance may all-together deter mentors from participating in the programs. For example, efforts to ensure that “connected” applicants (e.g., those with family, family friends, or school-based connections to the site) are not disproportionately advantaged over qualified but “un-vetted” candidates who apply at the AEOP website may lessen mentor interest if they perceive correlation with an increased responsibility for oversight during the apprenticeships and/or if they perceive that “un-vetted” apprenticeship candidates have been less successful. The Army, program administrators, and sites need to also consider practical solutions to other challenges posed to the host-site or event locations, as proximity alone is likely to advantage some populations more than others (e.g. students with greater proximity, or students with means for longer distance transportation or temporary relocation near the site). In-residence programs and/or travel accommodations (e.g., bus transportation from schools) may be needed to recruit and make participation feasible for underserved populations living at greater distances from the host or event sites. Beyond recruitment, additional support may be necessary to mitigate underserved students’ resource and educational gaps (identified by participants, mentors, and event directors), to ensure their participation is both feasible and successful.

3. Several AEOP programs have untapped potential to engage greater numbers of teachers in their programs that future programming should address. JSS and STPI in particular have the potential for nationwide reach with adjustments to their operational models.

Attempts to perform outreach primarily through JSS’ jrsolarsprint.org website and existing school- and community-based JSS programming may constrain the diversity of the population that it attracts, according to data collected from hosts and teachers. Outreach to underserved and underrepresented populations may not be a key objective of non-AEOP affiliated JSS hosts and teachers nationwide. However, outreach to these populations is an Army priority, and therefore AEOP’s JSS programming in 2014 should incorporate explicit efforts to market to and recruit these populations, and to support them in successfully participating in JSS. In an effort to engage underserved and underrepresented populations, JSS may need to identify and directly engage teachers and students that have not been exposed to JSS-based programming to date. For example, these efforts might include a) promoting JSS to the program administrator’s nationwide and diverse membership base, support and volunteer network, and local chapters, and supporting local and national competition options for students that are coordinated by or in partnership with the program administrator; b) efforts similar to those of eCM, including establishing unique partnerships with teachers at Title 1 schools, provisions of low or no-cost kits for students, professional development, and support for school-based communities of practice to help educator teams integrate JSS activities with their classroom STEM curricula; and c) strategically cross-promoting and forging partnerships with Army and university sites that host other AEOP pipelines (e.g., GEMS-SEAP-CQL and UNITE-REAP) to expand outreach to diverse populations when they are younger, and prepare them for future engagement in GEMS and UNITE. The concept of JSS, harnessing solar energy, highlights and connects to Army and DoD STEM interests particularly well, and would benefit from stronger partnerships with Army and DoD S&Es whenever possible.

STPI's focus to date has been on college-level content provided by Army and university S&Es through the STEM Teachers' Academy (STA). Teachers are provided opportunities to translate their learning into grade-level planning and teaching, and most teachers intend to implement these plans post-STA Follow up questionnaires suggest that most participants (69%-91%) do apply their learning to their classroom planning and teaching but only 16%-38% share their learning with other teachers at their school or district. Stronger partnership with other AEOP programs having readily available grade-level and standards aligned resources for integration with classroom curriculum (eCM, JSS, JSHS, and WPBDC) and with Army research laboratories having vested interest in research supporting fields embodied in those resources (e.g., solar energy for JSS, civil engineering for WPBDC), could provide a strong model for teacher professional development that promotes AEOP and Army interests.

4. Across AEOP participant and mentor data suggest that participants have more opportunities to do the *hands-on* aspects of STEM activity and fewer opportunities to engage in the *minds-on* aspects. Minds-on aspects of STEM activity have been linked to greater student affective and achievement outcomes than hands-on activities alone.[1] [2] Programs might consider how to expand participants' opportunities to engage in minds-on STEM activities such as generating questions, designing experiments, analyzing and interpreting data, and formulating conclusions for their questions during their program experiences. Promising models of similar efforts are available across AEOP. Whether these strategies are team competitions, weekly challenges, or capstone cases to be solved, or whether they include mentors modeling such minds-on practices for participants, scaffolding "thought exercises" to be completed by participants, or coaching participants in these activities, such efforts may maximize apprentices' professional development through programs, better mirror the day to day practices of scientists and engineers, and may also continue to challenge and inspire older AEOP participants and returning alumni who tend to exhibit less change in outcomes related to STEM competencies and ambitions.

5. Across AEOP, participants and mentors reported in evaluation assessments limited awareness of and participation in AEOP elements outside of that in which they were currently participating. Where local pipelines exist, past participation, awareness of, and future interest in the local pipeline is evident. However, there is little awareness of AEOP beyond the local pipeline. Mentor interviewees reported spending little or no time educating students about AEOP initiatives for which students qualify during daily program activities, aside from distributing AEOP brochures and referring participants to the AEOP website. Student interviewees generally could not name, or recognize when named, AEOP initiatives except for those participating in local pipelines. Yet, questionnaire data reveals that substantial student interest exists in AEOP opportunities when vaguely described. This interest, especially from students of underserved populations, would benefit from more robust attention by site coordinators and mentors during program activities. Where local pipelines cannot accommodate need, cross-promotion of *all* AEOP programs is vital to ensure advancement

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

[2] Maltese, A.V. & Tai, R. H. (2011) Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education Policy* 98, 877-906

and retention of talented alumni in the AEOP. Other AEOP elements may be able to provide continued engagement and greater geographical and demographic reach where local pipelines are simply unable. Continued guidance by program administrators is needed to ensure coordinators and mentors alike are knowledgeable of AEOP opportunities, and have reasonable plans and strategies for exposing participants to these opportunities in meaningful ways before, during, and after program activities, so that each participants knows their next steps in the AEOP.

That said, sufficient and engaging resources must be available to support site coordinators and mentors in their cross-promotion of programs. The AEOP marketing materials contain a core call-to-action: visit www.usaeop.com for more information. Yet, when users access the website, they report finding insufficient or outdated information, including static text and images. Users report the site lacks coherent message and presentation that generates excitement about AEOP programs, the kind of excitement that come from community-derived dynamic, video-based, or social media-linked content. Creation of a new AEOP website that meets the needs of programs and allows other complementary marketing activities (especially community-building through social media) to succeed and thrive should be a priority. Future evaluation should include more standardized measures and metrics to both elicit brand awareness but also to understand the impact of website and social media efforts on brand awareness among key stakeholders.

6. Across AEOP, most participants reported opportunities to learn about STEM research and careers, including Army/DoD STEM research and careers, during program activities. Direct engagement with Army and DoD STEM researchers and/or facilities during program activities are the most promising practices, and impact not only awareness but also interest. However, across AEOP, and especially where direct engagement with Army/DoD researchers and facilities are not possible, mentors call for comprehensive resources that highlight of a range of exciting Army and DoD STEM research and careers to improve their awareness and better support their individualized efforts to encourage participants to consider careers with the DoD. Many mentors reported lack of awareness of STEM careers beyond their own, lack of informational resources, lack of direction provided by program administrators, and lack of time for educating participants about STEM careers. An AEOP centralized effort to create a resource that profiles Army STEM interests and the education, on-the-job training, and related research activities of Army S&Es is recommended. Such a resource could start the conversation about Army STEM careers and motivate further exploration beyond the resource itself. A repository of public web-based resources (e.g., Army and directorate STEM career webpages, online magazines, federal application guidelines) could also be disseminated to each mentor and/or participant to help guide their exploration of Army/DoD STEM interests, careers, and available positions.[3] The National Institutes of Health-funded *Building Bridges: Health Science Education in Native American Communities* annually evolving Community Poster Project (http://www.unmc.edu/rhen/role_model_poster.htm) provides a promising model for encouraging underserved populations in considering STEM careers.

7. Strategic promotion of element-specific online resources, such as eCM, JSS, and WPBDC, which encourage and support participation in programs and classroom integration, and monitoring of use, quality, and perceived value through website analytics and user questionnaires should continue. Alignment of educational resources with the *Next*

[3] For example, http://www.goarmy.com/careers-and-jobs/army-civilian-careers.html,http://www.goarmy.com/careers-and-jobs/stem.html, individual directorate STEM webpages and resources such as RDECOM's Army Technology magazine, and usajobs.gov.

*Generation Science Standards* is highly recommended, attending both to AEOP objectives and the national call for shared standards across formal and informal education settings. Evaluators advise improving the visibility and/or awareness of existing resources to ensure users understand how resources may be used to best improve their participation. Revisions and additions to resources that accommodate widespread user need reported from the individual program evaluation assessments are encouraged. The visibility of information related to AEOP and Army STEM will, in part, determine the extent to which this program successfully raises awareness through the website. Strategic website revisions and other program-level marketing efforts that can strengthen the visibility and participant awareness of Army STEM and the AEOP are encouraged.

8. While 2013 evaluation participation provided improvement over 2012, coordinated efforts are still needed by the LO, Army, program administrators, and site coordinators to expand process evaluation efforts related to program implementation and to encourage and improve participant and mentor participation in evaluation efforts.

   Deep understanding of program activities that can be linked to outcomes are vital for identifying promising practices that can be rigorously studied, taken to scale, and shared across the AEOP and with the field. Standardized annual program reporting that builds on the research.gov model and addresses the contexts and priorities of AEOP is strongly encouraged. This mechanism would attend to Federal guidance for evaluation of STEM investments,[4] [5] build the capacity across AEOP to contribute to and use evaluation, and, when linked to outcomes, would provide stronger evidence upon which decision-making about programmatic revisions could be based.

   With respect to outcomes evaluation performed by the LO, findings of the CQL, GEMS, JSHS National Symposium, REAP, SEAP, 2013 STA, UNITE, and URAP participant questionnaires, as well as the JSHS Regional Director questionnaire could be reliably generalized to the respective populations. This is a substantial improvement over 2012. However, low response rates to evaluation assessments pose the most significant threat to the validity of findings from those assessments, and, furthermore, limit the possibility of making reliable comparisons of those data from year to year. While evaluators can assess representativeness of samples through alternative means, accurate demographic data must be available for the population in order to accomplish these determinations. And mentors' assessment of apprentice performance are important for triangulating apprentices' perceptions of growing confidence in their STEM competencies. Evaluators will endeavor to streamline instruments and appropriately incentivize participation in evaluation assessments; however, evaluators necessarily rely on the assistance of Army, program administrators, and site coordinators to promote a culture of evaluation among program sites, participants, and mentors.

[4] Committee on STEM Education, National Science and Technology Council, "Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan" (Washington, D.C., 2013)

[5] Government Accountability Office, Science Technology, Engineering, and Mathematics Education: Strategic Planning Needed to Better Manage Overlapping Programs Across Multiple Agencies. (Washington, D.C., 2012)

## 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 them 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 priorities and objectives toward STEM literate citizenry, STEM savvy educators, and sustainable infrastructure.

### AEOP Priorities

**Priority 1: STEM Literate Citizenry.**

- Broaden, deepen, and diversify the pool of STEM talent in support of our defense industry base.

**Priority 2: STEM Savvy Educators.**

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

**Priority 3: Sustainable Infrastructure**.

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

## 2013 Program Overviews

The 2013 portfolio of AEOP initiatives is outlined in Table 3 below. The table includes the number of 2013 applicants and participants organized by program. There were **41,475** unique participants of 2013 AEOP activities, *not* including "adult" participants such as teachers and scientists and engineers (S&Es). Participation numbers are summarized in Table 4.

| Table 3. 2013 AEOP Initiatives | |
|---|---|
| **College Qualified Leaders (CQL)<br>Program Administrator: American Society for Engineering Education (ASEE)** | |
| Description | Apprentice program at Army and DoD laboratories |
| Participant Population | College undergraduate students |
| No. of 2013 Applicants | 588 |
| No. of 2013 Participants | 260 |
| Placement Rate | 44% |
| No. of 2013 S&Es | 260 |
| **eCYBERMISSION (eCM)<br>Program Administrator: National Science Teachers Association (NSTA)** | |
| Description | Nationwide web-based STEM competition that includes 1 national event |
| Participant Population | 6th-9th grade students |
| No. of 2013 Participants | 21,345 (12,274 contestants, 9,071 non-competing participants) |
| Placement Rate | 58% |
| No. of 2013 Teachers | 1,049 (35+ mini-grants to teachers and schools) |

| | |
|---|---|
| No. of 2013 S&Es | 1,908 |
| **Gains in the Education of Mathematics & Science (GEMS)<br>Program Administrator: American Society for Engineering Education (ASEE)** | |
| Description | Hands-on summer program in Army laboratories |
| Participant Population | 4th-12th grade students (secondary audience: college undergraduate near-peer mentors) |
| No. of 2013 Applicants | 4,231 |
| No. of 2013 Participants | 2,107 (2,038 students,[6] 69 near-peer mentors) |
| Placement Rate | 50% |
| No. of 2013 Teachers | 45 |
| **High School Apprenticeship Program (HSAP)<br>Program Administrator: Army Research Office (ARO)** | |
| Description | Apprentice program in Army-funded labs at universities nationwide |
| Participant Population | 9th-12th grade students (secondary audience: graduate mentoring fellows) |
| No. of 2013 Participants | 29[7] (24 students, 5 graduate mentoring fellows) |
| No. of 2013 S&Es | 11 |
| **Junior Science & Humanities Symposium (JSHS)<br>Program Administrator: Academy of Applied Science (AAS)** | |
| Description | Nationwide research competition that includes 47 regional events and 1 national event |
| Participant Population | 9th-12th grade students |
| No. of 2013 Participants | 7,600 |
| No. of 2013 Teachers | 1,100 (47 awards to teachers) |
| No. of 2013 S&Es | 800 (University STEM faculty/students, industry, non-profit, and 100+[8] DoD volunteers) |
| **Junior Solar Sprint (JSS)<br>Program Administrator: Technology Student Association (TSA)** | |
| Description | Online solar car competition for 4th-8th grade students with online resource center competition advisors and hosts |
| Participant Populations | 4th-8th grade students, teachers, event hosts, and volunteers |
| No. of 2013 Participants | 140 (20 students, 80 teachers, 40 S&Es as event hosts and volunteers) |
| **Research & Engineering Apprenticeship Program (REAP)<br>Program Administrator: Academy of Applied Science (AAS)** | |
| Description | Apprentice program at colleges or universities for students from groups historically underserved and under-represented in STEM. |
| Participant Population | 9th-12th grade students |
| No. of 2013 Applicants | 1,500+ |
| No. of 2013 Participants | 101 |
| Placement Rate | 7% |
| No. of 2013 S&Es | 101 |
| **Science & Engineering Apprentice Program (SEAP)<br>Program Administrator: American Society for Engineering Education (ASEE)** | |

[6] Reflects GEMS participants paid stipends by program administrator ASEE. This number does not account for 151 students who were reported to have participated at USAMRICD or 47 volunteer/non-stipend participants at WRAIR. The addition of these students brings the total participant number to 2,236.
[7] In the HSAP program report, Graduate Mentoring Fellows (GMFs) were counted as mentors, having completed the mentor questionnaire and rubrics. Here we consider them participants as they received stipend support and professional development activities as GMFs.
[8] Reflects participation of DoD STEM professionals at National JSHS event. Additionally, an unknown number of ROTC representatives and other Army or DoD STEM professionals from 23 DoD laboratories and installations participated in JSHS regional events.

| | |
|---|---|
| Description | Apprentice program at Army and DoD laboratories |
| Participant Population | 9th-12th grade students |
| No. of 2013 Applicants | 814 |
| No. of 2013 Participants | 101 |
| Placement Rate | 12% |
| No. of 2013 S&Es | 101 |

| | |
|---|---|
| **STEM Teacher Program Initiatives (STPI)**<br>**Program Administrator: University of New Hampshire (UNH)** | |
| Description | STEM professional development initiatives for teachers |
| Participant Population | Middle and high school teachers (Harford and Cecil Counties, Maryland) |
| No. of 2013 Participants | 43 |
| No. of 2013 S&Es | 8 (2 University STEM faculty, 6 DoD) |
| **UNITE**<br>**Program Administrator: Technology Student Association (TSA)** | |
| Description | Pre-collegiate, engineering summer program at university host sites for students from groups historically underserved and under-represented in STEM |
| Participant Population | 9th-12th grade students |
| No. of 2013 Applicants | 434 |
| No. of 2013 Participants | 188 |
| Placement Rate | 43% |
| No. of 2013 Teachers | 32 |
| No. of 2013 S&Es | 145 Total (39 university STEM faculty, 94 university students, 2 industry, 10+[9] DoD) |
| **Undergraduate Research Apprenticeship Program (URAP)**<br>**Program Administrator: Army Research Office** | |
| Description | Apprentice program in Army-funded labs at universities nationwide |
| Participant Population | College undergraduate students (secondary audience: graduate mentoring fellows) |
| No. of 2013 Participants | 61[10] (47 students, 14 graduate mentoring fellows) |
| No. of 2013 S&Es | 18 |
| **West Point Bridge Design Contest (WPBDC)[11]**<br>**Program Administrator: Center for STEM Education, West Point** | |
| Description | Online bridge design competition and engineering experience |
| Participant Population | 6th-12th grade students |
| No. of 2013 Participants | 9,500 (7,971 contestants, 1529 non-competing participants) |
| Placement Rate | 80% |

[9] Eight Army and two Coast Guard STEM professionals participated in Career Day Panels. Additionally, an unknown number of ROTC representatives and other Army or DoD STEM professionals participated in STEM Expos and fairs which UNITE participants attended.

[10] In the URAP program report, Graduate Mentoring Fellows (GMFs) were counted as mentors, having completed the mentor questionnaire and rubrics. Here we consider them participants as they received stipend support and professional development activities as GMFs.

[11] WPBDC was not evaluated with the AEOP CA portfolio in 2013. Program administrators provided data for 2013 participation, demographics, and website analytics to serve as a baseline for FY14 evaluation.

| Table 4. 2013 AEOP Participation Numbers | | |
|---|---|---|
| CQL | College Qualified Leaders | 260 |
| eCM | eCYBERMISSION | 21,345 |
| GEMS | Gains in the Education of Mathematics & Science | 2,107 |
| HSAP | High School Apprenticeship Program | 29 |
| JSHS | Junior Science & Humanities Symposium | 7,600 |
| JSS | Junior Solar Sprint | 140 |
| REAP | Research & Engineering Apprenticeship Program | 101 |
| SEAP | Science & Engineering Apprentice Program | 101 |
| STPI | STEM Teacher Program Initiatives | 43 |
| UNITE | UNITE | 188 |
| URAP | Undergraduate Research Apprenticeship Program | 61 |
| WPBDC | West Point Bridge Design Competition | 9,500 |
| | **Total 2013 AEOP Participants** | **41,475** |

In 2013, the AEOP had **41,475** unique program participants. The discrepancy in the number of AEOP participants previously reported (66,484) was discovered through AEOP's evaluation efforts that the West Point Bridge Design Competition allowed participants to submit multiple entries to the bridge contest.

## Evaluation and Assessment Strategy

The 2013 AEOP portfolio was assessed by Virginia Tech, the Lead Organization (LO) of the AEOP CA. Virginia Tech assessed ten[12] of the AEOP elements in collaboration with AEOP CA consortium members[13], individual program administrators (IPAs), the Army Cooperative Agreement Managers (CAMs), Army Subject Matter Experts (ASMEs), and personnel responsible for implementing programs at specific sites (lab coordinators, etc.) David Heil & Associates conducted the evaluation for one additional AEOP element. The 2013 AEOP evaluation established baseline evaluations for some AEOP elements and built on evaluations performed in 2012 for others.

In 2012, the Army's vision for the AEOP was revised to include the priorities and objectives presented in Table 5. The 2013 evaluation was informed by these objectives and by the objectives of individual AEOP elements.

| Table 5. AEOP Priorities and Objectives |
|---|
| **PRIORITY ONE: STEM Literate Citizenry** |
| *Broaden, deepen, and diversify the pool of STEM talent in support of our Defense Industry Base.* |
| **Objectives** |
| • Encourage and reward student participation in STEM opportunities. |
| • Inspire students to excel in science and mathematics. |
| • Increase participation of underserved populations in the AEOP. |
| • Expand the involvement of students in ongoing DoD research. |
| • Increase awareness of DoD STEM career opportunities. |
| **PRIORITY TWO: STEM "Savvy" Educators** |
| *Support and empower educators with unique Army research and technology resources.* |
| **Objectives** |
| • Partner with schools and teachers at local and state educational agencies for shared standards in science and mathematics. |
| • Use incentives to promote teacher participation in the AEOP. |
| • Provide online resources for educators to share best practices. |
| • Provide and expand mentor capacity of the Army's highly qualified scientists and engineers. |
| **PRIORITY THREE: Sustainable Infrastructure** |
| *Develop and implement a cohesive, coordinated, and sustainable STEM education outreach infrastructure across the Army.* |
| **Objectives** |
| • Develop and implement cohesive program metrics for each individual program and across all of the AEOP. |
| • Provide STEM educational opportunities for students at all stages of their K-12 education. |
| • Integrate programs in a central branding scheme, inclusive of a centralized website, for a strategic and comprehensive marketing strategy. |
| • Establish a competitive process for funding new STEM investments that align to the overall program strategy. |

[12] The following AEOP initiatives were included in Virginia Tech's 2013 evaluation plan: CQL, GEMS, HSAP, JSHS (National Event and Regional Symposia), JSS, REAP, SEAP, STPI, UNITE, and URAP. David Heil & Associates was contracted by NSTA to conduct the evaluation for eCM.

[13] The 2012 AEOP CA consortium members included the Academy of Applied Science (AAP, JSHS, REAP), American Society for Engineering Education (CQL, GEMS, SEAP), the Technology Student Association (JSS, UNITE), and the University of New Hampshire (STPI). The National Science Teachers Association (NSTA) and the American Society for Engineering Education (ASEE) were identified through competitive RFP processes and joined the Consortium as the new managers of eCYBERMISSION (NSTA) and CQL, GEMS, and SEAP (ASEE) in FY2013. HSAP/URAP is managed by the Army Research Office.

The evaluation established a logic model that proposes a pathway of influence for the AEOP, ultimately linking AEOP inputs and activities to intended outcomes that align with AEOP priorities and objectives. The logic model provides a framework for the near- and long-term AEOP evaluation plan, ensuring that evaluation questions have real value to the AEOP and that evaluation assessments include appropriate measures of intended outputs and outcomes that align with the AEOP's priorities and objectives. Figure 1 below provides a simple graphical depiction of the AEOP Evaluation logic model.

Figure 1. AEOP Evaluation Logic Model

| Inputs | Activities | Outputs | Outcomes (Near-term) | Impact (Mid- and Long-Term) |
|---|---|---|---|---|
| • US Army sponsorship<br>• Broad roster of AEOP initiatives available for student engagement<br>• IPAs providing coordination and oversight of programs<br>• Operations conducted at Army/DoD research facilities, universities, schools, and local/regional and national competitions<br>• Army/DoD and university S&Es, local and DoDEA/DoDDS educators, and other volunteers serving as STEM "mentors"<br>• Online and on-site curricular resources<br>• Stipends and awards for students and educator participants<br>• Centralized branding and comprehensive marketing<br>• Centralized evaluation and annual reporting | Engagement in "authentic" STEM experiences through:<br>• Curriculum-driven summer programs at Army research institutions and universities<br>• Summer and academic year apprenticeship programs at Army research institutions and universities<br>• Local/regional and national STEM competitions<br>• Professional development opportunities for educators | • Increasing numbers and diversity of student and educator (learner) participants<br>• Increasing numbers and diversity of "mentor" participants<br>• Increasing numbers and diversity of Army/DoD scientists and engineers engaged in programs<br>• Increasing numbers of K-college schools served through participant engagement<br>• Increasing number of curricular resources distributed through websites and professional development<br>• Students, educators, "mentors," site coordinators, and IPAs contributing to evaluation | • Increased student interest and engagement in STEM (formal and informal)<br>• Increased participant STEM skills, knowledge, abilities, and confidence<br>• Increased participant knowledge of other AEOP opportunities<br>• Increased participant knowledge of Army/DoD STEM research and careers<br>• Changes in teacher approaches to teaching about STEM concepts, practices, and careers in their classrooms<br>• Implementation of evidence-based recommendations to improve programs | • Increased student participation in other AEOP opportunities and DoD scholarship/ fellowship programs<br>• Increased student interest in and pursuit of STEM coursework in secondary and post-secondary schooling<br>• Increased student interest in and pursuit of STEM degrees<br>• Increased student interest in and pursuit of STEM careers<br>• Increased student interest in and pursuit of Army/DoD STEM careers<br>• Continuous improvement and sustainability of the AEOP |

Given the relative infancy of the AEOP CA and recent adoption of shared AEOP objectives, evaluation has to date focused predominantly on documenting outputs and indications of potential near- and mid-term outcomes through annual evaluations. In 2013 evaluations of AEOP elements addressed questions related to benefits to participants, program strengths and challenges, and overall effectiveness in meeting AEOP and program objectives. In addition, each program evaluation noted which recommendations from previous evaluations had been implemented (evidence-based change) and what changes in participant outputs or outcomes had resulted from those program revisions.

The AEOP element evaluations generally sought to answer these fundamental questions:

**Key Evaluation Questions**

- What aspects of an AEOP motivate participation?
- What aspects of an AEOP's structures, processes, and resources are working well?
- What aspects of an AEOP could be improved?
- Did participation in an AEOP:
  - Increase participants' STEM competencies?
  - Increase participants' interest in or intent for future STEM engagement?
  - Increase participants' awareness of and interest in other AEOP opportunities?
  - Increase participants' awareness of and interest in Army/DoD STEM careers?

The 2013 AEOP evaluation plan is summarized by program in Table 5. In short, most evaluations utilized participant questionnaires, as well as focus groups or interviews with the participant population (herein called participants) and adult participants who led educational activities or supervised research (herein called mentors). Features unique to the assessment of certain programs or program types include the following:

- eCM included assessment of alumni and past winner outcomes and of 2013 program resources, activities, and participant outcomes; for the purposes of the 2013 AEOP portfolio evaluation report, only the 2013 evaluation will be reported here;
- GEMS and UNITE assessment involved pre-program and post-program student questionnaires to enable the measurement of participant growth through the program;
- SEAP, CQL, REAP, HSAP, and URAP assessment incorporated mentor questionnaires and rubrics used by mentors to describe their mentoring activities and measure participant knowledge and ability levels;
- JSS assessment included an analysis of website content and analytics, as well as questionnaires for event host and teachers who voluntarily registered at the JSS website to measure perceived feasibility and value online resources;
- JSHS assessment included questionnaires for both regional and national competitors, as well as regional directors, and national judges; and
- STPI assessment focused on its 2013 STEM Teacher Academy (STA) and incorporated a follow-up questionnaire for 2012 STA participants.

| Table 5. 2013 AEOP Assessment Strategy | | |
|---|---|---|
| **AEOP Element** | **Assessment Tools** | **Program-Level Objectives** |
| CQL | Program Evaluation:<br>• Participant questionnaire<br>• Mentor questionnaire and rubric<br>• Participant focus groups<br>• Mentor focus groups | • To nurture interest and provide research experience in STEM for college students and recent graduates contemplating further studies.<br>• To provide opportunities for continued association with the DoD laboratories and STEM enrichment of previous SEAP, GEMS, and other AEOP program participants, as well as allow new college students the opportunity to engage with DoD laboratories.<br>• To outreach to participants inclusive of youth from groups historically underrepresented and underserved in STEM.<br>• To increase participant knowledge in targeted STEM areas and develops research and laboratory skills as evidenced by mentor evaluation and the completion of a presentation of research (poster, paper, oral presentation, etc.).<br>• To educate participants about careers in STEM fields with a particular focus on STEM careers in DoD laboratories.<br>• To acquaint participants with the activities of DoD laboratories in a way that encourages a positive image and supportive attitude towards our defense community.<br>• To provide information to participants about opportunities for STEM enrichment and ways they can mentor younger STEM students through GEMS, eCYBERMISSION, and other AEOP opportunities. |
| eCM | Program Evaluation:[14]<br>• Alumni study<br>• Longitudinal study launch<br>• Annual evaluation:<br>  ○ Participant questionnaire<br>  ○ Participant focus groups | • To engage students in STEM, spark their interest through online collaborative learning and problem solving challenges, and to keep them engaged in these subjects throughout their K-12 tenure.<br>• To provide a positive learning experience for students, teachers, and Cyberguides to ensure that eCM students enhance/solidify their attitude toward STEM subjects and careers.<br>• To provide teachers a revamped Team Advisor resource guide for classroom integration and to empower them to better advise their students through the project cycle.<br>• To increase students' awareness to STEM careers in the Army and DoD.<br>• To increase program awareness to strategic partners in Army, DoD, and other Federal Agencies as well as academia, non-profits, and industry.<br>• To increase students' knowledge of other educational opportunities offered through the AEOP. |
| GEMS | Program Evaluation:[15] | • To nurture interest and excitement in STEM for middle and high school participants. |

[14] Conducted by David Heil & Associates

[15] An independent research study of the GEMS Near Peer Mentors program was conducted by investigators at Walter Reed Army Institute of Research. Preliminary findings of the research study have been published elsewhere and additional findings are pending publication. For more information, see

| | | |
|---|---|---|
| | • Pre-program participant questionnaire<br>• Post-program participant questionnaire<br>• Participant focus groups<br>• Mentor and teacher focus groups<br>• DoDEA teachers questionnaire | • To nurture interest and excitement in STEM for mentor and teacher participants.<br>• To implement STEM enrichment experiences that are hands-on, inquiry-based educational modules that enhance in-school learning.<br>• To increase participant knowledge in targeted STEM areas and laboratory skills.<br>• To outreach to participants inclusive of youth from groups historically underrepresented and underserved in STEM.<br>• To encourage participants to pursue secondary and post-secondary education in STEM.<br>• To educate participants about careers in STEM fields with a particular focus on STEM careers in Army laboratories.<br>• To provide information to participants about opportunities for STEM enrichment through advancing levels of GEMS. |
| HSAP | Program Evaluation:<br>• Participant questionnaire<br>• Mentor questionnaire and rubrics<br>• Graduate mentoring fellows eWorkshop questionnaire<br>• Participant focus groups<br>• Mentor focus groups<br>• Participant and Mentor phone interviews | • To provide hands-on science and engineering research experiences to high school participants.<br>• To educate participants about the Army's interest and investment in science and engineering research and the associated educational opportunities available to students through the AEOP.<br>• To provide students with experience in developing and presenting scientific research.<br>• To benefit students from the expertise of a scientists or engineer as a mentor.<br>• To develop students’ skills and background to prepare them for competitive entry to science and engineering undergraduate programs. |

Tenenbaum, L., Anderson, M., Jett, M, and Yourick, D. (2014) An innovative near-peer mentoring model for undergraduate and secondary students: STEM focus. *Innovations in Higher Education* (DOI) 10.1007/s10755-014-9286-3) and Anderson, M. & Yourick, D. (in review) Undergraduates in a U.S. Army internship acquire mentoring and instructional skills with pre-college students in the STEM disciplines. *Journal of STEM Education, Innovation and Research*

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|---|---|---|
| JSHS | Regional Symposia Evaluation:<br>• Participant questionnaire<br>• Regional director focus groups<br>• Regional director questionnaire<br>• Regional program reports<br><br>National Symposium Evaluation:<br>• Participant questionnaire<br>• Participant focus groups<br>• National judge questionnaire | • To increase the future pool of talent capable of contributing to the nation’s scientific and technological progress.<br>• To promote research and experimentation in STEM at the high school level.<br>• To recognize the significance of research in human affairs and the importance of humane and ethical principles in the application of research results.<br>• To search out talented youth and their teachers, recognize their accomplishments at symposia, and encourage their continued interest and participation in STEM.<br>• To expose students to academic and career opportunities in STEM and to the skills required for successful pursuit of STEM.<br>• To expose students to STEM careers in Army and/or DoD laboratories.<br>• To recognize innovative and independent research projects of youth in regional and national symposia. |
| JSS | Program Evaluation:<br>• Teacher questionnaire<br>• Event host questionnaire<br>• Website analytics | • To build interest in STEM through JSS for students and offer a national resource for teachers and mentors.<br>• To create an online competition and teaching tools aligned with educational standards.<br>• To market, administer, and evaluate JSS as part of a collaborative portfolio of Army sponsored STEM outreach programs. |
| REAP | Program Evaluation:<br>• Participant questionnaire<br>• Mentor questionnaire and rubrics<br>• Participant focus groups<br>• Mentor focus groups<br>• Participant and mentor phone interviews | • To provide high school students from groups historically under-represented and underserved in STEM, including alumni of the AEOP’s UNITE program, with an authentic science and engineering research experience.<br>• To introduce students to the Army’s interest in science and engineering research and the associated opportunities offered through the AEOP.<br>• To provide participants with mentorship from a scientists or engineer for professional and academic development purposes.<br>• To develop participants’ skills to prepare them for competitive entry into science and engineering undergraduate programs. |

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|---|---|---|
| SEAP | <u>Program Evaluation:</u><br>• Participant questionnaire<br>• Mentor questionnaire and rubric<br>• Participant focus groups<br>• Mentor focus groups | • To acquaint qualified high school students with activities of DoD laboratories through summer research and engineering experiences.<br>• To provide students with opportunities and exposure to scientific and engineering practices and personnel not available in their school environment.<br>• To expose those students to DoD research and engineering activities and goals in a way that encourages a positive image and supportive attitude toward our defense community.<br>• To establish a pool of students preparing for careers in science and engineering with a view toward potential government service.<br>• To prepare these students to serve as positive role models for their peers thereby encouraging other high school students to take more science and math courses.<br>• To involve a larger percentage of students from previously underrepresented segments of our population, such as women, African-Americans and Hispanics, in pursuing science and engineering careers. |
| STPI | <u>Program Evaluation:</u><br>• STA participant questionnaire<br>• 9-month post-STA participant questionnaire | • To enhance K12 STEM teaching and learning through STEM teacher professional development conducted with participation by Army scientists and engineers.<br>• To inform teachers and through them, their students, of STEM occupations and career opportunities offered by the Army.<br>• To inform teachers and through them, their students, of other STEM enrichment opportunities offered by the AEOP.<br>• To increase participation in STEM opportunities by teachers who work in settings with a large number of students from groups that are historically underserved and underrepresented in STEM. |
| UNITE | <u>Program Evaluation:</u><br>• Pre-program participant questionnaire<br>• Post-program participant questionnaire<br>• Participant focus groups<br>• Mentor and teacher focus groups | • To effectively show students the real word applications of math and science.<br>• To raise student confidence in the ability to participate in engineering activities.<br>• To inspire students to consider engineering majors in college<br>• To remove social barriers and negative attitudes about engineering.<br>• To promote collaboration and problem-solving in a team environment.<br>• To increase the number of STEM graduates to fill the projected shortfall of scientists and engineers in national and DoD careers.<br>• To educate students about other educational opportunities offered through the AEOP. |

| | | |
|---|---|---|
| URAP | Program Evaluation:<br>• Participant questionnaire<br>• Mentor questionnaire and rubrics<br>• Graduate mentoring fellows eWorkshop questionnaire<br>• Participant focus groups<br>• Mentor focus groups<br>• Participant and mentor phone interviews | • To provide hands-on science and engineering research experience to undergraduates in science or engineering majors.<br>• To educate students about the Army's interest and investment in science and engineering research and the associated educational and career opportunities available to students through the Army and the DoD.<br>• To provide participants with experience in developing and presenting scientific research.<br>• To provide participants with experience to develop an independent research program in preparation for research fellowships.<br>• To develop students' research skills with the intent of preparing them for graduate school and careers in science and engineering research.<br>• To benefit students from the expertise of a scientist or engineer as a mentor. |

Improvements in the 2013 AEOP evaluation generally focused on attending to 2012 AEOP and element-specific recommendations pertaining to evaluation, including stronger alignment of program evaluation and assessment with AEOP priorities and objectives and expansion from previous focus on Priority 1 to include Priority 2. Existing program-level assessments were reviewed and revised, as needed, by the evaluation team to ensure alignment with AEOP objectives under Priority 1 and to provide common metrics and measures across AEOP or program types where possible, such as in the apprenticeship programs. New items were constructed for focus group and interview protocols and to expand data collection efforts in support of objectives under AEOP Priority 2. Assessments were iteratively reviewed and revised by individual program administrators (IPAs), the Army Cooperative Agreement Managers (CAMs), Army Subject Matter Experts (ASMEs) and evaluators. All assessments were approved by Virginia Tech's Internal Review Board (IRB) for the protection of human research subjects.

Questionnaires were administered in paper-and-pencil and/or electronic format utilizing the Qualtrics© survey software system hosted by Virginia Tech or by Survey Monkey software through David Heil & Associates. Focus groups took place on-site, either at program events or at program host-sites. Phone interviews were conducting during business hours at a day and time agreed upon by both the interviewer and interviewee. Data collection, entry, analysis, and reporting was performed by the Virginia Tech AEOP evaluation team, with the exception of the eCM evaluation conducted by David Heil & Associates. Additional details about Virginia Tech's measures and sampling, data collection and analyses, and reporting and dissemination are provided in Appendix A.

## Study Sample

The evaluation of each element included an analysis of participation in questionnaires, the primary data collection instrument. The response rate and the statistical reliability achieved with each sample, as given by the margin of error at the 95% confidence level, were computed, as shown in Table 6. When the margin of error calculated for a sample exceeded acceptable levels, alternate methods for establishing representativeness were used if at all possible. For example, sample and population demographic data (when available) were compared to determine whether any statistically significant differences existed.

**Table 6. 2013 AEOP Questionnaire Participation**

| Program | 2013 Questionnaire | Sample | Population | Participation Rate | Margin of Error @ 95% Confidence[16] |
|---|---|---|---|---|---|
| CQL | Participant | 94 | 260 | 55% | ±8.1% |
| | Mentor | 22 | 260 | 13% | ±20.3% |
| eCM | Participant | 96 | 21,345 | <1% | ±9.9% |
| | Team Advisor | 76 | 1,049 | 7% | ±10.8% |
| GEMS | Participant | 1501 | 2,038 | 71% | ±1.5% |
| | DODEA Teacher | 5 | 12 | 42% | ±35.0% |
| HSAP | Participant | 15 | 33 | 45% | ±19.0% |
| | Mentor | 18[17] | 16 | 113% | ±0% |
| JSHS | Regional Symposia Participant | 87 | 7600 | <1% | ±10.5% |
| | Regional Director | 40 | 47 | 80% | ±6.0% |
| | National Symposium Participant | 114 | 235 | 49% | ±6.6% |
| | National Judge | 24 | 70 | 34% | ±16.3% |
| JSS | Teacher and/or Event Host | 15 | 120 | 13% | ±23.7% |
| REAP | Participant | 93 | 101 | 92% | ±2.9% |
| | Mentor | 46 | 95 | 48% | ±10.4% |
| SEAP | Participant | 42 | 101 | 40% | ±11.7% |
| | Mentor | 15 | 101 | 14% | ±23.5% |
| STPI | STA Participant | 35 | 43 | 82% | ±7.2% |
| | 2012 9 Month Post-STA Participant | 13 | 52 | 25% | ±23.8% |
| UNITE | Participant | 155 | 188 | 82% | ±3.3% |
| URAP | Participant | 36 | 47 | 77% | ±8.0% |
| | Mentor | 22 | 32 | 69% | ±11.9% |
| Total AEOP Questionnaire Participation | | 2,559 | 33,845 | 8% | ±1.9% |

Findings of the CQL, GEMS, JSHS National Symposium, REAP, SEAP, 2013 STA, UNITE, and URAP participant questionnaires, as well as the JSHS Regional Director questionnaire could be reliably generalized to the respective populations. Readers

[16] "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, 95% of the time, between 42% (47-5) and 52% (47+5) would have selected that answer. A 2-5% margin of error is generally acceptable at the 95% confidence level.

[17] Eighteen individuals self-identified as HSAP mentors in the HSAP mentor questionnaire and rubrics. Discrepancies could be due to other laboratory personnel serving in a mentor capacity for an HSAP apprentice (though not considered mentor-of-record) completing evaluation assessments, incorrect self-identification as an HSAP mentor, or university and ARO record keeping.

were cautioned to generalize other findings with consideration given to the margin of error and triangulation with other data sources or types. Mentors provided important perspective in the evaluation of programs but expanded efforts to encourage and support their participation in program evaluation is a critical need across AEOP evaluation.

Focus groups were conducted at 13 host-sites or events, including four Army research laboratories, eight university sites, and two national events. Sites hosting large or multiple AEOP elements were visited to maximize the number and diversity of interviewees joining focus groups and/or to investigate existing local pipelines (e.g., GEMS-SEAP-CQL, UNITE-REAP, HSAP-URAP). Purposive sampling was used for assembling diverse focus groups when larger populations were available at a site. Convenience sampling was employed when small numbers of participants were available at a site. In total, 289 participants and/or mentors joined focus groups in 2013.

Phone interviews were conducted to maximize qualitative data collection for programs in which on-site visits were not cost-effective—HSAP, REAP, and URAP programs having many sites and with small numbers of participants at each university site. Evaluators purposively sampled from programs' enrollment data to identify phone interview candidates exhibiting geographic, demographics, and STEM interest diversity. When used, phone interviews were employed in addition to onsite focus groups. In total, 42 participants and/or mentors participated in interviews across 30 university sites. Table 7 summarizes focus group and interview participation.

**Table 7. 2013 AEOP Focus Group and Interview Participation**

| Program | 2013 Focus Group and Interview | Focus Group Sample | # Sites | Interview | # Sites |
|---|---|---|---|---|---|
| CQL | Participant | 33 | 4 | | |
| | Mentor | 20[18] | | | |
| eCM | Participant | 16 | National Event | | |
| GEMS | Participant | 44 | 3 | | |
| | Mentor | 17 | | | |
| HSAP | Participant | 3 | 3 | 8 | 10 |
| | Mentor | 6[19] | | 7 | |
| JSHS | Regional Director | 25 | National Event | | |
| | National Symposium Participant | 18 | | | |
| JSS | None | | | | |
| REAP | Participant | 22 | 4 | 6 | 10 |
| | Mentor | 9 | | 6 | |
| SEAP | Participant | 24 | 4 | | |
| | Mentor | 20 | | | |
| STPI | None | | | | |
| UNITE | Participant | 43 | 3 | | |
| | Mentor | 10 | | | |
| URAP | Participant | 5 | 3 | 8 | 10 |
| | Mentor | 6 | | 7 | |
| Total AEOP Focus Group/Interview Participation | | 289 | 13 | 42 | 30 |

[18] Sample represents CQL and SEAP mentors who participated in joint-program focus groups.
[19] Sample represents HSAP and URAP mentors who participated in joint-program focus groups.

# Evaluation Findings

The findings from 2013 program evaluations are grouped according to AEOP priorities and address objectives under each priority.

## Priority One: STEM Literate Citizenry

Most program findings in 2013 provided evidence of the AEOP's success at contributing to the first priority, a STEM literate citizenry. Major trends that support the achievement of this AEOP priority along with evidence from assessment data[20] that informs the findings are presented.

**Finding #1: AEOP provided outreach to 41,312 students through its comprehensive portfolio of programs, yet considerable unmet need exists in many AEOP programs. Across the AEOP participants, mentors, and event directors call for expansion of DoD's unique and effective outreach programs that develop the Nation's future STEM talent.**

AEOP offered a comprehensive portfolio of STEM programs designed to nurture students STEM interests and aspirations throughout their educational career. AEOP includes **STEM competitions** (eCM, JSS, JSHS, and WPBDC; grades 4-12), **summer enrichment programs** (GEMS, UNITE, grades 4-12), and **apprenticeship programs** (CQL, HSAP, REAP, SEAP, URAP, grades 9-college), as well as one AEOP dedicated to **teacher professional development** (STPI). The GEMS near-peer mentors (NPM) and HSAP/URAP graduate mentoring fellows (GMF) programs also provided professional development to undergraduate and graduate student scientists and engineers (S&Es)-in-training, who lead educational activities and supervise apprenticeship research projects, respectively.

In 2013 AEOP provided outreach to **41,312 students** who participated in AEOP activities and/or used AEOP resources. This outreach included awarding 621 apprenticeships (CQL, HSAP, REAP, SEAP, URAP); 923 participant awards, 35+ mini-grants, and 53 travel awards for national competition participants (eCM); 165 participant awards, 47 teacher awards, and 235 travel awards for national competition participants (JSHS); and 2,226 weekly stipends to offset the expense of participant travel and meals (GEMS, UNITE). In addition, **2,289 teachers** and **3,490 S&Es e**ngaged in AEOP programs as participants, led educational activities or supervised research (herein called mentors), or served as competition advisors, judges, event hosts or other volunteers. These data do not reflect others who may have been impacted within the organizations of those served or serving in the AEOP. These data do not reflect the potentially broader and undetermined impact of AEOP's online educational resources made freely available through eCM, JSS, and WPBDC, or those resources available to GEMS NPMs and GEMS resource teachers. While largely undocumented, potential impact may be inferred from website analytics, such as JSS' 1552 unique views of educational resources, or WPBDC's 190,391 downloads of its bridge design software. AEOP has considerable reach in its formal programming. But, translation of AEOP experiences to the

[20] The extent to which assessment data may be generalized from the respondent sample to the respective population is discussed in the Study Sample. Findings of CQL, GEMS, JSHS National Symposium, REAP, SEAP, 2013 STA, UNITE, and URAP participant questionnaires, as well as the JSHS Regional Director questionnaire could be reliably generalized to the respective populations. Readers were cautioned to generalize other findings with consideration given to the margin of error and triangulation with other data sources or types.

organizations of the participants, teachers, and S&Es, as well as uptake of online educational resources in classrooms and extracurricular activities expand AEOP's reach even further.

Despite its reach, considerable unmet need exists in many AEOP elements. Many AEOP programs had greater applicant pools than could be accomodated in program placements: CQL -588 applications received for 260 positions; GEMS – 4,231 applications received for 2,107 positions; REAP 1500 applications received for 101 positions; SEAP-814 applications received for 101 positions; and UNITE received 434 applications for 188 positions. eCM had 9,161 and WPBDC had 1529 participants that did not submit their projects for competitive review and had they competed, would have required greater program resources to accommodate; GEMS had 47 who participated without stipend at one site.

Across the AEOP, participants and mentors consistently recommended program expansion as a priority for future programming. Expansion was defined in a variety of ways, including the following

- Increasing programs' geographic reach, including offering activities at more sites and/or offering provisions to support participants from schools or districts at a distance from existing sites;
- increasing programs' staffing capacity to address the considerable unmet need at existing sites (too many students for too few spots);
- increasing programs' outreach to schools and communities currently not served by AEOP programs, especially those with higher proportions of historically underserved and underrepresented populations in STEM;
- increasing programs' outreach to teachers currently not served by AEOP programs, especially in an effort to attract and support the successful participation of diverse student populations in AEOP programs;
- increasing numbers of apprenticeships and/or laboratories funded at university sites and formal opportunities for building participant "learning communities" at and across sites;
- increasing programs' repertoire of offerings to include a broader range of relevant and interesting STEM subject matter; and
- increasing programs' visibility locally and nationally to better showcase the DoD's unique and effective outreach programs that develop the nation's future STEM talent.

**Finding #2: AEOP provided outreach to participants from underserved and underrepresented groups, but some programs were more effective at this than others. Even the strongest pipelines have limited success retaining underserved and underrepresented populations.**

AEOP programs implemented a range of program- and site-level mechanisms intended to attract participants from populations that are historically underserved and underrepresented in STEM, those being females in certain STEM disciplines, racial or ethnic minority groups (e.g., American Indian or Alaskan Native, Black or African American, and Hispanic or Latino groups), and low-income groups. Across the AEOP efforts included targeted marketing via electronic, print, phone, and in-person communications and/or partnerships with agencies and organizations serving underserved and underrepresented groups, including

- tribal, rural, and urban K-12 districts, schools, and teachers;
- community groups (e.g., Girls and Boys clubs);
- minority serving institutions (MSIs) and historically black colleges and universities (HBCUs);

- professional organizations (e.g., 100 Black Men);
- state level agencies (e.g., South Dakota Office of Indian Education, Oceti Sakowin Education Consortium); and
- regional and national societies promoting STEM educational opportunities for minority groups (e.g., Southeastern Consortium for Minorities in Engineering, Society for the Advancement of Chicanos & Native Americans in Science, National Association of State Boards of Education).

These mechanisms not only diversify individual programs, but in the case of programs serving lower grade levels (eCM, GEMS, JSS, WPBDC) are intended to establish a base for inspiring and developing talented female, minority, and low-income students who are competitively eligible for more technical AEOP programs in high school (e.g. JSHS, SEAP) and college (e.g., CQL, URAP). Deliberate cross-promotion of programs to talented students from underserved or underrepresented populations are objectives of the GEMS-SEAP-CQL pipeline, as well as in the UNITE-REAP pipeline, piloted in 2013 (e.g., two UNITE alumni at each host site were advanced to REAP apprenticeship at the same site).

The success of these mechanisms in terms of expanding the participation of underserved groups in AEOP elements and retaining these students in local or AEOP-wide pipelines is, however, inconclusive. In 2013 and years prior the collection of participant demographic data (from applications) was not standardized across AEOP, including inconsistency in what demographic characteristics were collected, what categories where used within a demographic characteristic, and how or whether these data were collected. The evaluation data may provide the most consistent estimate for longitudinal and cross-AEOP comparisons of participant demographics, yet the reliability of these data are currently dependent upon response rates to evaluation questionnaires. In 2013 participant questionnaire samples were considered generalizable to the respective population through reliability statistics or alternative means for all programs except HSAP and Regional JSHS. However most 2012 program evaluations had less reliability due to low participation in evaluation assessments, the exceptions being GEMS and UNITE.

**Table 8. 2012 and 2013 Participant Demographics**

| | Females | | Racial & Ethnic Minorities | | Free or Reduced Lunch | |
|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 |
| CQL | NA | 35% | NA | 15% | | |
| eCM | NA | 36% | NA | 47% | NA | NA |
| GEMS | 46% | 47% | 25% | 31%* | 11% | 12% |
| HSAP | 14% | 8% | 14% | 38% | 14% | 18% |
| JSHS-Regl | NA | 64% | NA | 13% | NA | 19% |
| JSHS-Natl | 53% | 57% | 1% | 9%* | XX | 10% |
| REAP | 43% | 60%* | 21% | 50%* | 14% | 27%* |
| SEAP | 43% | 30% | 10% | 6% | 0% | 0% |
| UNITE | 60% | 61% | 84% | 81% | 16% | 47% |
| URAP | 38% | 14% | 19% | 11% | | |
| WPBDC | NA | 26% | NA | 37% | NA | NA |

* = $p < 0.05$

Table 8 summarizes participant demographics collected through evaluation in 2012 and 2013. These data indicate that in 2013 AEOP programs served participants identifying with groups that are historically underserved and underrepresented in STEM. While comparisons of 2012 and 2013 participant demographic data suggests that several AEOP elements have made progress toward this objective, in most cases, the lower reliability of 2012 evaluation data do not allow for conclusive determinations. GEMS provided the most conclusive evidence of success, with a statistically significant increase (+5%) in Black or African American participants, likely linked to one site's local partnership with the 100 Black Men organization. Despite the low reliability of 2012 REAP demographic data, the program's shift back to serving primarily underserved and underrepresented populations in 2013 reasonably produced statistically significant expansion.

To understand whether AEOP is successful at retaining students in the pipeline, past participation in AEOP programs is documented across all programs (see Priority 3 findings). The GEMS-SEAP-CQL pipeline likely provides the strongest example of AEOP efforts to retain participants in local pipelines, and for this reason, is the most appropriate for studying the retention of underserved and underrepresented populations. Table 9 summarizes the demographic data from 2013 GEMS, SEAP, and CQL participants who reported past participation in the GEMS-SEAP-CQL pipeline. These data suggest that many minority and low-income participants move through the beginning-intermediate-advanced pipeline of GEMS levels, but only a small proportion of those move into and through the SEAP-CQL pipeline.

**Table 9. 2013 Participants' Longitudinal Participation by Demographics**

| Current Participation | Past Participation | Freq. (%) | Females | Racial & Ethnic Minorities | Free or Reduced Lunch |
|---|---|---|---|---|---|
| GEMS | GEMS | 421 (30%) | 46% (n = 188/413) | 28% (n = 117/412) | 9% (n = 38/410) |
| SEAP | GEMS | 10 (24%) | 50% (n = 5/10) | 10% (n = 1/10) | 0% (n = 0/10) |
| | SEAP | 9 (21%) | 22% (n = 2/9) | 22% (n = 2/9) | 0% (n = 0/10) |
| CQL | GEMS | 10 (10%) | 20% (n = 2/10) | 0% (n = 0/10) | |
| | SEAP | 22 (24%) | 36% (n = 8/22) | 5% (n = 1/22) | |
| | CQL | 16 (17%) | 38% (n = 6/16) | 13% (n = 2/16) | |

In focus groups and interviews, AEOP participants, mentors, and event directors suggested the critical importance of expanding programs' inclusion of underserved and underrepresented populations. Participants of REAP and SEAP, for example, encouraged programs to broaden recruitment to capture interested, motivated, and creative students who may not yet be high STEM achievers in the traditional sense (e.g., GPAs, test scores, honors/AP tracks). They suggested recruiting from schools other than high-performing STEM charter or magnet schools. Mentors in GEMS and JSHS Regional Directors emphasized the importance of "boots on the ground" recruiting from schools in dense urban areas and remote rural locations that serve high populations of minority and low income students.

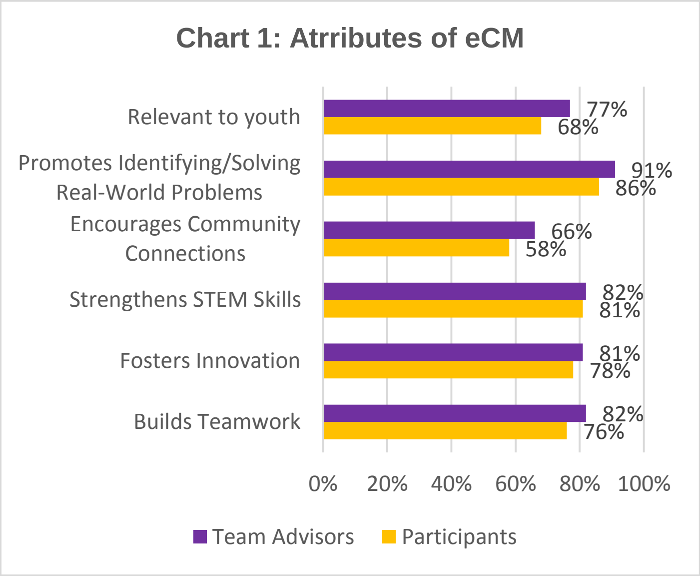
Beyond recruiting, however, mentors and event directors especially described a number of challenges they perceived that potentially hinder participation of underserved and underrepresented populations. Mentors reported that schools and teachers serving underserved populations are often under-resourced; in order to better support students' participation in AEOP elements (especially competition programs) they may need materials and equipment, professional development to support program integration with curriculum, funds for travel or substitutes, and stronger networks with STEM professionals to assist students in finding appropriate mentors. Participants and mentors shared that underserved students often have less access to STEM professionals who can serve as mentors; less access to technology, laboratories, and other resources needed to conduct research; no, limited, or less reliable travel options; and may need more remediation of knowledge and skills and more confidence-building (which often require longer-term engagement), and more competitive wage-earning options during summer months. Mentors and event directors suggested that beyond recruitment, mitigation of these challenges are needed in order that underserved students can both feasibly *and* successfully participate in AEOP.

eCM's mini-grant program provides a model for how AEOP might shift from a vision of equal support to one of more equitable support to ensure their participation is both feasible *and* successful. eCM offered a mini-grant program to teachers and schools with award amounts differentiated by number of students participating at a school and the proportion (%) of students at the school receiving free or reduced lunch (FRL). The mini-grants were advertised broadly, but also targeted specific urban districts with high populations of underserved and underrepresented students. In addition to mini-grants, eCM offers a suite of teacher supports, including teacher-developed online teacher advisor resource guide, online discussion forum with access to volunteers and Cyberguides, and program administrator-hosted webinars and professional development. The mini-grant and teacher supports were intended to affect critical mass at school and increase classroom integration. In 2013, 35+ teachers were awarded mini-grants for classroom integration of eCM. Similar efforts are likely needed across AEOP programs in order to achieve this objective, and more expanded collection of participant demographic and outcomes data are needed to understand whether these efforts are successful.

**Finding #3: AEOP provided participants with frequent exposure to real-world, hands-on, and collaborative STEM activities, which are less frequently available in their regular schools. Balancing hands-on *and* minds-on STEM activities is a promising practice that may produce greater student affective and achievement outcomes than hands-on activities alone.**

AEOP aims to engage participants in opportunities to explore STEM topics, practices, and careers through real-world, hands-on, and collaborative STEM activities that participants typically do not experience in school.

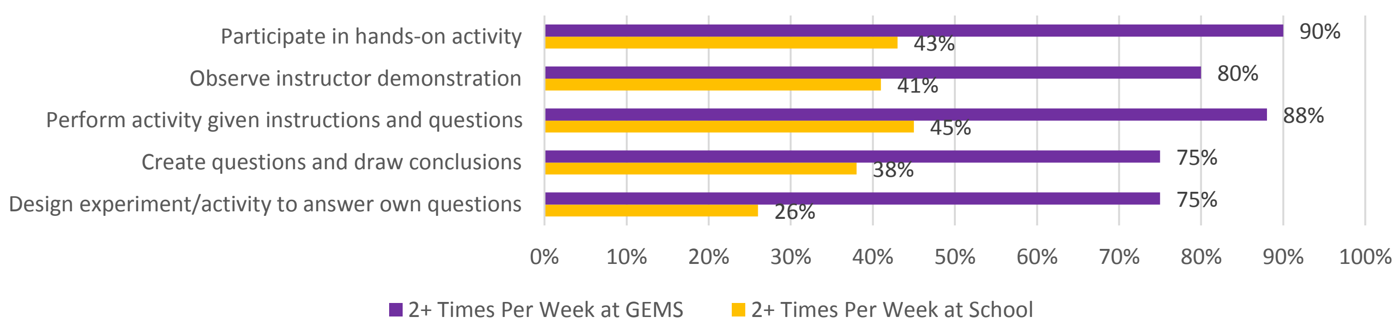
eCM participants and team advisors rated different attributes that eCM strives to embody, including relevant to youth, promotes solving real-world problems, strengthens STEM skills, and builds teamwork. As illustrated in Chart 1, the majority of eCM participants and team advisors agreed that these characteristics eCM "very well." In addition, when participants were asked to list three things they gained from participating in eCM, the top response was "teamwork" or how to work well as part of a team, followed closely by "life skills".



Evaluation assessments for CQL, GEMS, HSAP, REAP, SEAP, URAP provided comparisons between participants' perceptions of the nature and frequency of opportunities to engage in authentic STEM activity in their AEOP as compared to school.

For example, Chart 2 summarizes the proportions of GEMS students responding "2-3 times per week," "everyday," and "multiple times a day" data for five different STEM activities, some more "authentic" and others more characteristic of commonplace classroom instruction. Significantly greater proportions reported frequent opportunities to do *all* activities in GEMS as compared to in school, with a moderately strong to very strong effects observed. The largest differences and strongest effects are found in the items that involve participating in hands-on activities (first and third item), and opportunities to decide how to carry out experiment or activity to answer ones' own question (fifth item)—generally considered a challenging, minds-on activity in STEM.

**Chart 2: Participants' engagement in authentic STEM activities GEMS vs. School**




Similar comparisons made in the five apprenticeship programs are reported in Table 10. In this case, the proportions of participants reporting "4-5 times per week," "everyday," and "multiple times a day" in the AEOP vs. in their high school or college STEM coursework are summarized. Statistical significance is noted (*) and the range of effect sizes provided.

| Table 10. Apprenticeship Participants Reporting Authentic STEM Activities (4-5 Times Per Week or More) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Authentic STEM Activity** | **CQL** | **School** | **HSAP** | **School** | **REAP** | **School** | **SEAP** | **School** | **URAP** | **School** |
| **Define research question** | 35%* | 16% | 50% | 23% | 42%* | 17% | 35%* | 14% | 27%* | 10% |
| **Complete literature review** | 43%* | 25% | 50% | 31% | 50%* | 33% | 43% | 16% | 32% | 18% |
| **Critically evaluate information** | 50%* | 36% | 42% | 38% | 58%* | 34% | 37% | 39% | 48%* | 27% |
| **Organize and synthesize information** | 53% | 46% | 50% | 46% | 58%* | 42% | 42% | 33% | 35% | 21% |
| **Use published works ethically** | 41% | 31% | 50% | 38% | 56%* | 33% | 32% | 24% | 24% | 15% |
| **Work on a project team** | 69%* | 38% | 58% | 38% | 68%* | 30% | 66%* | 20% | 68%* | 39% |
| **Use science/ engineering equipment** | 61%* | 19% | 67%* | 8% | 64%* | 12% | 58%* | 10% | 63%* | 9% |
| **Clean and care for equipment** | 59%* | 24% | 58%* | 17% | 56%* | 24% | 55%* | 18% | 49%* | 9% |
| **Calibrate equipment** | 29%* | 18% | 42%* | 8% | 48%* | 16% | 36%* | 10% | 37%* | 9% |
| **Create solutions for experiments** | 29% | 16% | 25% | 17% | 47%* | 15% | 35% | 8% | 32%* | 9% |
| **Safely handle equipment/materials** | 71%* | 39% | 75%* | 33% | 75%* | 44% | 62%* | 39% | 50%* | 32% |
| **Use advanced measurement techniques** | 61%* | 26% | 67%* | 8% | 61%* | 23% | 58%* | 16% | 57%* | 18% |
| *Range of significant effects* | *d=.250-.636* | | *d=.634-1.44* | | *d=.236-.936* | | *d=.417-.964* | | *d=.359-.948* | |

*= $p < 0.05$, $d > .25$ = very weak but important, $d > .3$ = weak, $d > .5$ = moderate, $d > .7$ = strong, $d > .9$ = very strong

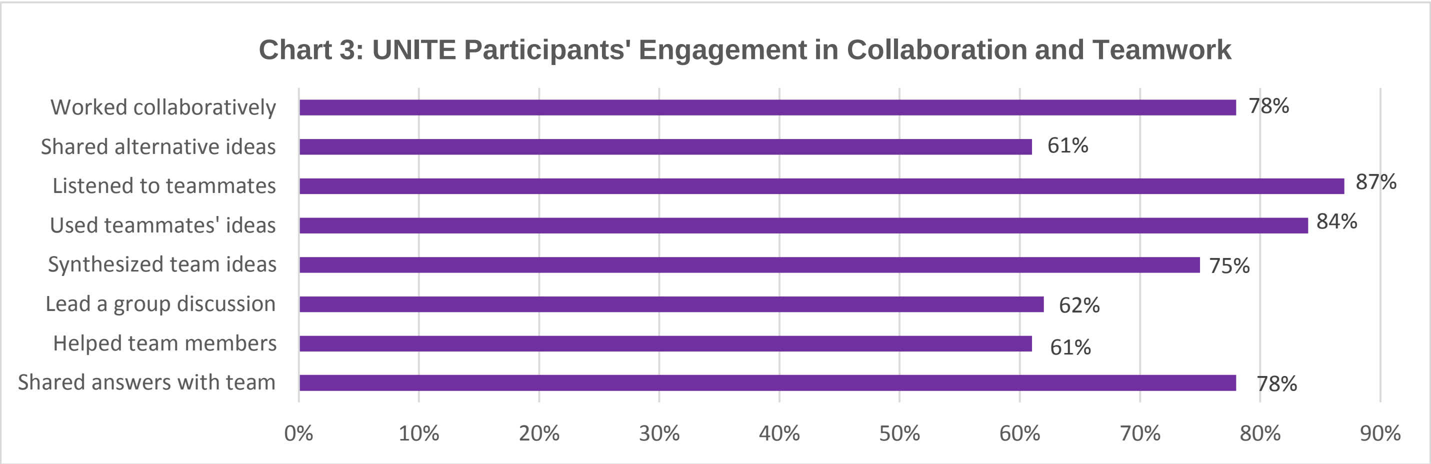
Across these AEOP programs, participants reported more frequent opportunities to engage in authentic STEM activities during their AEOP programs than in their schools. The differences in frequency of these activities occurring in AEOP programs and in school are statistically significant across many items (and in one program, all) with effects ranging from weak to very strong. The comparisons also reveal that AEOP programs have a greater effect in providing apprentices with opportunities for hands-on activities than it did the academic (minds-on) activities. In other words the number of significant differences and the magnitude of differences were greater for hands-on activities than minds-on activities.

Minds-on STEM activities have been linked to greater student affective and achievement outcomes than hands-on activities alone.[21] [22] Balancing hands-on activities with opportunities for participants to engage in minds-on STEM activities, such as generating questions or defining problems, designing experiments to test hypotheses and solutions, analyzing and interpreting data, and formulating conclusions about their hypotheses and solutions, may offer more challenging and engaging activities for especially older participants and alumni (repeat participants) who tend to exhibit less change in both competency and affective outcomes. For example, one GEMS program culminated with investigations conducted by participant teams, in which they applied their new learning in forensics to solve a case. Two UNITE sites that evaluators visited used weekly challenges and/or competitions to engage participant teams in applying the learning of that week to complete a "mission" or to improve and test their engineering designs. Apprenticeship programs were rich with examples of participants applying new STEM learning to design and conduct experiments that advanced the work of the laboratory. Participants and their mentors found these activities to be challenging and engaging opportunities that allowed participants the satisfaction of immediately see the real-world application of their new learning.

AEOP participants also have opportunities to engage in collaboration and teamwork—critical activities that develop transferrable competencies. Eight items in the post-UNITE questionnaire measured participants' perceptions of their engagement in collaboration and teamwork during UNITE (Chart 3). Most UNITE participants engaged in the various collaborative behaviors multiple times per week during UNITE. UNITE participants in all three focus groups reported that hands-on activities provided especially positive experiences to learn about working on teams, including practicing

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

[22] Maltese, A.V. & Tai, R. H. (2011) Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education Policy* 98, 877-906



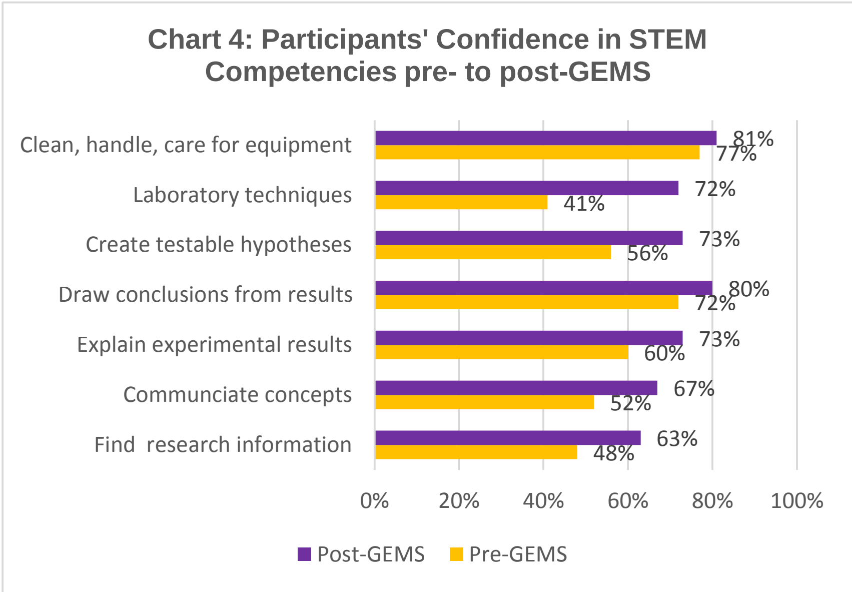

communication skills, delegating roles based on expertise, explaining using STEM principles, and problem-solving as teams—very atypical activities in their regular school setting.

In questionnaires, focus groups, and interviews, participants and mentors frequently reported that AEOP's greatest benefit is in providing opportunities for participants to engage in authentic STEM activities that are not typically available in school experiences, and, through these activities opportunities to develop or expand their STEM and transferrable competencies and confidence. Even JSHS participants, whose participation is less structured or prescribed than in other AEOP programs, reported opportunities to learn and/or apply foundational knowledge in STEM, STEM research practices, laboratory skills, written and oral presentation skills, and critical thinking skills through their research endeavors. Furthermore, their interactions with peers at regional and national symposia promote STEM discourse, collegiality, and collaboration.

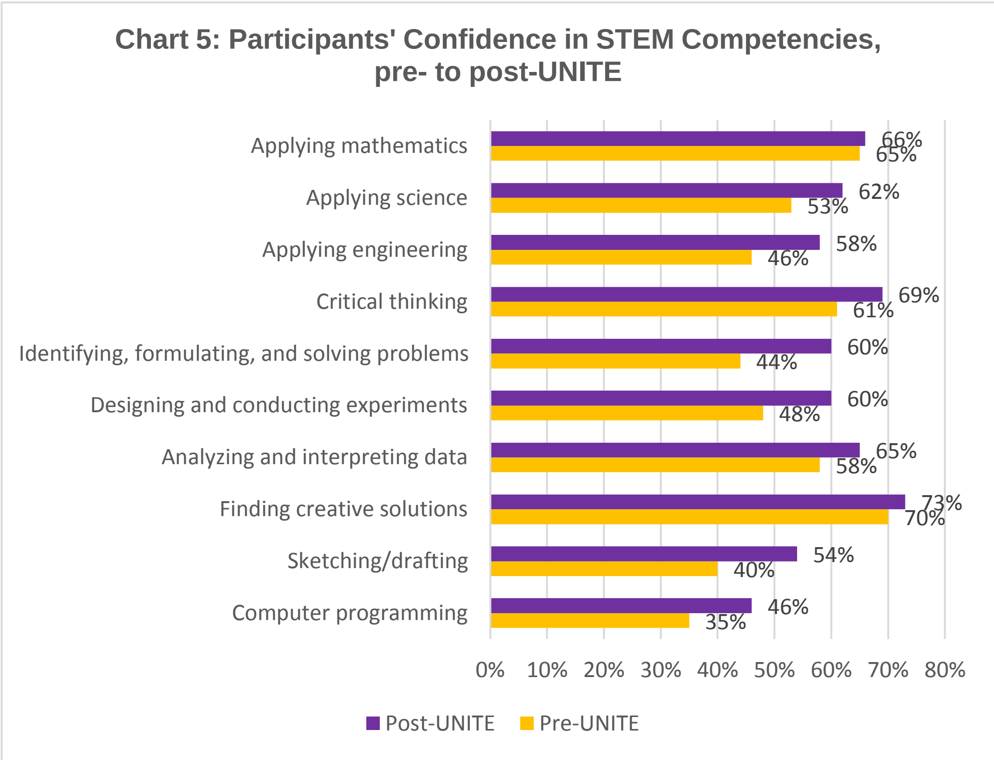
**Finding #4: AEOP participants and their mentors perceived that AEOP experiences improved their STEM-specific and transferrable competencies and confidence. Improvements in confidence related to hands-on skills and abilities are consistent with the frequency with which participants reported engaging in related activities during the program, further supporting the recommendation to balance hands-on and minds-on STEM activities in program activities.**

AEOP not only intends to inspire interest and engagement in STEM, but to develop students STEM-specific and transferrable knowledge, skills, and abilities and confidence to appropriately apply them. Across AEOP elements, evaluations assessed students' confidence in their STEM-specific and transferrable competencies. Apprenticeship programs also included rubrics that mentors used to assess the level of competency apprentices demonstrated in their work and presentations.

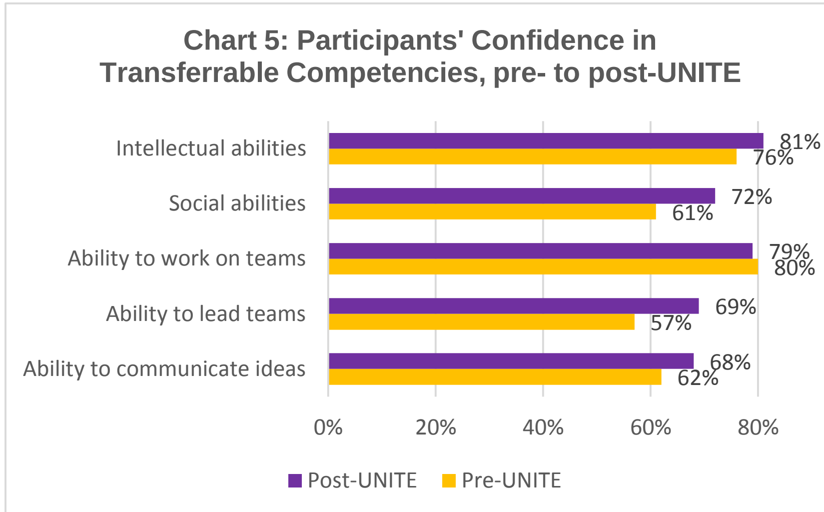
Seven items elicited GEMS participants' confidence in STEM competencies from pre- to post-GEMS. Chart 4 suggests that students have higher confidence in their STEM knowledge, skills, and abilities after GEMS. The proportions of students claiming the statement is "true of me" or "very true of me" increased across all seven skills and abilities, with the largest increase observed for knowledge of laboratory techniques (+31%) and the smallest for drawing conclusions from results (+8%). Pre- to post-GEMS comparisons using matched pairs data revealed significant changes in all items, though generally weak in effect. However, a strong effect is observed with students pre- to post-GEMS assessments of their knowledge of laboratory techniques.

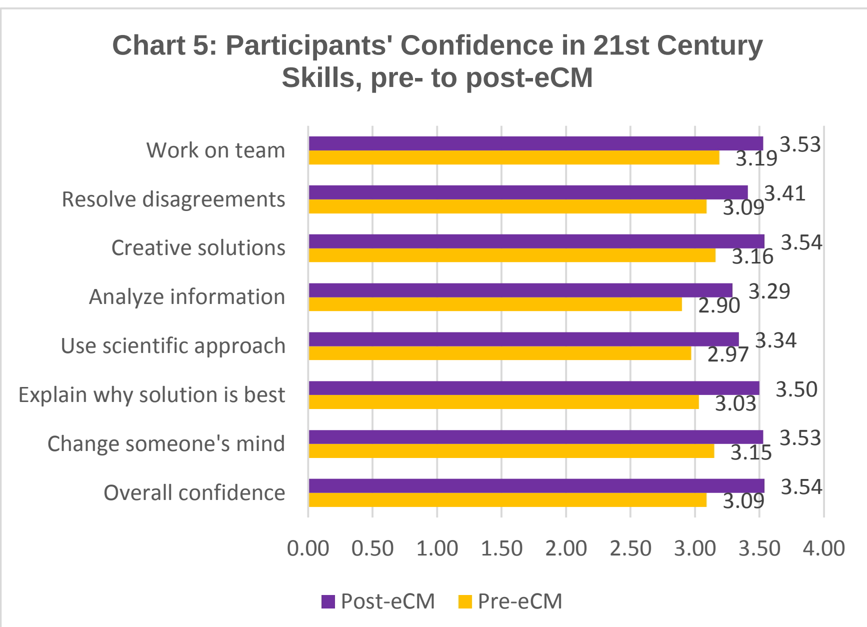



Similar items were used in UNITE evaluations, framed as engineering competencies aligned with standards of the Accreditation Board for Engineering and Technology. Shown in Chart 5, the proportions of students claiming the statement is "true of me" or "very true of me" increased across all skills and abilities. These data suggest growth in students' perceptions of confidence in their engineering skills and abilities from pre- to post-UNITE, with the largest change in abilities to identify, formulate, and solve problems (+16%), and the smallest change in ability to apply mathematics (+1%). Pre- to post-UNITE comparisons with matched pairs data indicate high confidence levels before and after participating in the UNITE program, and only significant change in confidence to identify, formulate, and solve problems and in sketching or drafting skills.



UNITE participants also self-assessed their transferrable competencies before and after participating in UNITE (Chart 6). Across all but one item the proportions of students' claiming the statement is "true of me" or "very true of me" increased, with the largest increases in confidence around social abilities and abilities to lead teams. Although a smaller proportion of students were confident in their ability to work on teams after UNITE, these data generally suggest growth in students' perceptions of confidence in their collaborative skills from pre- to post-UNITE. A comparison of matched pairs data revealed that student confidence in social abilities increased significantly from pre- to post-UNITE with a weak effect.




eCM participants rated their confidence in their ability to use seven 21st Century Skills—which integrate discipline-specific and transferrable competencies—on a 4-point scale of 1 = "not confident" to 4 = "very confident", before and after eCM. As shown in Chart 5, eCM participants reported greater confidence across all items following their participation in eCM, and all increases were statistically significant.

Participants of apprenticeship programs (CQL, HSAP, REAP, SEAP, and URAP) were asked whether they had more confidence across a range of STEM-specific competencies and the transferrable competency of teamwork after the program experience. In addition, mentors rated participants' skill and ability levels using rubrics reflecting a range of proficiency on a 6-point continuum representing "novice" to "expert" behaviors. Table 11 summarizes participant and mentor data across apprenticeship programs. The majority of participants (55%-87% responding "like me" or "just like me") perceived having more confidence across the range of skills and abilities after participating in the AEOP. Larger proportions gained confidence to safely and effectively use the laboratory, analyze data and understand results, and contribute to the research team. The majority of mentors rated their apprentice's skills and abilities in the "near expert" or "expert" levels of the proficiency continuum for all skills and abilities. Mentors more frequently gave higher ratings for teamwork and collaboration and quantitative literacy skills and abilities. Across all programs we found considerable agreement between participants' perceived growth in confidence and mentors' assessment of those STEM skills and abilities.

| Table 11. Apprenticeship Participants' STEM Competencies | | | | | |
|---|---|---|---|---|---|
| **Participants' "Like me" or "Just like me" Confidence Ratings** | **CQL** | **HSAP** | **REAP** | **SEAP** | **URAP** |
| **Review academic literature** | 68% | 42% | 63% | 65% | 72% |
| **Formulate hypotheses and design experiments** | 71% | 75% | 67% | 58% | 69% |
| **Safely and effectively use a laboratory** | 83% | 66% | 80% | 76% | 71% |
| **Perform equipment calibration and lab techniques** | 70% | 67% | 69% | 64% | 63% |
| **Analyze data and understand results** | 83% | 67% | 87% | 79% | 77% |
| **Account for limitation and assumptions in conclusions** | 81% | 67% | 75% | 76% | 63% |
| **Contribute to research team** | 86% | 55% | 82% | 76% | 80% |
| **Mentors' "Near Expert" or "Expert" Skills/Abilities Ratings** | **CQL** | **HSAP** | **REAP** | **SEAP** | **URAP** |
| **Information literacy** | 53% | 69% | 56% | 53% | 72% |
| **Scientific reasoning** | 67% | 73% | 62% | 47% | 72% |
| **Laboratory skills** | 62% | 58% | 56% | 53% | 79% |
| **Data collection** | 57% | 61% | 52% | 48% | 66% |
| **Quantitative literacy** | 70% | 69% | 72% | 59% | 73% |
| **Teamwork and collaboration** | 91% | 74% | 63% | 59% | 80% |

*= $p < 0.05$ for CQL-URAP comparison, or SEAP-REAP comparison

Taken together, it can be concluded that AEOP programs impact students' confidence in their STEM and transferrable competencies, and, in the apprenticeship programs, mentors' assessments of their performance corroborates those findings. Often the largest shifts in confidence were seen in skills and abilities related to hands-on aspects of STEM activity and in teamwork or collaboration. This is consistent with assessments of the frequency with which participants reported engaging in related activities during the program. When asked in focus groups and interviews to describe the benefits of participating in AEOP programs, participants and mentors alike responded that AEOP programs expand participants' STEM competencies (e.g., including laboratory skills, scientific reasoning, information literacy, scientific writing and presentation skills, programming skills), transferrable competencies (e.g., learning to work independently and collaboratively as a member of a project team, critical thinking, problem solving) and confidence to apply those competencies in authentic situations.

**<u>Finding #5:</u> AEOP expanded the number of participants engaged in ongoing DoD research, and exposed many others to DoD STEM interests. These efforts serve to improve participants' understanding of and attitudes toward DoD STEM research and researchers.**

AEOP contributes to and highlights the DoD STEM research interests through program activities that engage participants in or provide meaningful exposure to DoD research. Table 12 summarizes some of these efforts in 2013.

| Table 12. 2013 Participant Engagement in and Exposure to DoD Research | |
|---|---|
| **AEOP** | **Engagement in DoD Research** |
| CQL, SEAP | **361** high school and undergraduate participants serving as apprentices on DoD research projects at Army or DoD research laboratories. |
| HSAP, URAP | **71** high school and undergraduate participants serving as apprentices on DoD research projects at university research laboratories; **19** GMFs providing supervision of participants in apprenticeships. |
| GEMS | **2,038** elementary, middle and high school participants, **69** undergraduate NPMs, and **45** local and DoDEA teachers were engaged in DoD research through GEMS activities hosted by DoD research laboratories. |
| **AEOP** | **Exposure to DoD Research** |
| eCM | **52** participants and their **16** team advisors/chaperones (in-service teachers) were exposed to DoD research through the National Judging & Educational Event activities. NJ&EE programming included STEM Tech Expo and invited speakers who highlighted DoD research. Army Corner, highlighting Army STEM research and careers, and was publically accessible at the eCM website. |
| JSHS | **215** participants and their **93** competition advisors/chaperones were exposed to DoD research through the National Symposium activities. National JSHS programming included a STEM Showcase and invited speakers who highlighted DoD research. |
| UNITE | **153** high school participants and **148** program mentors participated in career day events that included learning about the work of DoD STEM personnel and/or DoD research facilities. |
| STPI | **43** participants (in-service teachers) learned about discipline-specific research being conducted through their 6 DoD professional development providers; teachers translated their learning into grade-level appropriate lessons that were to be used with students in their classrooms. |

In the most proximal sense, programs like CQL, HSAP, SEAP, and URAP engage participants in DoD research projects as apprentices. Apprentices make meaningful contributions to the DoD research project as they develop professionally through their mentored research experiences. In GEMS, DoD S&Es or NPMs under the mentorship of an S&E translate DoD research into grade level appropriate educational activities for GEMs participants. These participants engaged in ongoing DoD research through specific activities of AEOP programs designed to expose students to "real world" research through the questions and problems addressed by DoD researchers and their research. In 2013, **2,603** participants and local and DoDEA teachers engaged in DoD research projects, an increase of 16% over the 2,245 participants in 2012. More distal to DoD research, a number of AEOP elements implemented activities to expose more participants to the DoD's STEM research interests. AEOP elements implemented activities that highlighted cutting edge research and careers with the DoD—Expos, laboratory tours, expert panels, and professional development activities linking school curricular topics to DoD research.  At least **720** participants, local teachers, university faculty and students, and other volunteers were exposed to DoD research through these kinds of activities. Many more participants are likely to have been exposed to DoD STEM research through AEOP program activities that were not as well documented as these, such as the JSHS Regional Symposia which garnered participation of 23 DoD research laboratories or installations.

Evaluations of apprenticeship programs captured mentors' activities that were intended to expose participants to DoD STEM research programs (presumably beyond that in which apprentices engaged) and the potential outcomes of that exposure to DoD STEM research. Table 13 summarizes mentors' efforts to expose participants to DoD research programs, as well as participants' attitudes toward Army/DoD research and researchers. In all cases, the proportion responding "agree" or "strongly agree" are given. The majority of participants credited AEOP with improving their understanding Army/DoD STEM contributions (51%-87%) and agree that Army/DoD research and researchers have made valuable contributions to science and engineering fields and to society (71-92%). Comparisons of participant responses from AEOP elements at DoD research laboratories (CQL, SEAP), DoD-sponsored university laboratories (HSAP, URAP), and non-DoD affiliated university laboratories (REAP) suggest that experiences at DoD research laboratories generated significantly greater understandings of and positive attitudes toward DoD research than engagement in DoD-sponsored university laboratories (CQL vs. URAP) and non-DoD affiliated university laboratories (e.g., SEAP vs. REAP).

| Table 13. AEOP Participants' Exposure to and Attitudes about DoD STEM Research | | | | | |
|---|---|---|---|---|---|
| **Mentors' Activities** | **CQL** | **HSAP** | **REAP** | **SEAP** | **URAP** |
| **During [Program], I provided information to my apprentice(s) about civilian research programs within the Army/DoD** | 45% | 39% | 24% | 67% | 27% |
| **Participants' Perceptions** | **CQL** | **HSAP** | **REAP** | **SEAP** | **URAP** |
| **The Army/DoD has made many important contributions to science and engineering with applied research** | 92%* | 91% | 78% | 92%* | 79% |
| **Army/DoD researchers contribute much more to society than just "warfare" advancements** | 88%* | 81% | 73% | 84% | 71% |
| **Army/DoD researchers use cutting-edge technology to solve the world's problems** | 89% | 72% | 73% | 84% | 78% |
| **I would feel very comfortable taking a civilian job with the Army/DoD because their work is valuable to society** | 83% | 81% | 57% | 85%* | 74% |
| **After [Program] I have a better understanding of the important contributions that Army/DoD researchers have made everyday civilian life** | 85%* | 72% | 51% | 87%* | 66% |

*= $p < 0.05$ for CQL-URAP comparison and SEAP-REAP comparison

**<u>Finding #6</u>: AEOP exposed participants to Army and DoD STEM careers, but some elements were more effective at this than others. Direct engagement with Army and DoD STEM researchers and/or facilities during program activities are the most promising practices. Across AEOP mentors call for comprehensive resources that will improve their awareness of exciting Army and DoD STEM research and careers and that better support their efforts to encourage participants to consider careers with the DoD.**

Efforts to expose participants to Army/DoD's STEM research interests also serve to emphasize a variety of STEM careers, including those with the Army and DoD, that use and apply similar knowledge, skills, and abilities to those students learn through program activities. In addition to efforts listed in Table 12, mentors themselves use different strategies to expose participants to a variety of STEM careers, including Army/DoD STEM careers. Mentors at one GEMS site described that lessons culminate with information that helps them connect Army/DoD jobs and careers with the activities just completed by participants in the GEMS program.  These curricular supports were considered particularly useful to the NPMs and resource teachers who are less familiar with the work conducted by the Army/DoD. Mentors of the apprenticeship programs (CQL, HSAP, REAP, SEAP, URAP) reported highlighting STEM and DoD STEM careers that relate directly to participants' research projects, introducing participants to DoD collaborators, inviting participants to department-wide meetings and journal clubs where they meet other DoD S&Es, storytelling about former students' DoD STEM pathways, using online resources such as websites, webinars, and video (sources unspecified) to explore DoD STEM careers, and visiting DoD laboratories with participants.

GEMS and UNITE program evaluations assessed how many careers participants perceived learning about during program activities. These data are summarized in Chart 6. Most participants (87% GEMS, 94% UNITE) reported learning about 3 or more jobs, however, Army/DoD STEM careers received less attention (61% GEMS, 59% UNITE reported learning about 3 or more jobs.) In 2012, comparisons of GEMS programs at Army sites versus GEMS programs off-site suggested more frequent exposure to Army/DoD careers at the Army sites. However, comparisons between GEMS (occur at Army sites) and UNITE (occur at universities) suggest this is not always the case, revealing no statistically significant difference in reported exposure to Army/DoD STEM careers.

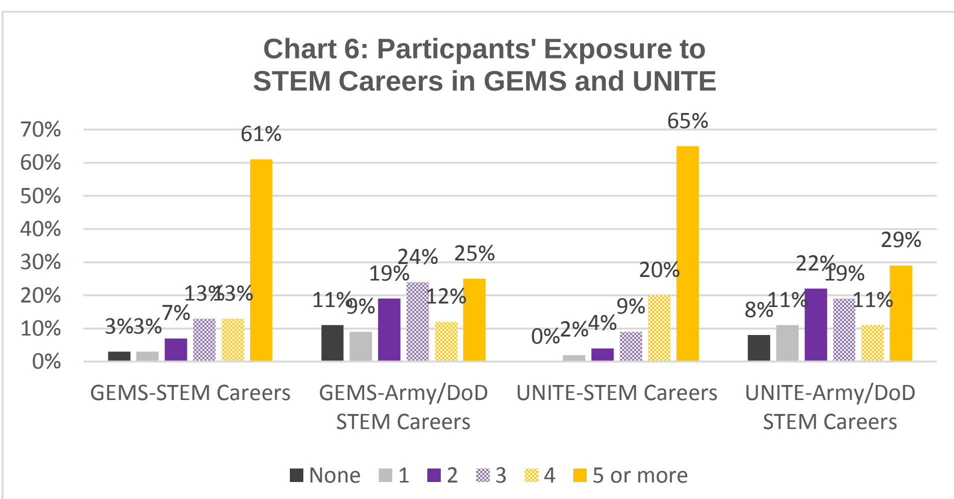
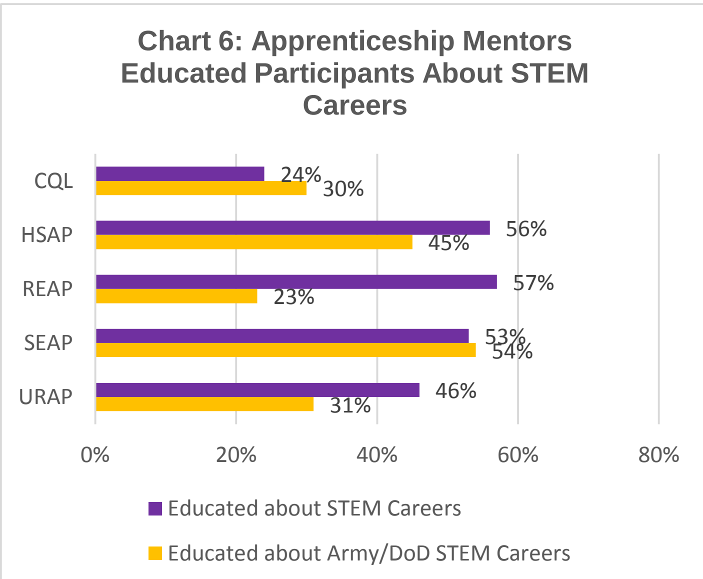


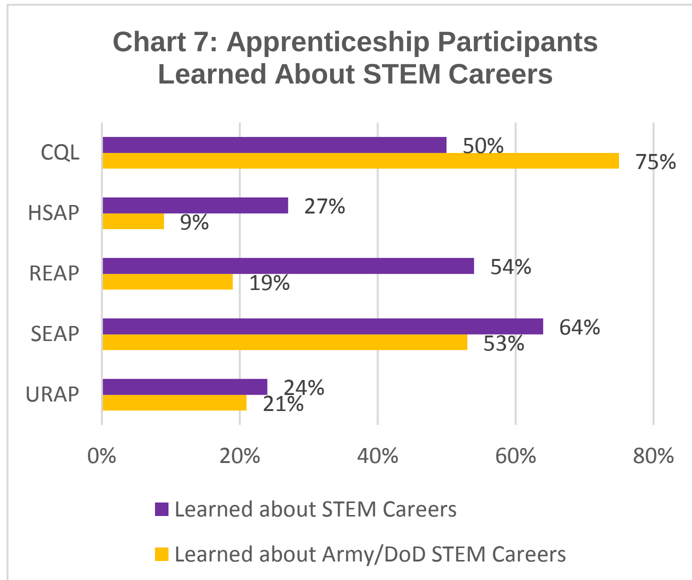
Chart 6: Particpants' Exposure to STEM Careers in GEMS and UNITE

UNITE provides a strong model for how non-DoD affiliated host sites may productively engage local DoD STEM professionals and/or research facilities to ensure exposure to relevant DoD STEM careers. In 2013 UNITE mandated that each host site include Army STEM professionals and/or research facilities in career day events,  and provided assistance to host sites to make necessary connections in support of this mandate.  These UNITE data suggest that meaningful engagement with

Army STEM professionals and research facilities can potentially offer the same effect as programs that are hosted at a DoD research laboratory.

Apprenticeship program evaluations (CQL, HSAP, REAP, SEAP, and URAP) compared mentors' efforts to educate apprentices about STEM careers and Army/DoD STEM careers (Chart 6) and participants' learning about them (Chart 7).




Charts 6 and 7 reveal a few notable trends. First, many participants had opportunities to learn about STEM and Army/DoD STEM careers, however, in most apprenticeship programs Army/DoD STEM careers received less attention. In some cases these differences were significant. Second, for most apprenticeship programs, significantly fewer mentors reported educating apprentices about careers as compared to apprentices reporting having learned about careers, suggesting that apprentices have their opportunities to and mechanisms for learning about careers beside direct contact with the primary mentor. This is consistent with focus group and interview data collecting, suggesting that mentorship is often a shared endeavor of the research laboratory. Third, comparisons of responses from participants at Army research laboratories and at university laboratories that are Army-sponsored (e.g., CQL vs. URAP, SEAP vs. HSAP) or non-Army affiliated (SEAP vs. REAP), reveal that significantly greater proportions of participants at Army research laboratories learn about Army and DoD STEM careers than do their counterparts at Army-sponsored or non-Army affiliated university laboratories. Apprentices at Army research laboratories have substantial exposure to Army/DoD STEM professionals in their daily work, and these data potentially provide evidence of the power of these Army-hosted apprenticeships on exposing participants to Army/DoD STEM careers, event when mentors don't explicitly educate their apprentices about them.

Across AEOP elements, mentors frequently reported in questionnaires, focus groups, and interviews that their limited awareness and lack of resources about Army/DoD STEM careers hindered their ability to mentor participants about Army/DoD STEM careers. Mentors at DoD sites reported challenges that were specific to DoD sites, including the negative impacts of furloughs (e.g., lack of time to discuss careers when furloughed and furloughs impart negative perceptions of Army/DoD work) and general perceptions that participants were disinterested in Army/DoD STEM careers. Mentors suggested the following programmatic revisions for supporting them in better educating participants about Army/DoD STEM careers:

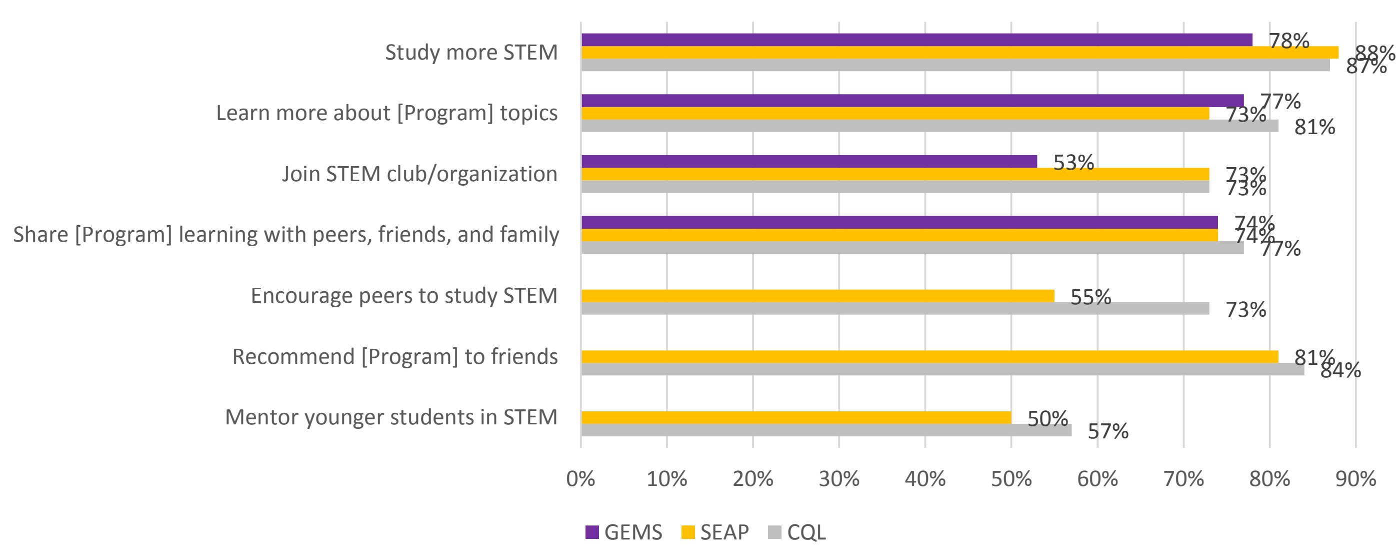
- Provide comprehensive resources, such as interactive website, video series, or booklet that detail various research foci and possible careers at Army/DoD laboratories. These could be disseminated through mentors or directly to apprentices;
- Provide information about Army/DoD funding for STEM pathways, including internship programs, scholarships, fellowships, and ROTC; and
- Provide opportunities for guest speakers from Army/DoD to visit sites or opportunities for apprentices to visit Army/DoD sites.

**<u>Finding #7:</u> AEOP programs served both to sustain existing STEM educational and career aspirations of its participants and to inspire new achievement, including intentions to pursue DoD STEM careers. AEOP has the potential to serves a critical need in providing authentic STEM experiences that both inspire and sustain participants' interest in STEM fields and that provide exciting and obtainable STEM career options to medical fields.**

Program evaluations captured a range of its participants' interests and aspirations in STEM, including participants' intentions to engage in STEM-related activity, including extracurricular activities (at home, in communities, after-school) and in formal school learning and careers.

While educational and career aspirations were more consistently measured across the AEOP, some programs evaluations did include items pertaining to less formal STEM learning and engagement. For example GEMS, SEAP, and CQL programs

**Chart 8: GEMS-SEAP-CQL Participants' Future STEM Engagement**

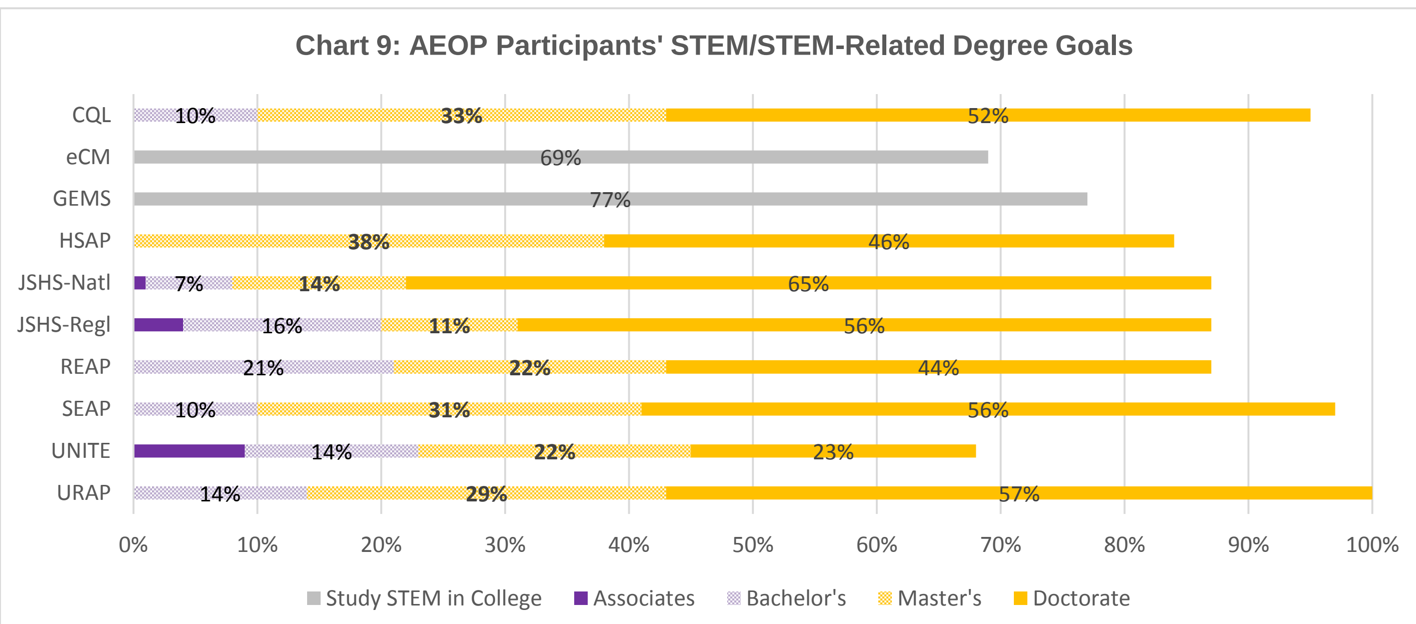



share similar objectives, including encouraging participants to serve as a peer role model and/or mentors. Chart 8 summarizes participants' intentions to engage in various STEM activities as a result of their participation in the respective

AEOP. The majority of participants intended to pursue STEM and STEM-based activities after participating in AEOP programs, and many intend to serve as STEM role models or mentors and AEOP ambassadors.

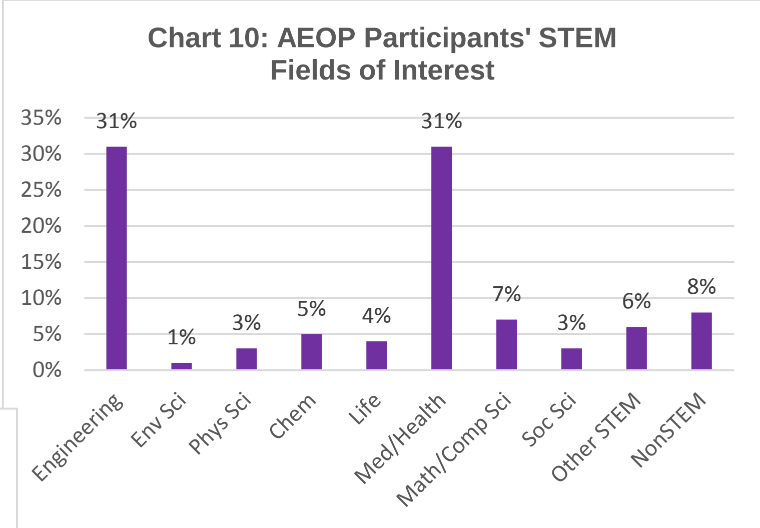
eCM assessments also included pre- to post-eCM comparisons of students' engagement in ten different STEM activities extracurricular including things like reading books/magazines, solving puzzles, participating in competitions, using tools to observe things, designing computer programs or websites, watching TV programs and visiting museums or zoos. The proportion of students participating in the activities once a month or more increased for each of the activities. Total pre- and post-eCM engagement scores were calculated and compared for each student, and a statistically significant increase found in students engagement across the participant sample.

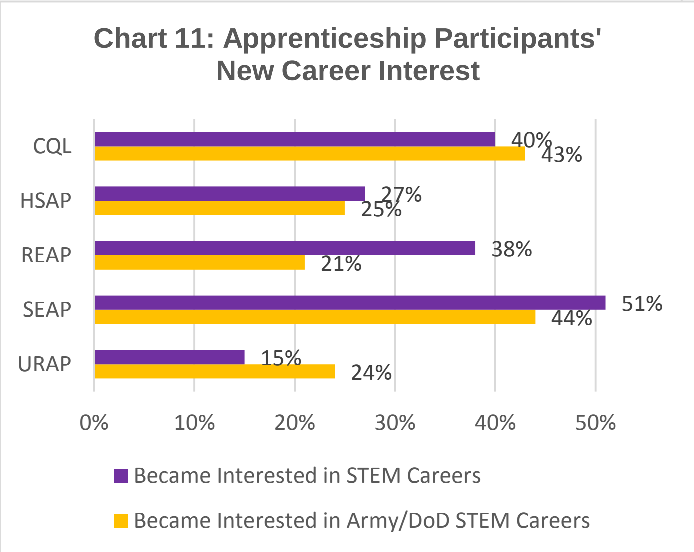
AEOP participants were asked about their educational goals and confidence to achieve those goals. Charts 9 summarizes participants' responses related to STEM or STEM-related degree goals across programs in the AEOP. Chart 2 reveals a trend across most AEOP programs: the majority of AEOP participants (68%-100%) intend to pursue advanced degrees in STEM or STEM-related fields. Additionally, across those same AEOP programs most participants (76%-93%) are confident (reported "certain" or "very certain") that they will earn those degrees. With the exception of eCM, GEMS, and UNITE, these items were only administered post-program and we can not discern if these outcomes were established prior to participation, or to what extent their participation in the AEOP effected change in these outcomes.




eCM, GEMS, and UNITE assessments examined the potential effect of participation on students' educational and career aspirations. 72% of eCYBERMISSION participants were *more* motivated to study STEM, and 69% were *more likely* to major in STEM in college after participating. In pre- to post-GEMS comparisons, significantly *greater proportions* of participants intended to study more STEM in high school (+9%) and in college (+4%) after participating in GEMS, though the effects were very weak to weak in magnitude. In pre- to post-UNITE comparisons, no significant changes were found in participants' educational goals or confidence after participating in UNITE. These data are not surprising given the different intentions of these programs. eCM and GEMS, exclusively or primarily marketed to middle school participants, are intended to inspire interest in STEM, whereas UNITE is intended to support talented but underserved participants in achieving ambitious goals in STEM. Clearly, they have accomplished those objectives.

Most AEOP participants were also asked to report STEM fields of interest to them, either as a fields of study (GEMS, HSAP, JSHS, REAP, SEAP, UNITE) or as a career field (CQL, URAP). Chart 10 summarizes data collected across AEOP programs. Similar trends were observed across programs and are illustrated clearly in Chart 4.[23] AEOP participants more frequently report interest in engineering and the STEM-related medical/health field.



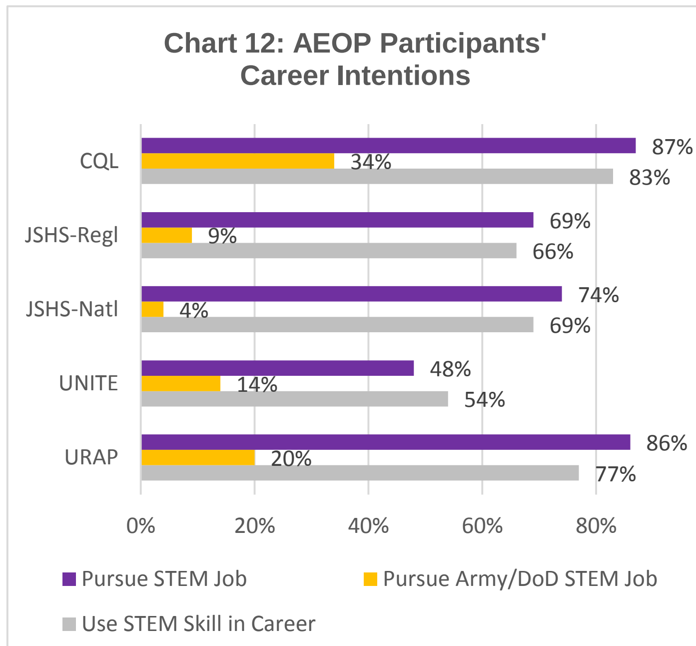




Many students pursue STEM to obtain the necessary foundation of basic science and mathematics required for acceptance into professional degree programs in medicine/health sciences, as is likely also the case with AEOP participants.[24] Recent studies suggest that as many as one third of students leaving undergraduate STEM majors are pre-medical students who have abandoned their pursuit of a medical career (known as the "pre-med phenomenon"). [25]All AEOP programs, but especially apprenticeship programs, serve a critical need in providing authentic STEM experiences that both inspire and sustain participants' interest in STEM fields and that provide exciting and obtainable STEM career options to the relatively small and therefore highly competitive medical field.

[23] Most of the 8% Non-STEM interest was reported by GEMS participants, including fields such as business, law, athletics, and military or police service.
[24] Georgetown Center on Education and the Workforce (2013), Author STEM http://genprogress.org/voices/2011/10/25/17168/report-more-jobs-this-year-for-recent-graduates/
[25] UCLA's post-Baccalaureate Experiences, Success, and Transition (BEST) project has studied barriers to and facilitators of underrepresented minority students' pathways toward careers in STEM fields since 2004. A number of applicable reports may be found at http://www.heri.ucla.edu/publications-brp.php, including Higher Education Research Institute (2010). *Degrees of success Bachelor's Degree Completion Rages among Initial STEM Majors*.

Previous findings illustrated that AEOP programs expose participants to STEM careers, including STEM careers within the Army and DoD. Chart 11 summarizes participants' interest in new careers they learned about during their AEOP experience. AEOP programs generate new interest in STEM careers, including considerable interest in STEM careers within the Army and DoD. While these proportions may seem low, other studies suggest that educational and career intentions are fairly stable at high school and college levels—these low numbers therefore represent achievement. Comparisons of responses from participants at DoD research laboratories versus DoD-sponsored university laboratories (e.g., CQL vs. URAP) and non-DoD affiliated university laboratories (e.g., SEAP vs. REAP), reveal that significantly greater proportions of participants at DoD research laboratories became interested in Army and DoD STEM careers than did their counterparts at university laboratories. In focus groups and interviews most participants reported potential interest in *any* STEM job or career that matched their professional interests, and nearly all included jobs or careers within Army/DoD as possibilities.

Some program evaluations captured AEOP participants' career intentions after the AEOP (Chart 12). In these AEOP elements the majority of participants intended to pursue jobs in STEM and use their STEM skills in a future career. While significantly smaller proportions intended to pursue STEM jobs with the Army/DoD, considerable intent is evident, especially from participants that are nearing entry into the career field (CQL, URAP). In the case of UNITE, which primarily serves participants from underserved and underrepresented populations, a pre- to post-UNITE comparison of career intentions yielded significantly greater proportion of students intending to pursue Army/DoD STEM jobs and careers, with a weak but substantially important effect.




In addition eCM, GEMS, and JSHS potentially effected participants' career intentions. eCM's assessments revealed that 65% of participants are considering a career in STEM after eCM, and are likely to do a job that requires science skills (73%) or will allow them to discover something new (76%). Significantly greater proportions of GEMS participants intend to pursue STEM jobs or careers after GEMS as compared to before GEMS (65% pre, 70% post), though the effect is very weak. Some JSHS participants also reported new intent, claiming that JSHS activities and exhibitions motivated them to explore DoD/government service careers (24% Regl, 39% Natl), and invited speakers inspired them to pursue DoD/government service careers (27% Regl, 37% Natl). In addition, the majority of JSHS participants considered invited speakers to be the most inspirational JSHS activities. According to questionnaires, speakers inspired participants with their lifelong passion and enthusiasm for STEM, and motivated to seek longer-term STEM pathways (e.g., research topics, fields, and careers). Interestingly, despite this newfound inspiration and motivation, JSHS participants reported low intent to pursue

Army/DoD STEM jobs, and they often perceived misalignment between their own professional interest and DoD STEM interests.

AEOP-wide, participants reported (and mentors corroborated) in questionnaires, focus groups, and interviews that they were motivated by and realized benefits from  opportunities AEOP programs afforded to them to clarify, explore, and/or advance their STEM pathways. Participants had opportunities to explore new STEM topics and fields of interest, clarify education or career goals, build applications and resumes, prepare for and preview college studies, engage in professional networking, and preview unique professional working environments. While advancement of participants' STEM pathways—occurring implicitly and explicitly in program activities—is clearly a success of AEOP, generating more interest in Army/DoD STEM careers may require individualized efforts that highlight the match between participant's professional interests and DoD research and careers.

## Priority Two: STEM Savvy Educators

Some AEOP elements provide professional development and/or online resources to teachers, S&Es-in-training, or other program staff and volunteers. Specific findings to support the achievement of the AEOP objectives related to STEM Savvy Educators, along with evidence from assessment data the findings that informs the findings are presented.

**Finding #1:** **AEOP efforts to expand and reward teacher engagement were successful. "Boots on the ground" efforts to establish relationships with schools and teachers, and incentives for teachers, especially those that assist teachers in supporting their students' engagement in AEOP programs, are promising practices for further expanding teacher participation. Several AEOP programs have untapped potential to engage greater numbers of teachers in their programs.**

AEOP engaged teachers and other local educators, such as university education faculty, state educational agency employees, community program educators in program activities through a number of roles. Teachers and other local educators had a variety of roles in AEOP programs, including as participants, as leaders of educational activities or supervisors of research projects (herein called  mentors), or as competition advisors, event hosts, or other volunteers. Program evaluations suggest that teachers, in particular, play a critical role for AEOP programs—they are conduits through which students are informed about, become interested in, and are supported in their participation in AEOP. Teachers often "market" programs to students, encourage their participation, nominate them as participants, support their projects and presentations, drive them to activities and events, and even chaperone students at distant national events. Participation of DoDEA and DoDDS students and of students from underserved and underrepresented groups is especially dependent upon teachers serving them. Recruiting new teachers is a priority for AEOP programs in which student participation is heavily dependent on teacher support, such as in eCM, JSHS (Regional), and JSS.

AEOP programs used a variety of mechanisms to market programs and provide outreach to teachers. Marketing and outreach campaigns reported by programs and sites were often multi-pronged. Efforts included included print, electronic, phone, and face-to-face communication with key stakeholders, including teachers, counselors, school administrators, and district supervisors. Communications leveraged program administrators' and sites own websites, list-serves, and mailing lists, as well as those of state, county, and district and state educational agencies, universities, educational associations, and professional organizations in contact with teachers and other school and district personnel. While electronic communications cast the widest marketing net, JSHS Regional Directors considered "boots on the ground" approaches—direct contact with teachers in their schools and classrooms—as the most effective means of establishing relationships with teachers. They also considered reasonable incentives such as travel funds, substitute teacher pay, materials and resources (or funds for them), and professional development as the most effective means of supporting their involvement. eCM included similar "boots on the ground" approaches in their marketing and outreach, including meeting with urban school districts to to foster mini-grant participation and, therefore, integration of eCM programming with existing classroom and school curricula. eCM's program administrator also explored partnerships with other agencies providing outreach to underserved teachers and students. One such partnership will be initiated in FY14 program activiites.[26]

| Table 14. 2013 AEOP Teacher Engagement in AEOP programs | |
|---|---|
| **AEOP** | **Engagement in AEOP** |
| eCM | **1,049 teachers** served as team advisors (TAs) to eCM contestants, retaining greater than 50% of team advisors and realizing an overall increase of 52% from 2012.<br>**28** team advisors participated from 21 DoDEA/DoDDS schools.<br>**35** teachers were awarded mini-grants to support the integration of eCM in their classrooms. |
| GEMS | **45 teachers** from local and DoDEA/DoDDS schools served as resource teachers or observers (generally referred to as mentors) to GEMS activities hosted by DoD research laboratories; teachers assisted DoD S&Es and/or near-pear mentors translate complex STEM concepts and practices into educational curriculum, coached and supervised near-pear mentors, and provided adaptive support to student participants. |
| JSS | **20 teachers** registered at jrsolarsprint.org or participated in professional development sessions at the 2013 TSA National Conference. |
| JSHS | **1,100 teachers** served as competition advisors, research mentors, chaperones, and event volunteers in JSHS Regional and National activities. |
| STPI | **43 teachers** participated in the Science Teacher Academy (STA), where they studied discipline-specific tracks related to the research of 6 DoD and 2 university S&E professional development providers; teachers translated their learning into grade-level appropriate lessons that were to be used with students in their classrooms. |
| UNITE | **32 teachers** from local schools served as instructors, chaperones, and assistants during educational activities hosted at university host sites. |

In 2013 AEOP programs engaged **2,289** teachers in program activities, as compared to the 835 documented in 2012.[27] Table 14 summarizes teacher engagement by program. eCM awarded 35 mini-grants to teachers to support classroom integration of eCM programming. JSHS honored 47 teachers with $500 each to reward outstanding contributions to STEM teaching and support future STEM-teaching endeavors. JSHS Regional Directors described in questionnaires and focus groups offering similar provisions to teachers, most frequently, funds for teacher and participant travel and substitute

[26] For example, eCM is sponsoring Institute Teacher Scholarships that cover the travel, lodging, meals, institute materials, and possibility of a $300 mini-grant for grades 6-9 teachers to attend 38th Annual SECME Summer Institute and support the integration of eCM in their classrooms or extracurricular activities at school.
[27] 2012 teacher count only included awarded teachers. Accurate estimates of teachers contributing to JSHS as competition advisors, research mentors, chaperones, and event volunteers were collected for the first time in 2013.

teachers, however those provisions were not quantified for the purposes of evaluation as many result from external sponsorship of JSHS regional symposia.

Most JSHS Regional Directors (81%) reported that in order to access new populations of students, they must be able to recruit from new schools and teachers. Many JSHS Regional Directors reported that funds for their “boots on the ground” marketing and recruiting efforts (e.g., 65% need travel support), and incentives that support teachers’ and students’ participation (e.g., 57% travel support for teachers and students, 42% substitute teachers) are critical for expansion of JSHS’ regional outreach , especially to reach underserved and underrepresented populations, which are often in under-resourced schools found in urban and remote rural communities. Other practices reported for supporting their participation included establishing similar middle school programs, non-competitive poster sessions, e-mentoring student-researcher matching programs, professional development for teachers, and incentives for underserved students (college credit, discounted registration fees, scholarships).

JSS also has untapped potential for expanding teacher participation in AEOP. JSS’s administrator has a membership of over 200,000 middle and high school students and teachers, in 2,000 schools in 49 states. The administrator’s other programming is rooted in individual and team-based competitions for students that are supported through curriculum integration and service-oriented chapter membership. JSS has struggled to make meaningful connections to existing, non-AEOP affiliated JSS local events that are independently hosted nationwide, but has not yet leveraged the numbers and motivation of its own membership base.  JSS as a National Conference competition event, as well as co-sponsorship of local events with Army facilities (e.g., those working with solar and other renewable energies) could serve as a strong models for JSS programming that embody the vision of the AEOP priorities and objectives and highlight Army/DoD STEM priorities.

STPI intends to increase participation in STEM opportunities by teachers who work in settings with a large number of students from groups that are historically underserved and underrepresented in STEM. However, STPI’s programming (the STEM Teachers Academy, STA) has only local reach around Harford Community College (Bel Air, MD). Alternative models, such as a teachers-in-residence institute model with academic year follow up at national conferences or technology-mediated virtual professional development, are necessary for expansion of STPI’s reach to teachers (and ultimately students) that are not within commuting distance from Harford Community College, and ultimately, to realize nationwide reach. This is especially necessary if STPI is to provide outreach to teachers serving underserved groups, as there are no Title 1 secondary schools in the communities currently served by STPI.

**<u>Finding #2:</u> AEOP provided professional development to teachers through direct instruction from Army scientists and engineers (S&Es). Teachers’ translation of their learning from the STEM Teachers Academy (STA) to the classroom and school may depend on the relevance of content to teachers’ contexts and the structure of STA professional development model. Alternative models are needed to establish national reach, including teachers and schools serving underserved and underrepresented populations.**

The STPI is the only AEOP element that exclusively serves teachers through STEM content professional development and experiential learning environments for STEM teachers. As such, it is poised to expand the AEOP mission of outreach to classrooms and schools of participating teachers. The major activity of STPI is the STEM Teachers Academy (STA), a 1-week summer institute experience for teachers focused largely on expanding teachers' STEM content knowledge through learning experiences guided by Army S&Es. In 2013 STA programming also included considerable attention to *A Framework* (NRC, 2012) in its inclusion of a lesson planning project that aimed to support teachers' ability to plan and teach lessons utilizing levels of inquiry and eight fundamental science and engineering practices. The intent is that teachers could individually apply STA learning to their everyday lesson planning and teaching in their own classroom, as well as serve as leaders in their schools through collaboration and professional development activities they provide to other teachers. A 9-month post-STA evaluation is administered to ascertain the extent to which STA influences teachers when they go back to their schools. There is, however, no post-institute follow up experience with teachers nor any requirement for teachers to apply new learning to classroom learning and reflect on its impact.

Table 15 summarizes some key findings from data collected by STPI participants during the spring (2012 cohort, 9 month post-STA) and summer (2013 cohort, post-STA) highlight the extent to which STA meets the written (and unwritten) objectives STPI has put forth for STA:

| Table 15. STA Outcomes | |
|---|---|
| **Objective 1: To enhance K-12 STEM teaching and learning through enhanced STEM teacher professional development conducted with participation by ARMY scientists and engineers.** | • Teachers' retrospective pre-post responses suggest they have gained understanding and confidence across the broad categories of the program, including content understandings, levels of inquiry, *NGSS* science and engineering practices, and current research and everyday applications related to subject matter. |
| | • The majority of teachers (80-91%) report that they will apply their learning across the broad categories targeted in STA in their everyday lesson planning and teaching. The majority of teachers (53-62%) also report intent to collaborate with other teachers at the school in their lesson planning endeavors. However, only 34% of teachers intend to share their learning with other teachers by providing professional development (PD) based on their experiences in STA. |
| | • The 2012 follow-up revealed that while many teachers applied their STA learning to their own teaching practice (85% reported developing lessons, 69%-93% reported implementing lessons), fewer engaged other teachers in their endeavors through collaborating with others in lesson planning (23-38%). Only 15% (1 teacher) reported actually planning and providing professional development activities to others. |

STA teachers' comments suggest that more careful consideration be given to the relevance of content to their teaching contexts, in terms of the scope of the subject matter selected and support in translating that subject matter into grade level appropriate lessons; more careful consideration be given to the structuring and scaffolding of the lesson planning project; and an appropriate balance of opportunities to learn about the range of STEM content areas (e.g., more math, less biofuels) and opportunities to engage with colleagues in the lesson planning project.

These data should be carefully considered in determining the extent to which program objectives are attainable (especially expectations that teachers apply learning and serve as teacher leaders in their schools) given the overall program model for teacher development and the nature and duration of program activities. In addition, the research should be more carefully considered in reflecting on whether the program model and activities embody research-based practices for effective, transformative professional development.

The GEMS DoDEA Teachers Pilot Program, established in 2013 in partnership with DoDEA, engaged 12 DoDEA teachers in learning about DoD research in Army laboratories and observing GEMS program activities. Of the five teachers who participated in evaluation questionnaires and/or interviews, most (>80%) reported the experiences strengthen their STEM knowledge base, encouraged new teaching strategies, provided new educational resources and ideas for classroom teaching, and new ideas for integrating STEM career information. Teachers reported adequate opportunities to learn from professional S&Es (100%) and to seek out similar opportunities in the future (60%). While teachers reported the experience increased their awareness of other AEOP programs (80%), nearly 80%-100% reported having never learned about various AEOP elements. 100% of DoDEA teachers intend to encourage students and other teachers to explore and participate in AEOP initiatives. Teachers generally found the experience to be adaptable to their classroom contexts, but the extent to which their learning and intentions have translated to classroom teaching has not yet been discovered, as 9-month post-GEMS surveys have not yet been deployed. Teachers do recommended that future programming include stronger integration of DoDEA teachers in the planning and delivery phases of GEMSand providing them with more information about various elements in the AEOP portfolio.

**<u>Finding #3:</u> 2013 AEOP online resources support teachers in program engagement and classroom integration, but certain resources are underutilized. Underutilization may result from a lack of awareness or lack of understanding of how they may be best utilized to support participant engagement and/or classroom integration.**

AEOP programs offer a range of online education resources to teachers. Some AEOP programs offer online resources that offer professional development, resource sharing, and collaboration needed to support program activities (e.g., GEMS wikis). Some AEOP programs offer online resources to allow teachers to support participants in productively participating in AEOP programs (e.g., eCM, JSS, JSHS, WPBDC). These latter resources, which are all publically available, potentially allow for the engagement of many more teachers and local educators than those “officially” participating in program activities. Table 16 lists AEOP online educational resources.

**Table16. 2013 AEOP Online Resources**

| AEOP | Online Resource(s) and Availability |
|---|---|
| **eCM** | The eCM teacher-generated Team Advisor (TA) Resource Guide and other TA resources (e.g., alignment with national and state standards, worksheets, scientific inquiry and engineering design rubrics, webinars, video) are publically available at the ecybermission.com website. |
| **GEMS** | The GEMS Wiki is available to local and DoDEA teachers and near-peer mentors serving as GEMS mentors for online training and resource sharing. |
| **JSS** | Educational resources (e.g., course outline and lesson plans, alignment with national standards, video, and JSS Host Guide) are publically available at the jrsolarsprint.org website. |
| **JSHS** | Educational resources (e.g., JSHS guidelines, sample papers, presentation tips, and helpful articles) are publically available at the jshs.org website. |

Two AEOP program evaluations—eCM and JSS—assessed online resources freely available at their websites, to determine what was working well and what could be improved. In the case of eCM, participants and team advisors reported whether they had experienced various resources and were asked to rate the quality of any resources they had used. In the case of JSS, teachers and event hosts that had voluntarily registered at jrsolarsprint.org reported whether they had used the JSS online resources and the perceived utility and value of those resources. Webiste analytics were also reviewed from jrsolarspint.org to establish a baseline for use beyond those registered at the site.

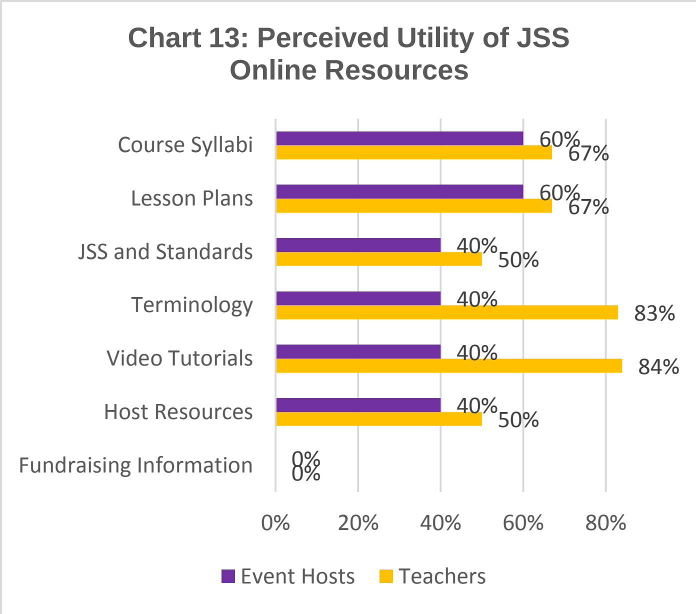
**Table 17. JSS Website use analytics: Educational resources level.**

| Page Views | Unique Events |
|---|---|
| Lesson plans | 1499 |
| Basics of Model Solar Car Design | 523 |
| Friction Investigation | 230 |
| Investigating Model Car Materials | 113 |
| Transmission Investigation #2 | 108 |
| Understanding Solar Energy | 108 |
| Aerodynamic Shape Investigation #2 | 105 |
| Aerodynamic Shape Investigation #1 | 91 |
| Transmission Investigation #1 | 89 |
| Sun's Angle Investigation | 83 |
| Design Review | 49 |
| The Design Process | 0 |
| Build tutorials | 344 |
| 2, 4, or 8 week syllabus | 117 |

In eCM, a large number of resources are available to team advisors and participants. Evaluation assessments suggest that some resources were underutilized by both participants and team advisors. Nearly 80% of team advisors and 50% of participants did not access social media resources and blogs. Similarly Army Corner, webinars, and video were not accessed by 70% of team advisors and 60% of participants. Cyberguides—civilian and military S&Es who provide STEM discipline-specific support to team advisors and participants through discussion forums, instant messenging, chat rooms, and webinars—were not used by 40% of team advisors and students. The two resources used by most team advisors and participants—and likely reflecting their critical role in successful participation—were the Mission Folder Tips and Worksheets. Less than 15% of team advisors and 20% of participants had not used these resources. Most users rated resources as excellent or good, with no resource receiving more than 20% fair or poor responses, combined. Team advisors tended to give fewer fair or poor responses than participants. The underutilization of resources and user ratings of fair and poor do suggest there is room for improvement in the resources. Especially with respect to the underutilization of resources intended to support participation—webinars, video, and a cornerstone of eCM, Cyberguides—generating greater awareness of what they are and how they can best be used to support team's work might improve use. Recommendations provided by users in open-ended suggestions for improvements indicate the same.

In JSS, resources are primarily intended for event hosts and teachers. Website analytics suggest that JSS online resources have more impact than just the 120 teachers and event hosts registered at the site. For example, analytics of the educational resources level, shown in Table 17, revealed these resources received considerable traffic in the first year despite relatively limited marketing to existing non-AEOP affiliated JSS local events and two TSA National Conference sessions.

Fifteen JSS local event hosts and teachers who voluntarily registered with the jrsolarsprint.org also completed evaluation assessments that elicited users' level of use and their perceptions of utility and value. 71% of event hosts and 75% of teachers reported using the JSS online resources provided at jrsolarsprint.org. Chart 13 summarizes the proportion of users finding resources "useful" or "very useful." As shown, event hosts and teachers generally reported that AEOP's JSS online resource center provided them with useful content. More teachers understandably found course syllabi, lesson plans, JSS and Standards, terminology, and video tutorials useful—these resources relate more to classroom and extracurricular activities with which JSS resources might be integrated. Curiously, neither event hosts nor teachers found the fundraising information useful, yet in later items of the questionnaires both groups requested information about fundraising that could be found in the fundraising resources. This may suggest lack of visibility of this resource versus others at the JSS website. There is clearly room for improvement in online resources, evidenced by the considerable proportion of respondents did not use or find resources useful.



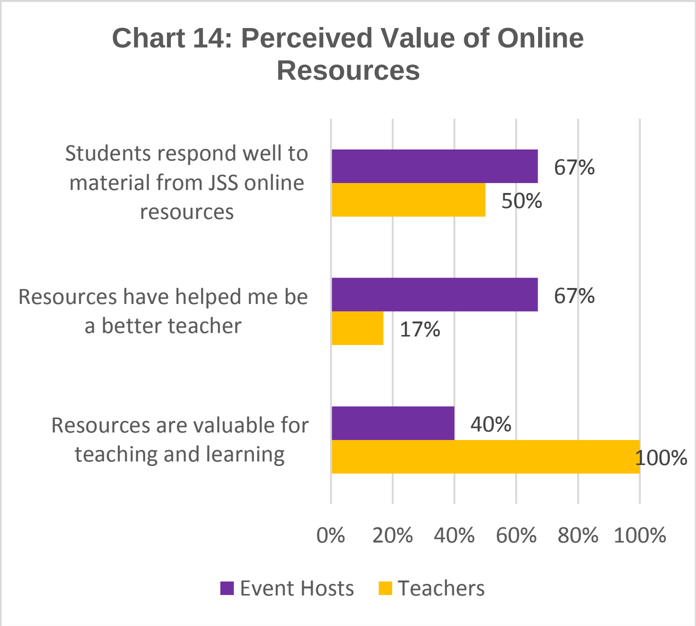




Chart 14 demonstrates that event hosts and teachers also reported that AEOP's JSS online resources are valuable. As might be expected, event hosts are likely to have different resource needs than educators and therefore do not agree to the same extent as teachers about the value of the online resources. 67% of event hosts and 50% of teachers agreed that their students responded well to the material from JSS's online resources. 100% of teachers reported that they are valuable teaching and learning resources, yet only 17% found they helped them be a better teacher. Teachers' low agreement, in particular, suggests there is room for improvement. One important recommendation offered by users, especially given the national call and movement toward cross-sector sharing of state-led standards, was that JSS educational resources be aligned with Next Generation Science Standards. Others called for more and better examples, photos, and video tutorials, additional resources such as a simulator and a new equipment, and specific suggestions for improving the lesson sequence or connections to other available curricula.

**<u>Finding #4:</u> AEOP expanded efforts to recruit, prepare, and study the experiences of S&E mentors, including tracking the development and impact of GEMS near-pear mentors, HSAP/URAP graduate mentoring fellows, and JSHS national judges. S&Es contribute valuable perspective pertaining to Priority 1 and Priority 2 objectives that informed many if not all 2013 evaluation recommendations; data collection about and from S&Es should be expanded and standardized in future evaluation.**

Across AEOP programs and sites, explicit efforts were made to recruit S&Es to serve in a variety of critical roles. S&Es included retired and practicing S&Es, S&Es-in-training, DoD and DoD-sponsored S&Es, and S&Es working across academic and industry sectors. Their roles included research mentors, instructors or assistants, "career" speakers, judges, program promoters, virtual experts, and other event volunteers.

eCM provided a strong model for how S&E recruitment might be accomplished. eCM posted roles, responsibilities, and email and phone contacts for volunteer sign-up prominently at the eCM website (ROLES tab). eCM administrators advertise to their own membership base of 55,000 STEM teachers and partner with other regional and national associations for advertising to their membership, including the Southeastern Consortium for Minorities in Engineering, Society for the Advancement of Chicanos & Native Americans in Science, National Association of State Boards of Education. Program administrators conducted an eCM "road show" at Army Research, Design, and Engineering Centers and research laboratories and partnered with the Armed Forces Communications and Electronics Association to recruit additional volunteers. Through these efforts they recruited 110 eCM Ambassadors ("boots on the ground" program promotion), 103 Cyberguides (virtual expert assistance to participants/teams), and 1695 Virtual Judges (virtual evaluation of team submissions).

In total, programs reported engaging **3490** retired and practicing S&Es, and S&Es-in-training, that participated in AEOP activities and events. Table 18 summarizes these S&Es and their roles. 400 are DoD or DoD-sponsored S&Es providing direct mentorship to participants in apprenticeships. 88 S&Es-in-training (69 GEMS near peer mentors and 19 HSAP/URAP Graduate Mentoring Fellows) were both participants themselves and mentors to other participants. 70 DoD S&Es served as JSHS National Symposium judges. An undetermined number of DoD and DoD-sponsored S&Es participate in programs across the AEOP.

| Table 18. 2013 AEOP S&E Engagement in AEOP programs | |
|---|---|
| **AEOP** | **Engagement in AEOP** |
| **CQL** | **260 DoD S&Es** serve as research mentors for apprentices |
| **eCM** | **1,908 S&Es** serve as Ambassadors (110), Cyberguides (103), and Virtual Judges (1695).<br>7 DoD laboratories participate in STEM Tech Expo at the National Judging & Educational Event. |
| **GEMS** | **Unknown number of DoD S&Es** facilitate educational activities and/or serve as career speakers<br>**69 near-peer mentors** apprentice in DoD laboratories and translate their DoD research experience into educational activities for GEMS participants. |
| **HSAP** | **11 DoD-sponsored S&Es** and **5 DoD-sponsored Graduate Mentoring Fellows** served as research mentors for apprentices |
| **JSHS** | **800 S&Es** (including university faculty/students, industry, non-profit, and **100+ DoD S&Es**) served as judges and event volunteers in JSHS.<br>23 DoD laboratories participate in JSHS regional events.<br>100+ DoD S&Es from 17 DoD laboratories participate in JSHS national event) |
| **JSS** | **40 S&Es** registered at jrsolarsprint.org as local event hosts and volunteers representing academia and industry |
| **REAP** | **101 S&Es** serve as research mentors for apprentices |
| **SEAP** | **101 DoD S&Es** serve as research mentors for apprentices |
| **STPI** | **8 S&Es** (**6 DoD S&Es** and 2 university faculty) provide discipline-specific professional development to teachers |
| **UNITE** | **145 S&Es** (including university faculty/students, industry, non-profit, and **10+DoD S&Es**) served as instructors, classroom assistants, and career speakers during educational activities hosted at university host sites. |
| **URAP** | **28 DoD-sponsored S&Es** and **14 DoD-sponsored Graduate Mentoring Fellows** served as research mentors for apprentices |

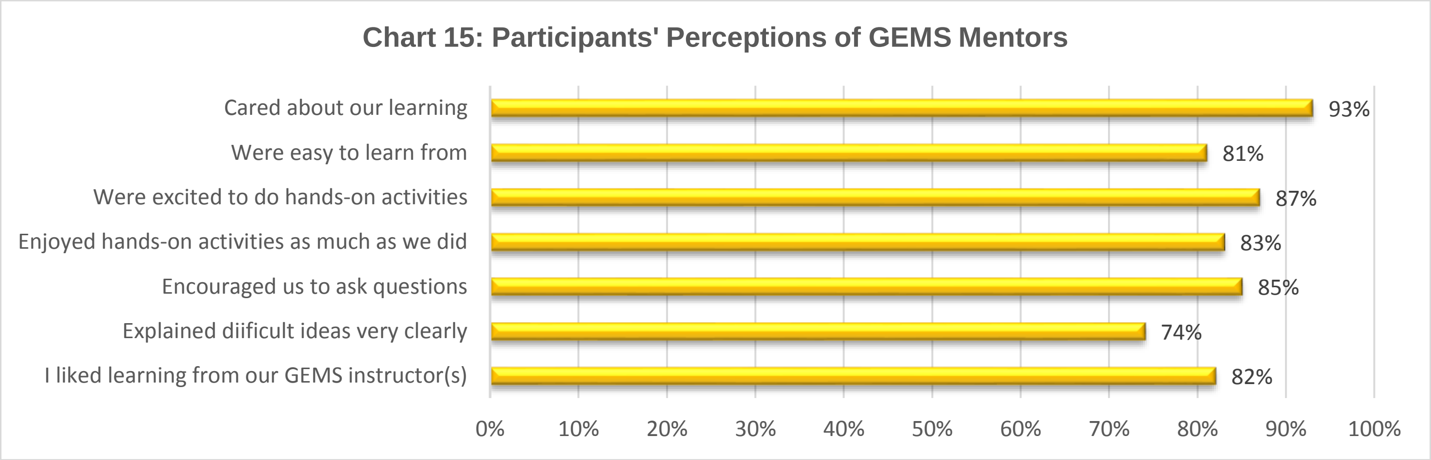
Apprenticeship program (CQL, HSAP, REAP, SEAP, and URAP) evaluation assessments asked mentors about past participation in the AEOP as either a participant or mentor. Table 19 summarizes their responses. All programs recruited mentors from the past apprentice participant pool. This finding, as well as mentor focus groups and interviews, suggest that as participants, they valued the experience and wished to provide similar opportunities for others. The proportions of new and returning mentors and the range in numbers of participants mentored suggests that both mechanisms for recruiting S&E mentors—engaging new S&Es annually and by repeated engagement with past/returning S&E mentors—are used, and in most programs tend toward the latter. This two-pronged recruitment mechanism serves to both broaden and deepen capacity within the S&E mentor pool, many of whom work for the DoD or conduct DoD-sponsored research.

| Table 19. 2013 AEOP S&E Engagement in AEOP programs | | | |
|---|---|---|---|
| **AEOP** | **Past Program Participant** | **Past/Returning Program Mentor** | **Program Participants Mentored Historically** |
| **CQL** | 18% | 50% | Avg. = 3, Range 1-10 |
| **HSAP** | 28% | 61% | Avg. = 4, Range 2-12 |
| **REAP** | 4% | 76% | Avg. = 11, Range 1-60 |
| **SEAP** | 20% | 60% | Avg. = 5, Range 1-20 |
| **URAP** | 35% | 62% | Avg. = 3, Range 1-6 |

*GEMS near-peer mentors (NPMs)* received unique professional development opportunities to prepare them as aspiring STEM researchers and as mentors of GEMS students and. NPMs participated in wiki-based online or on-site training through their specific GEMS site in spring 2013, followed by two weeks of onsite training before the launch of GEMS programs in the summer. NPM preparation included laboratory safety courses, pedagogical training, laboratory training, and development of lessons that translated their laboratory experiences into a teaching experience. NPMs were mentored by a DoD S&E who supervised their STEM research in the lab setting, much like the undergraduate research model. NPMs were also mentored by a licensed STEM teacher, who provided supervision and support as they translated their research into grade-level appropriate lessons for GEMS students, much like the typical pre-service student teaching models.

An independent investigation of the NPM program was conducted to better understand the impact to near-peers themselves. This study[28] included open-response pre- and post-NPM program questionnaires focused on determining NPM's expectations of their experience (pre-program) and their development resulting from their experience (post-program). According to study authors, NPMs' responses demonstrated growth in the following areas related to mentor capacity:

- awareness of mentoring as a necessary part of learning;
- willingness to serve as mentors and STEM literacy advocates;
- instructional skills, including flexibility, time management, patience, and communication with diverse learners;
- attention to and learning from the learning styles, needs, outlooks, and capabilities of learners; and
- awareness and interest in teaching as a profession.




The post-GEMS questionnaire elicited students' perceptions of their GEMS mentors, which included Army S&Es, NPMs, and resource teachers. Items included perceptions of mentor qualities such as caring about student learning, excitement about hands-on learning, teaching and mentoring skills, and students' learning from their mentors. Chart 15 summarizes

[28]Anderson, M. & Yourick, D. (in review) Undergraduates in a U.S. Army internship acquire mentoring and instructional skills with pre-college students in the STEM disciplines.

the proportions of students who selected “agree” or “strongly agree” for each statement. Students clearly found their GEMS mentors to be excited, accessible, and impactful as most students generally agreed (greater than 70%) with all items.

*HSAP/URAP Graduate Mentoring Fellows (GMFs)* pilot program intended to provide professional development to ARO-sponsored graduate students who often provide mentorship for HSAP and URAP apprentices. The intended professional development consisted of multiple eWorkshops around relevant topics (e.g., effective mentorship and assessment) and an online forum for support through virtual roundtables.  Personnel changes at ARO substantially impacted the implementation of the Graduate Mentoring Fellows pilot program. Only one 45-minute eWorkshop was provided, and it quickly reviewed information about AEOP programs and strategies for effective mentoring.  GMFs completed a post-HSAP/URAP assessment that elicited their perceptions of and learning from the eWorkshop, and their use of new learning during their mentoring of HSAP/URAP apprentices. All data from this assessment of the eWorkshop have been summarized and discussed previously in the 2013 Graduate Mentoring Fellows Data Brief (Report GMF_01_08302013).

The GMF study suggests that the eWorkshop had varying degrees of success with teaching GMFs about the critical components of effective mentorship. The low frequencies with which GMFs reported employing these strategies suggest that awareness is insufficient for implementation. Further, GMFs did not feel well-supported by the program activities. GMF’s offer insightful recommendations for programmatic revisions that would potentially improve the experience of GMFs and the apprentices they mentors,  including: increased communication between ARO, faculty mentors, and GMFs about expectations and objectives of mentorship; enhanced training and ongoing support of GMFs; and access to resources that enable GMFs to provide mentorship about AEOP options and Army STEM careers. The GMF program might look to the NPM program as an effective model, making necessary adjustments to accommodate the type of STEM activity mentors are supervising (e.g., facilitating curriculum-based activities in GEMS vs. mentoring research activities in HSAP/URAP).

For apprenticeship programs (CQL, HSAP, REAP, SEAP, URAP) mentor and participant questionnaires elicited perceptions of mentor activities and their outcomes related to supporting participants’ engagement in STEM research and mentor activities related to supporting apprentices’ educational and career pathways. GMFs serve as mentors for many HSAP or URAP participants. Charts 16 and 17 (next page) summarize the proportions of mentors and participants across all apprenticeship programs who “agree” and “strongly agree” with statements of about these activities. Across all items but one (help with CV/resume) greater than 60% of participants reported experiencing such activities. In each program only a small proportion of apprentices and mentors strongly disagreed or disagreed that any of these mentor activities occurred. Across most items, larger proportions of participants reported experiencing these mentor activities as compared to mentors. Participants and mentors frequently described participants working with more than one researcher in the lab. This may explain participants’ stronger perceptions of mentor activities (more mentors, therefore more mentor activities) whereas mentors answered the question in reference to the frequency of their own work with a single apprentice in the lab. Data suggest that URAP mentors are more focused on engaging and training apprentices about the research to be accomplished (whether they use a team of researchers or not) while less of mentors’ focus is given to supporting apprentices’ educational and career pathways.

**Chart 16: Perceptions of Mentor Activities: Support STEM Research**

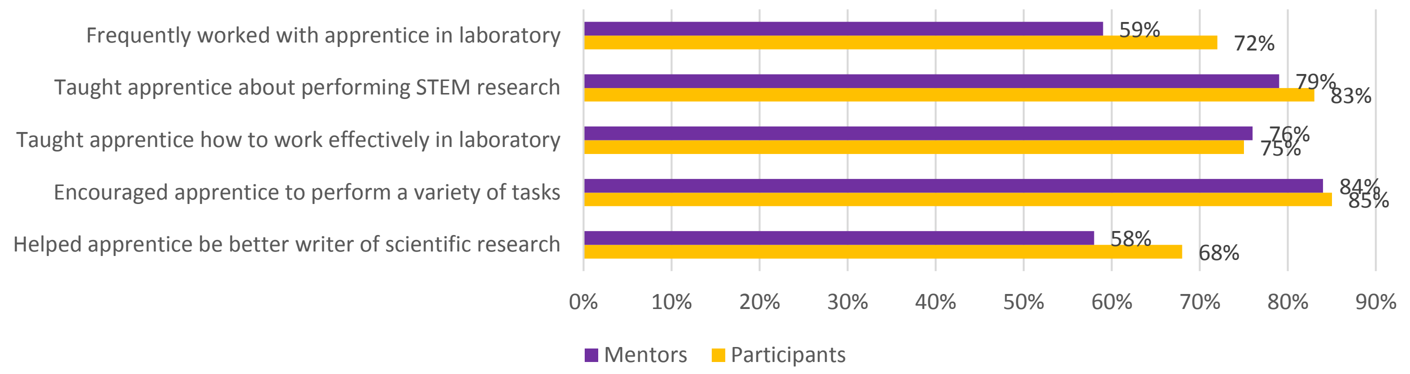



**Chart 17: Perceptions of Mentor Activities: Supporting STEM Pathways**

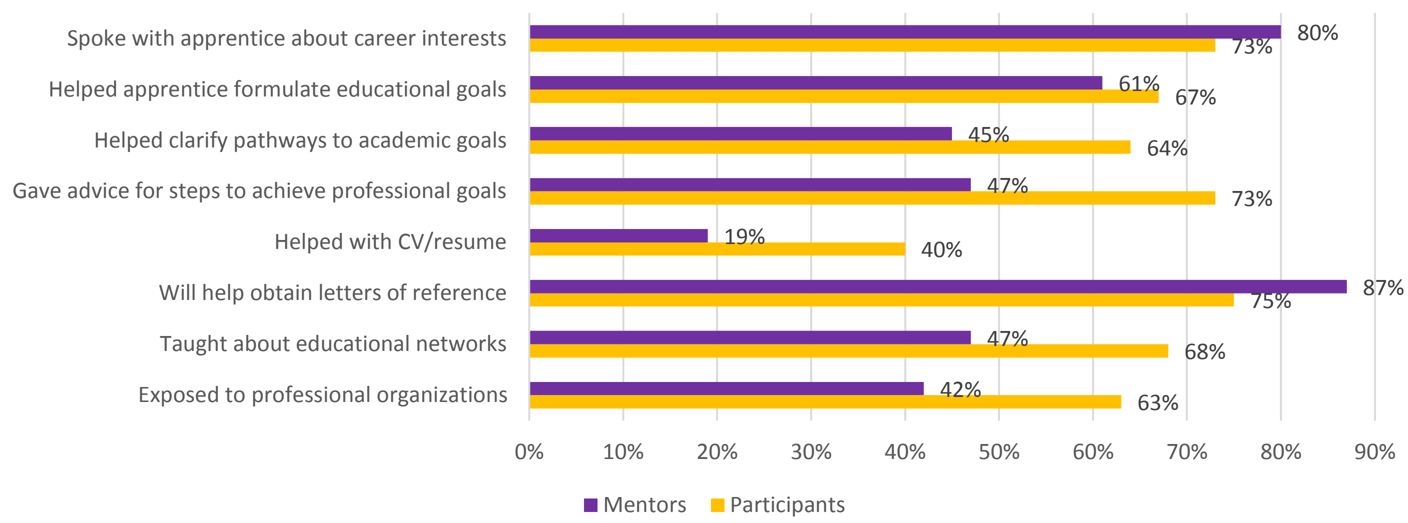
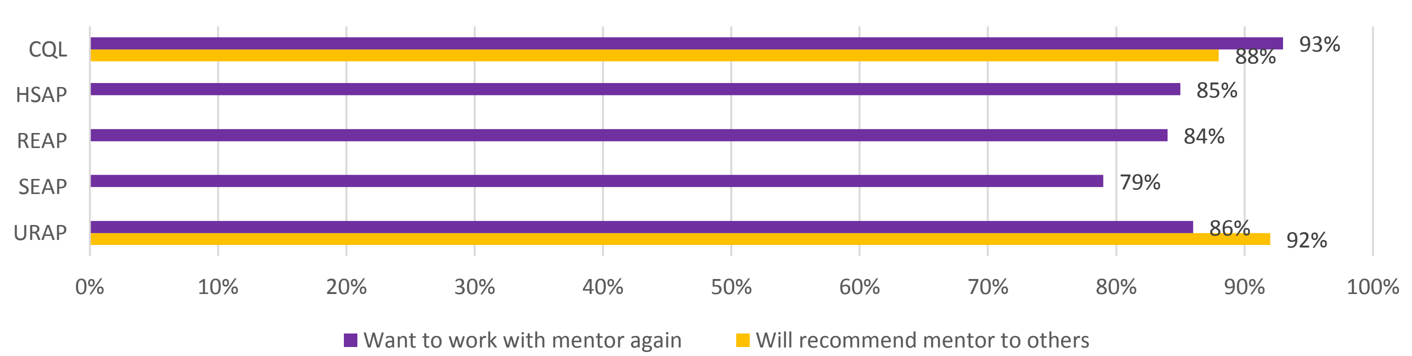



**Chart 18: Apprenticeship Participants' Satisfaction with Mentors**

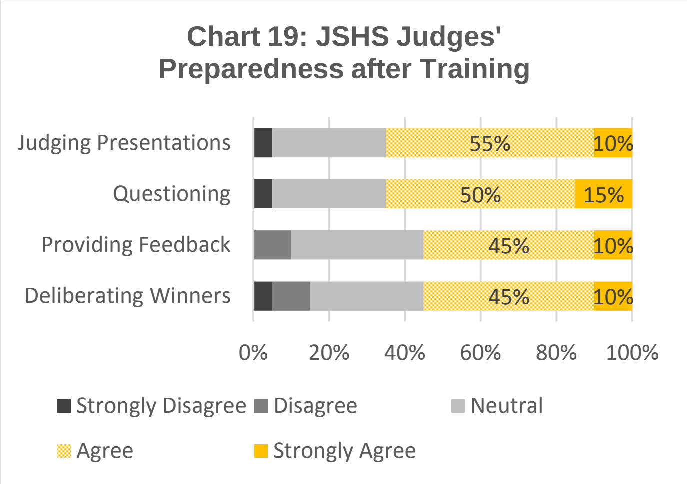


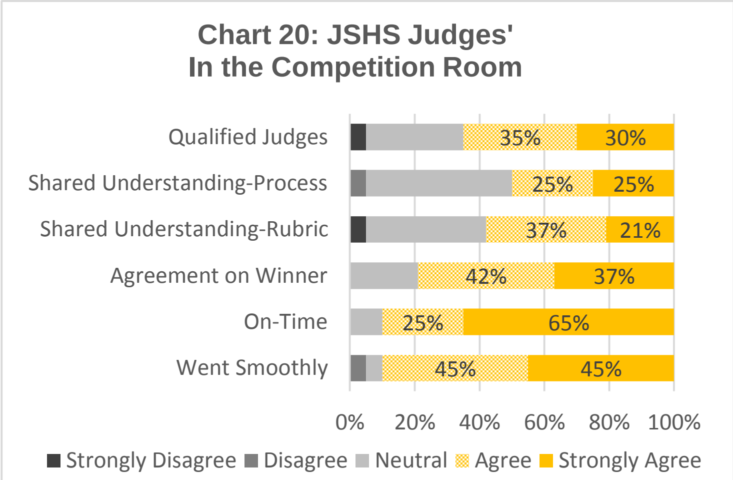
In addition to participants' positive reports about specific mentoring activities, most participants (79%-93%) in apprenticeship programs would like to work with their mentor again, and most undergraduate participants (88%-92%) would recommend their mentor to others. These data are summarized in Chart 18.

The study of *JSHS National Judges* included 24 of 70 DoD S&E judges who provided insight about their experiences with online judging resources, at-event training, and the judging process itself, as well as suggestions for improving the judging experience. Because the coordination of JSHS rotates services on an annual basis, so does the pool of DoD's serving as judges. It is important to learn from their experiences in order to create the most effective resources and training to support their work, especially for those without previous experience judging for the JSHS.

Judges found the online guidance (96%) and online access to abstracts and papers (100%) to be useful for preparing them for judging at N-JSHS. On average spent about 4 hours reviewing abstracts and papers prior to their arrival at the event, with only 2 judges reporting difficulty with that portion of the online system. Many judges (65%) did not find the online scoring system to be useful. Subsequently, one third of judges suggested clarifying the relationship between the online scoring and at-event judging processes and/or making improvements to the system to ensure ease of use during the event.

At-event training was also provided to judges, though some judges reported lack of awareness of such training. Chart 19 summarizes N-JSHS judges' self-reported preparedness after participating in the at-event training, in terms of judging presentations, questioning presenters, providing feedback to presenters, and deliberating the selection of winners. Chart 20 summarizes judges' perceptions of the judging process that occurred in their competition room.




A majority of judges felt prepared to judge presentations (65%) and question presenters (65%), and most reported that their judging was on-time (90%) and went smoothly (90%). However, more than 40% did not agree that they were prepared to provide feedback, or to deliberate winners, or that judges in the competition room had shared understandings of the judging process and tools. This suggests that JSHS online and at-event resources for N-JSHS judges are not consistently preparing all N-JSHS judges for their important work. National judges provided these suggestions for improving the judging process:

- select judges carefully, ensuring that judges are experienced;
- provide detailed training, especially for new judges, so they aren't perceived as inexperienced or inattentive;
- provide full papers to judges in advance of the judging to ensure judges are prepared; and
- ensure that moderators allow sufficient and consistent lengths of time for judges to question students.

Judges play a more distant role as mentors through their discourse with and feedback provided to participants (contestants) at or following the event, yet this unique mentorship is highly valued. In focus groups, JSHS students reported how important judges' feedback was for improving their presentations, including improving the clarity of visuals, writing, and the overall presentation of ideas. They also reported leveraging judges' feedback to set the direction for future research, such as adjusting research questions or exploring alternative research designs and methods. When asked how they would improve the judging process, participations suggest more and useful feedback and fair judging processes are needed. The range of judging processes and feedback mechanisms described by JSHS Regional Directors suggests considerable variation exists in how existing guidelines for judging and feedback are interpreted and implemented. Regional Directors also suggested improvements that could be made in judging and feedback processes, including

- offering more training and going support to judges;
- revision to judging criteria to reward ownership or autonomy;
- more time for judges to give feedback; and
- mechanisms to provide instant and peer feedback.

Program evaluations endeavored to capture S&Es AEOP experiences through questionnaires (CQL, HSAP, JSHS, JSS, REAP, SEAP, URAP) and focus groups (same, plus GEMS and UNITE). They contributed valuable perspective pertaining to Priority 1 and Priority 2 objectives that informed many if not all 2013 evaluation recommendations. S&Es serving GEMS, UNITE, and STPI had particularly limited or no voice in 2013 evaluations. 2014 evaluation should expand the participation of these and other S&Es participating in new initiatives and ensure systematic collection of data relating to AEOP Priority 1 and Priority 2 objectives.

## Priority Three: Sustainable Infrastructure

While efforts have been made to support the development of a sustainable infrastructure for AEOP, past and 2013 evaluations have not focused considerable effort on assessing progress toward these objectives. Program evaluations do offer baseline data for these efforts and identify potential areas for growth.

**Finding #1: AEOP evaluation efforts expanded in 2013 with the evaluation of eleven programs, increased focus on AEOP Priority 2 objectives, and shifts toward common program metrics that align with AEOP programs guiding framework. Future evaluation efforts are informed by and strive to adhere to Federal guidance and best practices for rigorous program evaluation, while attending to AEOP priorities.**

The Lead Organization (LO) of the AEOP CA, Virginia Tech, provides objective assessment of most programs in the AEOP portfolio and of the AEOP portfolio following a centralized evaluation plan that includes annual data collection, analysis, and reporting. The evaluation conducted by the LO has undergone continuous development and expansion in the three years since the inception of the AEOP CA. The 2013 evaluation was carried out under the guidance of a new Evaluation Director, hired mid-term to improve the rigor of the evaluation, to better align the AEOP's evaluation with Federal and field guidance, and to improve the capacity of the evaluation team and Consortium members to contribute to and use evaluation. During 2013, the Evaluation Director drafted *Moving toward the Next Generation of AEOP Evaluation*, a vision document that guided the execution of the 2013 evaluation plan and the development of FY14 evaluation plan. Table 19 describes the expansion of AEOP Evaluation.

| **Table 19. 2013 Expansion of AEOP Evaluation** | |
|---|---|
| **Increased Programs Evaluated** | Eleven program evaluations were conducted—ten by the LO and one by David Heil & Associates—as compared to eight conducted in 2012. |
| **Assessed Special Populations** | Three program evaluations assessed experiences and outcomes for special populations of teachers and S&Es,[29] including GEMS DoDEA teachers, HSAP/URAP graduate mentoring fellows, and JSHS national judges. |
| **Assessed Online Resources** | Two program (eCM, JSS) evaluations assessed online resources through website analytics and/or user questionnaires. In addition, WPBDC administrators provided baseline analytics on software downloads. |
| **Deployed Mixed Methods Approaches** | Nine of the eleven program evaluations deployed mixed methods approaches, including participant and mentor focus groups and/or interviews in eight program evaluations, and participant focus groups in a ninth program. |
| **Established Common Metrics and Measures** | Evaluation of apprenticeship programs (CQL, HSAP, REAP, SEAP, and URAP) established and deployed common measures for participants and mentors, included batteries of items that supported triangulation of findings. |
| **Generated Data Briefs to Support Annual Program Planning** | All programs were provided with end-of-program data briefs that summarized data for key AEOP outputs and outcomes of 2013 programs in order to inform individual and AEOP FY14 Annual Program Plans. Full evaluation reports followed in Winter 2013 and Spring 2014. |

AEOP Evaluation conducted by and in collaboration with the LO is informed by and strives to adhere to best practices for rigorous program evaluation. In the FY14 AEOP evaluation and beyond

- questions, methods, and assessments are designed to align with Army, DoD, and Federal STEM priorities as well as with individual program objectives;
- a set of common metrics and measures will be employed across all AEOP programs; they align with the output and outcome measures that align with AEOP objectives and are inventoried by the Office of Science and Technology Policy;[30]
- assessments will be adapted from or informed by existing instruments of the field, and when assessments must be designed by the evaluation team, appropriate measures will be taken to assess and improve assessment performance of those measures before deployment;
- individual programs of the AEOP portfolio will be evaluated annually—including both process and outcomes evaluations—to ensure the utility of evaluation findings and recommendations in program revision and policy decision-making; and

[29] An independent study of the GEMS near-peer mentors program was conducted by investigators at WRAIR.
[30] Office of Science and Technology Policy, "2010 Federal STEM Education Inventory Data Set" (Washington, D.C., 2012)

- evaluation plans, including methods and assessments, will be reviewed and revised annually to respond to changing AEOP or program priorities and evaluation resources, and emerging evaluation theory and practice.

**Finding #2: Marketing, promotion, and branding activities expanded to reach Consortium members, participants, and the public with a unified message about AEOP's pipeline of programs. Data suggest, however, that AEOP- and program-level marketing of AEOP programs have less success than sites' marketing efforts at attracting students to and retaining them in the pipeline. Participants' interest in AEOP will benefit from greater emphasis on cross-promotion of AEOP opportunities during program activities.**

In 2013 Virginia Tech worked with Army partners and Consortium members to synchronize the overall marketing, promotion, and branding toward unified messaging of AEOP programs as a pipeline of opportunities for students, teachers and schools. The Priority of the communications activities included:

- educating target audiences and the broader public about why generating interest in STEM is of vital importance to the U.S. Army;
- improving coordination, efficiency, and effectiveness of AEOP programs through communication; and
- increasing communication and promotion of AEOP to underrepresented groups.

Table 20 summarizes AEOP communication activities were either initiated or fully executed in 2013, inclusive of both internal and external to AEOP communications activities.

| Table 20. AEOP Communications Activities | |
|---|---|
| **Internal Communications Activities** | • Bi-weekly meetings with Army partners, focused on planning social media content generation and distribution, website updates, and live events.<br>• Quarterly updates with program administrators, focused on activities and events for exhibiting and generation of social media content.<br>• Annual review and revision AEOP and program marketing materials.<br>• Updates to the AEOP website, as requested by program administrators.<br>• Friday Message to Consortium, focused on weekly updates and requests for content for social media and success stories. |
| **External Communications Activities** | • Daily postings at social media channels (Facebook, Twitter, and Google Plus). Twice-weekly postings to LinkedIn and Pinterest.<br>• Exhibiting at major events, such as U.S.A. Science & Engineering Festival, National JSHS (N-JSHS), eCM National Judging & Educational Event (NJ&EE), the Army All-American Game, and other events as possible.<br>• Design, procurement, and distribution of AEOP-branded instructional supplies, including pencils, notepads, lab coats, and brochure.<br>• Production of AEOP marketing video.<br>• Production of original video content at N-JSHS and eCM NJ&EE.<br>• Design, procurement, and distribution of table top exhibits for program administrators to use (e.g., at national conferences or other promotional uses). |

While all 2013 program evaluations assessed how participants and mentors come to learn about the programs in which they are participating, either through open-ended questionnaire or focus group/interview items, they did not systematically inquire about the role any AEOP external communication activities played in their awareness. Yet, they contribute to our understanding of the impact of those efforts.

Participants of competition programs (eCM, JSHS) and summer programs (GEMS, UNITE) most frequently reported first learning of programs through teachers and parents. Other school-based associations (guidance counselors, principals), family members and friends were commonly cited as well. A considerable proportion of apprenticeship program participants reported a family member or family friend who worked at the site of their apprenticeship (37% CQL, 23% HSAP, 30% REAP, 30% SEAP, and 28% URAP). Not surprisingly, they frequently reported learning of programs from family and family friends. In SEAP and CQL (both take place at Army research laboratories) greater than 30% of participants interviewed learned of their program through onsite marketing of the GEMS-SEAP-CQL pipeline of programs. And in university-based apprenticeship programs (HSAP, REAP, URAP) participants most frequently reported learning of the opportunity through their high school teachers and university instructors, through other non-AEOP programs in which they had participated, and through advertisements (flyers, emails) from the school or university. This is consistent with HSAP, REAP, and URAP, mentors' frequent reports of actively recruiting participants through local schools, through non-AEOP programs offered at their campus, and in the classrooms and by the recommendations of their colleagues.

Across the AEOP only small proportions (often less than 10%) of current participants learned of programs from past participants (e.g., word of mouth) and only rarely (generally less 5%-10% of participants who responded to these items) did participants learn about programs by coming into contact with national level AEOP marketing (e.g., AEOP website, social media channels, brochure). Participants who reported visiting the website did so to complete an application at the request of a site coordinator or mentor, and reported finding the site difficult to navigate, lacking sufficient or sufficiently current information, and prone to malfunction. Site-level marketing and connections with people at those sites currently plays a larger role than AEOP- or national level marketing in attracting participants to AEOP programs. Teachers (or more broadly, school staff) and parents (as well as extended family and family friends) appear to be the primary information conduits that channel students to AEOP programs.

In addition to AEOP-level efforts toward centralized marketing, promotion, and branding, AEOP objectives include that cross-promotion of AEOP programs occurs within each program, to include informing participants about additional opportunities within the AEOP for which they may be eligible and encouraging successive participation in the AEOP pipeline. SEAP and CQL also have program-level objectives related to development of participants as role models and mentors, and informing them of ways they can mentor younger STEM students through GEMS, eCM, and other AEOP programs. Most programs highlighted AEOP in their opening and/or closing events and provided participants with AEOP-branded instructional supplies (pencils, notebooks, laboratory coats, brochures) during events.

Across the AEOP assessments captured participants' past participation in AEOP programs, as well as their level of awareness and interest that resulted from program activities. Tables 21, 22, and 23 summarize these data, respectively. In all three tables, the proportions of participants from each program (row heading) having participated in other AEOP programs (column headings) are shown. Gray shading represents other AEOP programs that were not listed in the evaluation assessment, or were listed but we would not expect participants to have any previous participation due to eligibility requirements (e.g., grade level). Despite being ineligible as a participant, SEAP and CQL participants are encouraged to participate in AEOP programs as mentors, so data was collected about their interest in lower grade-level AEOP programs. JSHS data were summarized for national JSHS participants. eCM data summarizes proportions who reported having no or little knowledge of high school AEOP programs.

The data in Tables 21-23 highlight a few important trends. Most programs have small proportions of participants that participate more than once. GEMS, SEAP, and CQL have the highest numbers of repeat participants. Across most programs only a small proportion (1%-10%) report participating in each of the other AEOP programs. The notable exception is the GEMS-SEAP-CQL pipeline of programs where 30% advance through GEMS, 25% from GEMS into SEAP, and 25% from SEAP into CQL. The most striking finding is illustrated in Table 22. At the time questionnaires were administered (near or after the conclusion of most programs' activities), many participants (and in most cases, *most participants*) indicated that they have never heard about various AEOP opportunities for which they may be eligible now or in the future. Table 23 demonstrates that AEOP participants have considerable interest in other AEOP opportunities, interest that would benefit from stronger cross-promotion by programs, sites, and mentors with whom participants most closely interact.

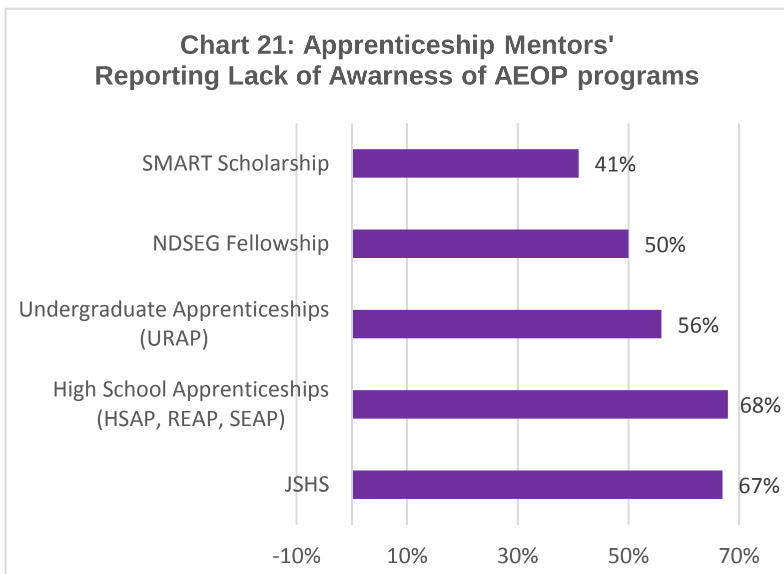
**Table 21. AEOP Participants Reporting "Participated Already"**

| | Competition Programs | | | | Summer Programs | | High School Apprenticeships | | | College Apprenticeships | | Scholarships/ Fellowships | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | eCM | JSS | JSHS | WPBDC | GEMS | UNITE | HSAP | REAP | SEAP | URAP | CQL | SMART | NDSEG |
| **CQL** | 1% | 0% | 1% | 2% | 10% | 1% | 2% | | 24% | 17% | | 1% | 0% |
| **eCM** | | | | | | | | | | | | | |
| **GEMS** | 2% | 1% | | | 30% | | | | | | | | |
| **HSAP** | 0% | 8% | 8% | 0% | | 0% | 0% | 25% | | | | | |
| **JSHS** | 1% | 2% | | 1% | 1% | | 0% | 1% | 0% | | | | |
| **REAP** | 0% | 0% | 0% | 2% | | 10% | 0% | 10% | 0% | | | | |
| **SEAP** | 8% | 0% | 0% | 8% | 24% | 0% | 8% | | 21% | | | | |
| **UNITE** | 1% | 1% | | 3% | | 11% | | | | | | | |
| **URAP** | 3% | 3% | 3% | 6% | | 3% | 3% | | | 18% | | 9% | 0% |

**Table 22. AEOP Participants' Reporting "Never Heard of It"**

| | Competition Programs | | | | Summer Programs | | High School Apprenticeships | | | College Apprenticeships | | Scholarships/ Fellowships | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | eCM | JSS | JSHS | WPBDC | GEMS | UNITE | HSAP | REAP | SEAP | URAP | CQL | SMART | NDSEG |
| **CQL** | 94% | 98% | 97% | 94% | | 99% | 82% | | 0% | 56% | | 29% | 63% |
| **eCM** | | | 31% | 44% | 67% | 31% | 52% | 47% | 42% | | | | |
| **GEMS** | | | | | | | | | | | | | |
| **HSAP** | 92% | 83% | 83% | 92% | | 92% | 42% | | | 50% | | 58% | 58% |
| **JSHS** | 92% | 94% | | 90% | 92% | | 86% | 79% | 75% | 80% | 83% | | |
| **REAP** | 93% | 96% | 88% | 88% | | 84% | 57% | | | 69% | | 66% | 79% |
| **SEAP** | 82% | 97% | 95% | 79% | | 97% | 47% | | | 37% | | 32% | 68% |
| **UNITE** | | | | | | | | | | | | | |
| **URAP** | 94% | 97% | 91% | 88% | | 94% | 88% | | | | 58% | 65% | 70% |

| Table 23. AEOP Participants' Reporting "Interested/Would Participate if Available" | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Competition Programs** | | | | **Summer Programs** | | **High School Apprenticeships** | | | **College Apprenticeships** | | **Scholarships/ Fellowships** | |
| | **eCM** | **JSS** | **JSHS** | **WPBDC** | **GEMS** | **UNITE** | **HSAP** | **REAP** | **SEAP** | **URAP** | **CQL** | **SMART** | **NDSEG** |
| **CQL** | 6% | 2% | 2% | 5% | | 0% | 16% | | 0% | 35% | | 70% | 37% |
| **eCM** | | | | | | | | | | | | | |
| **GEMS** | 43% | | 44% | 49% | 80% | 49% | 74% | | | 71% | | | |
| **HSAP** | 8% | 8% | 8% | 8% | | 8% | | 33% | | 50% | | 42% | 42% |
| **JSHS** | 7% | 4% | | 9% | 7% | | 10% | 15% | 17% | 16% | 13% | | |
| **REAP** | 7% | 4% | 10% | 10% | | 7% | 27% | | | 28% | | 29% | 18% |
| **SEAP** | 11% | 3% | 5% | 13% | | 2% | 29% | | | 60% | | 60% | 26% |
| **UNITE** | | | 42% | 39% | | | 74% | | | 79% | | | |
| **URAP** | | | | | | | | | | 21% | | 21% | 27% |




Apprenticeship program mentors were asked to report their level of awareness of AEOP and DoD opportunities to assess the extent to which mentors are prepared to inform apprentices (and other youth they may contact) about educational opportunities through the AEOP and other DoD programs. Chart 21 summarizes mentors who "strongly disagreed" or "disagreed" (reflecting lack of awareness) they were knowledgeable of programs. Across these AEOP programs many mentors (41-67%) were unaware of various AEOP undergraduate apprenticeships, high school apprenticeships, and JSHS. Fewer were aware of SMART scholarship and NGSEG fellowship opportunities, but, from participant reports, did not consistently share information with participants. When asked whether they provided information to their apprentices about AEOP and DOD educational programs, across all apprenticeship programs between 10%-26% answered in the affirmative.

The mentor assessments asked about strategies used, challenges faced, and ways in which programs could support mentors in educating apprentices about AEOP opportunities. Mentors generally cited their own lack of awareness of AEOP programs, and lacking or insufficient resources (e.g., including AEOP brochure and website) to provide a coherent message and sufficient information to generate participant excitement about programs.  Some mentors had no knowledge of program-level expectations to educate apprentices about AEOP programs, and others reported that a lack of time during the program to discuss AEOP programs prevented them from addressing this objective. In questionnaires, focus groups, and interviews mentors suggested the following programmatic revisions for supporting them in educating their apprentices about AEOP opportunities, including:

- more and better resources about AEOP programs for mentors to provide to apprentices;
- on-site training or informational sessions to increase mentor awareness about AEOP initiatives;
- improved communication from program or site-coordinators to mentors about the expectation and deadlines for delivering AEOP information to apprentices; and
- Information that participants can pass along to peers after completion of the program.

Another AEOP, STPI, endeavored to inform teachers and through them, their students, of other STEM enrichment opportunities by the AEOP. In evaluation assessments, most 2013 cohort teachers (59-84%, avg. 68%) reported receiving information about other AEOP initiatives during STA, but a significant proportion report having never heard of them. Only 3-7% of 2013 cohort teachers report intent to incorporate AEOP programming and resources into either their class lessons or their extracurricular activities, though a majority of teachers expressed their intent to encourage student participation. The lack of intent to incorporate them may suggest that teachers have limited awareness of how AEOP programs support their teaching contexts, including how they align with and support the current state-led standards movement. The 9-month post-STA questionnaire for 2012 STA teachers revealed that most did not encourage their school students to pursue AEOP opportunities. Of the teachers that did encourage student participation, 50% recommended GEMS, 25% recommended ECM, up to 18% recommended one of the high school apprenticeship programs, and 8% recommended JSHS. More notable is that many 2012 teachers claim to be unaware of AEOP programs themselves 9 months after STA (25%-83%, avg. 56%).

Program evaluations suggest that across the AEOP all groups (e.g., youth participants, mentors) engaged in AEOP programs generally have limited awareness of AEOP programs other than those in which they are currently participating. Yet participant interest exists that would benefit from greater awareness. The Army, program administrators, site and event coordinators, mentors, and other volunteers share the responsibility for exposing participants to other AEOP initiatives and for encouraging continued participation in programs for which apprentices qualify. Continued guidance by program administrators is needed for educating site and event coordinators, mentors, and other volunteers about AEOP opportunities, in order that all participants leave with an idea of their next steps in AEOP.

# Summary of Findings

The 2013 AEOP evaluations collected data about participants, their perceptions of program processes, resources, and activities, and indicators of achievement related to outcomes aligned with AEOP and program objectives. A summary of findings is provided in Table 21.

| Table 21. Summary of Findings | |
|---|---|
| **Priority 1: STEM Literate Citizenry**<br>*Broaden, deepen, and diversify the pool of STEM talent in support of our Defense Industry Base.* | • **Finding #1: AEOP provided outreach to 41,312 students through its comprehensive portfolio of programs, yet considerable unmet need exists in many AEOP programs. Across the AEOP participants, mentors, and event directors call for expansion of DoD's unique and effective outreach programs that develop the Nation's future STEM talent.**<br>• **Finding #2: AEOP provided outreach to participants from underserved and underrepresented groups, but some programs were more effective at this than others. Even the strongest pipelines have limited success retaining underserved and underrepresented populations.**<br>• **Finding #3: AEOP provided participants with frequent exposure to real-world, hands-on, and collaborative STEM activities, which are less frequently available in their regular schools. Balancing hands-on *and* minds-on STEM activities is a promising practice that may produce greater student affective and achievement outcomes than hands-on activities alone.**<br>• **Finding #4: AEOP participants and their mentors perceived that AEOP experiences improved their STEM-specific and transferrable competencies and confidence. Improvements in confidence related to hands-on skills and abilities are consistent with the frequency with which participants reported engaging in related activities during the program, further supporting the recommendation to balance hands-on and minds-on STEM activities in program activities.**<br>• **Finding #5: AEOP expanded the number of participants engaged in ongoing DoD research, and exposed many others to DoD STEM interests. These efforts serve to improve participants' understanding of and attitudes toward DoD STEM research and researchers.**<br>• **Finding #6: AEOP exposed participants to Army and DoD STEM careers, but some elements were more effective at this than others. Direct engagement with Army and DoD STEM researchers and/or facilities during program activities are the most promising practices. Across AEOP mentors call for comprehensive resources that will improve their awareness of exciting Army and DoD STEM research and careers and that better support their efforts to encourage participants to consider careers with the DoD.**<br>• **Finding #7: AEOP served both to sustain existing STEM educational and career aspirations of its participants and to inspire new achievement, including intentions to pursue DoD STEM careers. AEOP has the potential to serves a critical need in providing authentic STEM experiences that both inspire and sustain participants' interest in STEM fields and that provide exciting and obtainable STEM career options to medical fields.** |

| | |
|---|---|
| **Priority 2: STEM Savvy Educators**<br>*Support and empower educators with unique Army research and technology resources.* | • **<u>Finding #1:</u> AEOP efforts to expand and reward teacher engagement were successful. "Boots on the ground" efforts to establish relationships with schools and teachers, and incentives for teachers, especially those that assist teachers in supporting their students' engagement in AEOP programs, are promising practices for further expanding teacher participation. Several AEOP programs have untapped potential to engage greater numbers of teachers in their programs.**<br>• **<u>Finding #2:</u> AEOP provided professional development to teachers through direct instruction from Army scientists and engineers (S&Es). Teachers' translation of their learning from the STEM Teachers Academy (STA) to the classroom and school may depend on the relevance of content to teachers' contexts and the structure of STA professional development model. Alternative models are needed to establish national reach, including teachers and schools serving underserved and underrepresented populations.**<br>• **<u>Finding #3:</u> AEOP online resources supported teachers in program engagement and classroom integration, but certain resources are underutilized. Underutilization may result from a lack of awareness or lack of understanding of how they may be best utilized to support participant engagement and/or classroom integration.**<br>• **<u>Finding #4:</u> AEOP expanded efforts to recruit, prepare, and study the experiences of S&E mentors, including tracking the development and impact of GEMS near-pear mentors, HSAP/URAP graduate mentoring fellows, and JSHS national judges. S&Es contribute valuable perspective pertaining to Priority 1 and Priority 2 objectives that informed many if not all 2013 evaluation recommendations; data collection about and from S&Es should be expanded and standardized in future evaluation.** |
| **Priority 3: Sustainable Infrastructure**<br>*Develop and implement a cohesive, coordinated, and sustainable STEM education outreach infrastructure across the Army.* | • **<u>Finding #1:</u> AEOP evaluation efforts expanded in 2013 with the evaluation of eleven programs, increased focus on AEOP Priority 2 objectives, and shifts toward common program metrics that align with AEOP programs guiding framework. Future evaluation efforts are informed by and strive to adhere to Federal guidance and best practices for rigorous program evaluation, while attending to AEOP priorities.**<br>• **<u>Finding #2:</u> AEOP marketing, promotion, and branding activities expanded to reach Consortium members, participants, and the public with a unified message about AEOP's pipeline of programs. Data suggest, however, that AEOP- and program-level marketing of AEOP programs have less success than sites' marketing efforts at attracting students to and retaining them in the pipeline. Participants' interest in AEOP will benefit from greater emphasis on cross-promotion of elements during program activities.** |

## What AEOP participants are saying…

*"I very much enjoyed my [**CQL**] internship at USACIL. I became an "expert" in a specific topic, and was able to present my findings to other colleagues and scientists in the field. I believe the most valuable experience was being able to work under the same conditions as they are overseas and to collaborate with the DNA and latent print analysts."* – CQL Apprentice

*"[He] was well trained, understood the research process and the tools needed to complete the project. He worked well with others and provided some training to existing employees in some of the techniques. I would have hired him full time if I could."* – CQL Mentor

*"**eCYBERMISSION** has increased my confidence and passion that I can excel and contribute towards the STEM fields, and has no doubt increased my desire to attend a STEM-based high school and college."* -eCYBERMISSION Contestant

*"This **GEMS** experience was truly phenomenal experience that helped me decide to pursue a career as, hopefully, an Army research engineer."* – GEMS Student

*"I think [**GEMS**] motivates students in STEM fields because it relates science back to real life. In school they just learn facts and they're not actually able to connect it back to real life… [applying school concepts] is what **GEMS** does."* **–** GEMS Mentor

*"It was satisfying to have grown over these past few weeks from knowing virtually nothing to being able to have a discussion with Ph.D. based on my topic. It is not a usual thing for students like me to have to opportunity to present my work to well-established scientists. Furthermore, I feel very fortunate to have researchers teach me their work and try to show me their passions in their respective fields."* – HSAP Apprentice

"*The **HSAP/URAP** is a great program that is exposing its students to cutting-edge scientific research, which excited them about pursuing careers in science. They become aware of the support and opportunities available through Army/DOD."* – HSAP/URAP Mentor

*"My participation in **JSHS** encouraged other classmates to get involved. Thank you for supporting JSHS in overseas DoDDS schools which do not have the same number of opportunities as statewide students."* – JSHS Contestant

***"**I am so blessed that I had the chance to participate in **JSHS** at the Regional and National levels this year. The experience was absolutely life-changing, and has reaffirmed my interest in majoring in a STEM field in college.**"*** – JSHS Contestant

*"Students have an exciting opportunity to apply the scientific concepts they are learning in class to a real-world challenge with **JSS.** Kids develop teamwork and problem-solving abilities, investigate environmental issues, gain hands-on engineering skills, and use principles of science and math to get the fastest, most interesting, and best-crafted vehicle possible."* – JSS Event Host

"*If a genie granted me a wish to spend the summer any way I like, I would use that wish to participate in the **REAP** program again. I leaned things from data software to fundamentals of research. It has given me a leg up on college and has inspired me to pursue my interest in independent experimentation and research. This has been one of the most valuable summers of my high school years. I am grateful for the opportunity and knowledge **REAP** has given me. Thank you."* - REAP Apprentice.

*"It took some time to get her to understand that she was an integral part of the laboratory…The success was, of course, that she actually became one of the research team," - REAP Mentor*

*I'm highly satisfied with the* **SEAP** *research project. It has proven to be a challenging and entertaining learning experience, and I feel that I have grown as a student and researcher as a result of my involvement with the program. The most valuable part of the experience was, by far, the real-world research laboratory experience…"* – SEAP Apprentice

*"*[**SEAP**] *is worthwhile for the mentors, the laboratories, and the students. A lot of these students want to go into STEM industry. These students get the experience that they need to get the jobs that they want – professional development."* - SEAP Mentor

*"*[**STA**] *was one of the best professional opportunities I have ever had in my professional training. I knew of the potential impact upon my learning and thus the learning of my students -- this was my first opportunity to put what was a 'theory' into real life action. Our team consisted of science teachers in 6th, 7th, 8th grade and a math teacher in 6th grade. Powerful Opportunity -- thanks."* – STEM Teacher Academy Teacher (STPI)

*"If it were not for the amazing opportunities opened to me by this* [**UNITE**] *program, I do not think I would have been so knowledgeable about STEM careers and know what I want to do with my life. Now, I am able to say as a rising senior I am ready for the long and significant road ahead."* - UNITE Student

*"After they completed the* [**UNITE**] *program and presented their career aspirations… I thought to myself, 'this is such a diverse group, these people are going to make this world great'. They have such advanced goals for being so young. It was so exciting to hear them explain, you can see the excitement on some of their faces. You could see the passion when they spoke about what they wanted to do."* – UNITE Mentor

*"I've learned that hands-on is very important. When you touch something…that is where you learn. So just writing problems is good for theory but if you want to see what is going on in nature you have to start using instruments and do experiments.* [**URAP**] *gives you that…"* – URAP Apprentice

*"The program was an excellent way to become exposed to and acquainted to research. It was a valuable way to learn how to perform experiments, literature surveys, and academic writing. I have no doubt that it will have a strong influence on the rest of my academic career (I now know substantially more about aero dynamics than I did earlier this summer). I am glad to have been able to participate."* – URAP Apprentice

*"Exposing good laboratory skills and discussion with graduate students made him fully understand what the next step needed to do in STEM research is critically important. I fully believe in this effort, and need to grow to help U.S. training and guidance on students toward STEM.* [**URAP**] *is a building block for U.S. students for international competitiveness in addition to Army/DoD. Overall, I am very excited about the program and looking forward to more opportunity."* – URAP Mentor

# Discussion and Recommendations

1. Across the AEOP there is considerable differential between the number of applicants being considered for AEOP programs and the number of spaces available for participants, indicating significant unmet need. AEOP programs expose interested and talented youth to STEM through engagement opportunities that are unique to the Army and DoD. In light of evidence of program successes, and considering that participants perceive benefit that is beyond what typical school offerings can provide, it is recommended that the Army expand initiatives where possible. It is recommended that the Army expand all programs showing evidence of need.

   The AEOP is purposefully structured to promote a pipeline that offers participants with opportunities for continued exposure to, engagement in STEM pathways that culminate in careers that support the DoD mission. In particular, efforts should be made to ensure that AEOP alumni have the opportunity to advance to the next-level AEOP program that is available to them. Ideally, space in programs would exist for all alumni who are interested and qualified, as well as for new qualified individuals seeking entry to the AEOP pipeline at any given point. This may be impossible for local pipelines (GEMS-SEAP-CQL) to accommodate given the large number of entry-level participants wishing to continue their work at the Army laboratories and the limited positions available to them in the more advanced AEOP programs. Where local pipelines cannot accommodate need, cross-promotion of AEOP programs is vital to ensure advancement and retention of talented alumni in the AEOP.

   Further, any expansion of AEOP programs should balance the needs of existing sites and the communities they currently serve with geographic expansion to new sites and communities. To expand the capacity of existing sites, greater investment may be required to expand site administrative staff, physical infrastructure needs, and mentor participation, most notably of S&Es. Programs may benefit from a careful examination of and attention to program- and site-level structures, processes, and resources that both enable and discourage S&Es' participation in programs. Program- and site-level accommodations may be required to further improve S&Es' awareness of programs, feasibility of their participation, and overall motivation to participate. Where appropriate, expansion should include the highly successful partnership models in which S&Es, undergraduate/graduate S&Es-in-training as near-peer mentors, and resource teachers work together to support the translation of complex content into age-appropriate and pedagogically sound activities for youth participants.

2. AEOP objectives include expanding participation of historically underrepresented and underserved populations. While AEOP elements conduct program-level marketing of programs targeting those populations, assessment data suggests that site-level marketing, recruiting, and selection processes have greater influence in determining participants. Data also suggest while most AEOP elements or their sites have some success in recruiting underserved participants to AEOP, there is less success with retaining them in local and AEOP-wide pipelines.

   AEOP programs may benefit from more guidance from Army leadership regarding program- and site-level priorities and processes for maximizing the inclusion and retention of underrepresented and underserved students as appropriate for the individual programs. This guidance may include recommendations for any number of promising marketing practices employed in 2013 programming that targeted recruitment of underserved populations, or those aimed at providing equitable support to ensure successful participation of those populations, and/or more explicit mechanisms for advancement of those participants within AEOP, such as modeled in the UNITE-REAP pipeline. Both UNITE and REAP serve primarily underserved and underrepresented populations. In the UNITE-REAP pipeline, a minimum number of qualified UNITE alumni were invited to and completed a REAP apprenticeship established at the same host site, thus ensuring the advancement of students from underserved populations from one AEOP program to another.

While explicit guidance is encouraged for all individuals who participate in selection processes, such guidance may all-together deter mentors from participating in the programs. For example, efforts to ensure that "connected" applicants (e.g., those with family, family friends, or school-based connections to the site) are not disproportionately advantaged over qualified but "un-vetted" candidates who apply at the AEOP website may lessen mentor interest if they perceive correlation with an increased responsibility for oversight during the apprenticeships and/or if they perceive that "un-vetted" apprenticeship candidates have been less successful. The Army, program administrators, and sites need to also consider practical solutions to other challenges posed to the host-site or event locations, as proximity alone is likely to advantage some populations more than others (e.g. students with greater proximity, or students with means for longer distance transportation or temporary relocation near the site). In-residence programs and/or travel accommodations (e.g., bus transportation from schools) may be needed to recruit and make participation feasible for underserved populations living at greater distances from the host or event sites. Beyond recruitment, additional support may be necessary to mitigate underserved students' resource and educational gaps (identified by participants, mentors, and event directors), to ensure their participation is both feasible and successful.

3. Several AEOP programs have untapped potential to engage greater numbers of teachers in their programs that future programming should address. JSS and STPI in particular have the potential for nationwide reach with adjustments to their operational models.

   Attempts to perform outreach primarily through JSS' jrsolarsprint.org website and existing school- and community-based JSS programming may constrain the diversity of the population that it attracts, according to data collected from hosts and teachers. Outreach to underserved and underrepresented populations may not be a key objective of non-AEOP affiliated JSS hosts and teachers nationwide. However, outreach to these populations is an Army priority, and therefore AEOP's JSS programming in 2014 should incorporate explicit efforts to market to and recruit these populations, and to support them in successfully participating in JSS. In an effort to engage underserved and underrepresented populations, JSS may need to identify and directly engage teachers and students that have not been exposed to JSS-based programming to date. For example, these efforts might include a) promoting JSS to the program administrator's nationwide and diverse membership base, support and volunteer network, and local chapters, and supporting local and national competition options for students that are coordinated by or in partnership with the program administrator; b) efforts similar to those of eCM, including establishing unique partnerships with teachers at Title 1 schools, provisions of low or no-cost kits for students, professional development, and support for school-based communities of practice to help educator teams integrate JSS activities with their classroom STEM curricula; and c) strategically cross-promoting and forging partnerships with Army and university sites that host other AEOP pipelines (e.g., GEMS-SEAP-CQL and UNITE-REAP) to expand outreach to diverse populations when they are younger, and prepare them for future engagement in GEMS and UNITE. The concept of JSS, harnessing solar energy, highlights and connects to Army and DoD STEM interests particularly well, and would benefit from stronger partnerships with Army and DoD S&Es whenever possible.

STPI's focus to date has been on college-level content provided by Army and university S&Es through the STEM Teachers' Academy (STA). Teachers are provided opportunities to translate their learning into grade-level planning and teaching, and most teachers intend to implement these plans post-STA Follow up questionnaires suggest that most participants (69%-91%) do apply their learning to their classroom planning and teaching but only 16%-38% share their learning with other teachers at their school or district. Stronger partnership with other AEOP programs having readily available grade-level and standards aligned resources for integration with classroom curriculum (eCM, JSS, JSHS, and WPBDC) and with Army research laboratories having vested interest in research supporting fields embodied in those resources (e.g., solar energy for JSS, civil engineering for WPBDC), could provide a strong model for teacher professional development that promotes AEOP and Army interests.

4. Across AEOP participant and mentor data suggest that participants have more opportunities to do the *hands-on* aspects of STEM activity and fewer opportunities to engage in the *minds-on* aspects. Minds-on aspects of STEM activity have been linked to greater student affective and achievement outcomes than hands-on activities alone.[31] [32] Programs might consider how to expand participants' opportunities to engage in minds-on STEM activities such as generating questions, designing experiments, analyzing and interpreting data, and formulating conclusions for their questions during their program experiences. Promising models of similar efforts are available across AEOP. Whether these strategies are team competitions, weekly challenges, or capstone cases to be solved, or whether they include mentors modeling such minds-on practices for participants, scaffolding "thought exercises" to be completed by participants, or coaching participants in these activities, such efforts may maximize apprentices' professional development through programs, better mirror the day to day practices of scientists and engineers, and may also continue to challenge and inspire older AEOP participants and returning alumni who tend to exhibit less change in outcomes related to STEM competencies and ambitions.

5. Across AEOP, participants and mentors reported in evaluation assessments limited awareness of and participation in AEOP elements outside of that in which they were currently participating. Where local pipelines exist, past participation, awareness of, and future interest in the local pipeline is evident. However, there is little awareness of AEOP beyond the local pipeline. Mentor interviewees reported spending little or no time educating students about AEOP initiatives for which students qualify during daily program activities, aside from distributing AEOP brochures and referring participants to the AEOP website. Student interviewees generally could not name, or recognize when named, AEOP initiatives except for those participating in local pipelines. Yet, questionnaire data reveals that substantial student interest exists in AEOP opportunities when vaguely described. This interest, especially from students of underserved populations, would benefit from more robust attention by site coordinators and mentors during program activities.

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

[32] Maltese, A.V. & Tai, R. H. (2011) Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education Policy* 98, 877-906

Where local pipelines cannot accommodate need, cross-promotion of *all* AEOP programs is vital to ensure advancement and retention of talented alumni in the AEOP. Other AEOP elements may be able to provide continued engagement and greater geographical and demographic reach where local pipelines are simply unable. Continued guidance by program administrators is needed to ensure coordinators and mentors alike are knowledgeable of AEOP opportunities, and have reasonable plans and strategies for exposing participants to these opportunities in meaningful ways before, during, and after program activities, so that each participants knows their next steps in the AEOP.

That said, sufficient and engaging resources must be available to support site coordinators and mentors in their cross-promotion of programs. The AEOP marketing materials contain a core call-to-action: visit www.usaeop.com for more information. Yet, when users access the website, they report finding insufficient or outdated information, including static text and images. Users report the site lacks coherent message and presentation that generates excitement about AEOP programs, the kind of excitement that come from community-derived dynamic, video-based, or social media-linked content. Creation of a new AEOP website that meets the needs of programs and allows other complementary marketing activities (especially community-building through social media) to succeed and thrive should be a priority. Future evaluation should include more standardized measures and metrics to both elicit brand awareness but also to understand the impact of website and social media efforts on brand awareness among key stakeholders.

6. Across AEOP, most participants reported opportunities to learn about STEM research and careers, including Army/DoD STEM research and careers, during program activities. Direct engagement with Army and DoD STEM researchers and/or facilities during program activities are the most promising practices, and impact not only awareness but also interest. However, across AEOP, and especially where direct engagement with Army/DoD researchers and facilities are not possible, mentors call for comprehensive resources that highlight of a range of exciting Army and DoD STEM research and careers to improve their awareness and better support their individualized efforts to encourage participants to consider careers with the DoD. Many mentors reported lack of awareness of STEM careers beyond their own, lack of informational resources, lack of direction provided by program administrators, and lack of time for educating participants about STEM careers. An AEOP centralized effort to create a resource that profiles Army STEM interests and the education, on-the-job training, and related research activities of Army S&Es is recommended. Such a resource could start the conversation about Army STEM careers and motivate further exploration beyond the resource itself. A repository of public web-based resources (e.g., Army and directorate STEM career webpages, online magazines, federal application guidelines) could also be disseminated to each mentor and/or participant to help guide their exploration of Army/DoD STEM interests, careers, and available positions.[33] The National Institutes of Health-funded *Building Bridges: Health Science Education in Native American Communities* annually evolving Community Poster Project (http://www.unmc.edu/rhen/role_model_poster.htm) provides a promising model for encouraging underserved populations in considering STEM careers.

7. Strategic promotion of element-specific online resources, such as eCM, JSS, and WPBDC, which encourage and support participation in programs and classroom integration, and monitoring of use, quality, and perceived value through

[33] For example, http://www.goarmy.com/careers-and-jobs/army-civilian-careers.html,http://www.goarmy.com/careers-and-jobs/stem.html, individual directorate STEM webpages and resources such as RDECOM's Army Technology magazine, and usajobs.gov.

website analytics and user questionnaires should continue. Alignment of educational resources with the *Next Generation Science Standards* is highly recommended, attending both to AEOP objectives and the national call for shared standards across formal and informal education settings. Evaluators advise improving the visibility and/or awareness of existing resources to ensure users understand how resources may be used to best improve their participation. Revisions and additions to resources that accommodate widespread user need reported from the individual program evaluation assessments are encouraged. The visibility of information related to AEOP and Army STEM will, in part, determine the extent to which this program successfully raises awareness through the website. Strategic website revisions and other program-level marketing efforts that can strengthen the visibility and participant awareness of Army STEM and the AEOP are encouraged.

8. While 2013 evaluation participation provided improvement over 2012, coordinated efforts are still needed by the LO, Army, program administrators, and site coordinators to expand process evaluation efforts related to program implementation and to encourage and improve participant and mentor participation in evaluation efforts.

   Deep understanding of program activities that can be linked to outcomes are vital for identifying promising practices that can be rigorously studied, taken to scale, and shared across the AEOP and with the field. Standardized annual program reporting that builds on the research.gov model and addresses the contexts and priorities of AEOP is strongly encouraged. This mechanism would attend to Federal guidance for evaluation of STEM investments,[34] [35] build the capacity across AEOP to contribute to and use evaluation, and, when linked to outcomes, would provide stronger evidence upon which decision-making about programmatic revisions could be based.

   With respect to outcomes evaluation performed by the LO, findings of the CQL, GEMS, JSHS National Symposium, REAP, SEAP, 2013 STA, UNITE, and URAP participant questionnaires, as well as the JSHS Regional Director questionnaire could be reliably generalized to the respective populations. This is a substantial improvement over 2012. However, low response rates to evaluation assessments pose the most significant threat to the validity of findings from those assessments, and, furthermore, limit the possibility of making reliable comparisons of those data from year to year. While evaluators can assess representativeness of samples through alternative means, accurate demographic data must be available for the population in order to accomplish these determinations. And mentors' assessment of apprentice performance are important for triangulating apprentices' perceptions of growing confidence in their STEM competencies. Evaluators will endeavor to streamline instruments and appropriately incentivize participation in evaluation assessments; however, evaluators necessarily rely on the assistance of Army, program administrators, and site coordinators to promote a culture of evaluation among program sites, participants, and mentors.

[34] Committee on STEM Education, National Science and Technology Council, "Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan" (Washington, D.C., 2013)

[35] Government Accountability Office, Science Technology, Engineering, and Mathematics Education: Strategic Planning Needed to Better Manage Overlapping Programs Across Multiple Agencies. (Washington, D.C., 2012)

# Appendices

## Appendix A: 2013 AEOP Evaluation

### *Methods and Design*

The AEOP Evaluation used mixed methods approaches[36][37][38] that allow for broad generalization from "quantitative" trends generated in larger surveys of AEOP participants and in-depth focusing of the evaluation through the "qualitative" insights generated through observation and interview of smaller samples of participants. Evaluation assessments included critical review of program documentation, participant questionnaires, focus groups or interviews, and on-site observations. Triangulation is used to improve the validity of findings by drawing information from different data sources (e.g., IPAs, students, and "mentors"), different methods of inquiry (e.g., program documentation, survey, focus group and interview data), and different investigators.[39] For example, in evaluation reports evaluators cite major trends from the qualitative data—emergent themes with high frequencies in respondents addressing them—to provide additional evidence of, explanation for, or illustrations of survey data. Evaluators pose plausible explanations when divergence between data sources or data types was evident; any such explanations are potentially subject to further exploration in iterative evaluation efforts. Periodically, less unique perspectives are reported and identified as such when they provide illustration that captures very distinctly the spirit of the AEOP, or a sentiment that is so antithetical to the AEOP mission that it warrants further investigation.

AEOP Evaluation endeavors to consistently employ the most rigorous designs possible accounting for the infancy of the AEOP CA and its objectives, the expanse and variety of activities of different AEOP programs and their sites, and the resources available for evaluation activities. Past AEOP Evaluation has primarily employed designs described by the Academic Competitiveness Council as "Other Designs:"[40] those that do not employ the most rigorous "scientific" randomized control trials and quasi-experiments. AEOP Evaluation uses pre-post program designs, retrospective pre-post designs, and post-program only designs. In both pre-post and retrospective pre-post designs, changes in self-perceptions of outcome measures (e.g., confidence in applying a STEM research skill, from pre- to post-program) can be measured and the significance of that change can be investigated with appropriate statistical analyses. These and more rigorous designs are most methodologically appropriate for programs in which a treatment is more clearly defined and consistently delivered to a group of participants, such as in the curriculum-based summer programs. Post-program only designs are less useful for indicating whether participants have changed during the program, so efforts were also made to corroborate student perceptions of activities and program effects with those of mentors. These designs are currently used for programs in which the treatment is less clearly defined and where greater variations occur in the delivery to a group of participants, such as in the apprenticeship programs.

[36] John Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (Thousand Oaks, CA: Sage Publications, 2003)
[37] Michael Patton, Qualitative Research & Evaluation Methods (Thousand Oaks, CA: Sage Publications, 2001)
[38] Jennifer Greene and Valerie Caracelli, Eds. "Advances in mixed method evaluation," New Directions for Evaluation, 1997, 74.
[39] Michael Bamberger, Jim Rugh, and Linda Mabry. Real World Evaluation (Thousand Oaks, CA: Sage Publications, 2006)
[40] Op. cit., U.S. Department of Education

### *Measures and Sampling*

Reviews of programs implemented were conducted and reported by some IPAs and provided to the LO in an effort to triangulated reviews of program implementation with other data.

Questionnaires, focus groups, interviews, and on-site observations were used to assess program implementation, primarily through participants' perceptions of program activities, and also provide participants' self-assessments of program effects.

- Surveys were administered to participants in primarily online formats. Paper formats are provided for programs and sites with limited or restrictive access to computer or internet technologies. All participants of the primary audiences for the program are invited to participate in these surveys, often through emails sent by the evaluation team, IPAs, or site coordinators. Questionnaires consisted of closed or forced-response "quantitative" items as well as opened or constructed-response "qualitative" items.
- Onsite focus groups are conducted with a strategic sampling of sites and participants. Different sampling strategies were used, depending on the context of the program. Purposive sampling was used for assembling focus groups when larger numbers of participants were available to join the focus group at a site. In this case, participants were selected to ensure equal representation of males and females and a range of age/grade levels, race/ethnicity demographics, and STEM interests. Convenience sampling—all participants are invited to join the focus group without regard to diversity represented by the group—was employed when small numbers of participants were available at a site.
- Phone interviews were conducted to maximize participation for programs in which on-site visits are less cost-effective such as programs having many sites and with small numbers of participants at each site. Purposive sampling was used for identifying phone interview candidates to ensure diversity in geography (program sites), participant demographics, and STEM interests. When used, phone interviews were employed in addition to onsite focus groups.
- Onsite observations were conducted whenever in-person focus groups were conducted. While observations were unstructured (i.e. not formal observation protocol), they included assessment of critical aspects of participant engagement in AEOP programming.

### *Data Collection and Analysis*

Data collection occurred proximal to program activities. Questionnaires for GEMS and UNITE programs using a pre-post design were released just prior to the beginning of program activities and again toward or after the conclusion of program activities. Questionnaires for other programs using post-program only designs were released toward or after the conclusion of the program activities for a period of 10-30 days after the release. Focus groups (onsite and online) and phone interviews are conducted during program activities, but, when possible, toward the conclusion of a program or sites activities as to maximize referent experiences.

Quantitative and qualitative data are compiled and analyzed after all data collection has concluded. Evaluators summarized quantitative data with descriptive statistics such as frequencies, means, and standard deviations. Where appropriate evaluators conducted inferential statistics to study any differences in participants' pre-post program outcomes, differences between participants' perceptions of program and school, and differences between different participant groups' perceptions or outcomes that could demonstrate the potential effect of their participation in an AEOP. Inferential statistics were used to identify statistically and practically significant differences. Statistical significance indicates whether a result is different than chance alone. Statistical significance is determined with t, Z, McNemar, ANOVA, or Tukey's tests, with significance defined at $p < 0.05$. Because statistical significance is sensitive to the number of respondents, it is more difficult to detect significant changes with small numbers of respondents, such as at the site level. Practical significance, also known as effect size, indicates how weak or strong an effect is and is usually studied in relation to statistical significance. Practical significance is determined with Cohen's *d* or Pearson's *r*, with *d* or *r* of .250, which is considered weak but "substantively important" at $p < 0.05$.[41] Statistically and/or practically significant findings were noted as "statistical" or "significant" in the reports and results of statistical tests reported in appendices or footnotes. For brevity of this report, significant effects are often noted as such, with no additional details.

Evaluators analyzed qualitative data, including constructed-response questionnaire and focus group data for emergent themes. These data are then summarized by theme and by frequency of participants addressing a theme. When possible, two raters analyze each complete qualitative data set. When not possible, a portion of the data set are analyzed by both raters to determine and ensure inter-rater reliability. Thus, the summary of themes and frequency represent consensus ratings.

To the extent possible, findings were triangulated across data sources (students, mentors), data types (quantitative survey data and qualitative data from questionnaires, focus groups, and program reports), and different evaluators conducting the analyses and reporting. This triangulation enhances the credibility of findings synthesized from single data sources or data types. For example, evaluators cite major trends from the qualitative data—emergent themes with high frequencies in respondents addressing them—to provide additional evidence of, explanation for, or illustrations of quantitative data. We have posed plausible explanations when divergence between data sources or data types is evident; any such explanations are worthy of further exploration in the full study and, potentially, in future evaluation efforts. Periodically, less unique perspectives are reported and identified as such when they provide illustration that captures the spirit of UNITE or AEOP objectives.

### *Reporting and Dissemination*

Data, findings, and recommendations were presented to each program and the Army in a formal summary report. Full study reports were delivered to programs and the AEOP from December 2013 through March 2014. Individual Program Administrators were provided 7-10 days to provide critical comment of their program evaluation. Any comments provided were attached as an appendix to the final report submitted to the Army. Full reports will be made available on a public page of the AEOP website.

[41] U.S. Department of Education, What Work's Clearinghouse Procedures and Standards Handbook, accessed June 30 http://ies.ed.gov/ncee/wwc/pdf/reference_resources/wwc_procedures_v3_0_draft_standards_handbook.pdf

# Appendix B: 2013 College Qualified Leaders (CQL) Evaluation

## Executive Summary

The College Qualified Leaders (CQL) program, managed by the American Society for Engineering Education (ASEE), is an Army Educational Outreach Program (AEOP) that matches talented college students and recent graduates (herein referred to as apprentices) with practicing Army Scientists and Engineers (Army S&Es, herein referred to as mentors), creating a direct apprentice-mentor relationship that provides apprentice training that is unparalleled at most colleges. CQL allows alumni from Gains in the Education of Mathematics and Science (GEMS) and Science and Research Apprentice Program (SEAP) to continue their relationship with the mentor and/or laboratory, and also allows new college students to enter the program as well. CQL apprentices offers the provision of summer, partial year, or year-round research at the Army laboratory, depending on class schedules and school location. CQL apprentices receive firsthand research experience and exposure to Army research laboratories. CQL fosters desire in its participants to pursue further training and careers in STEM while specifically highlighting and encouraging careers in Army research.

In 2013, CQL provided outreach to 260 apprentices and their mentors at 10 Army laboratory sites (herein called CQL sites). This is a decline of 5% from the 274 apprentices in 2012. In 2013, 588 students submitted applications to the program, up 58% from 373 student applicants in 2012.

This report documents the evaluation of the 2013 CQL program. The evaluation addressed questions related to program strengths and challenges, benefits to participants, and overall effectiveness in meeting AEOP and program objectives. The assessment strategy for CQL included: in-person focus groups with apprentices and mentors at 4 CQL sites and online post-program questionnaires distributed to all apprentices and mentors.

| Table 1. 2013 CQL Fast Facts | |
|---|---|
| Major Participant Group | College Students |
| Participating Students | 260 |
| Participating Army S&Es | 260 |
| Participating Army Agencies | 10 |
| Total Cost | $2,407,923 |
| Total Stipends | $2,341,279 |
| Cost Per Student Participant | $9,261 |

## Summary of Findings

The 2013 evaluation of CQL 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 2.

| Table 2. 2013 CQL Evaluation Findings | |
|---|---|
| **Participant Profiles** | |
| All evaluation data contribute to the overall narrative of CQL's efforts and impact, and highlight areas for future exploration in programming and evaluation. However, confidence in evaluation findings varies by participant group. | • Statistical reliability calculated for the apprentice questionnaire (margin of error = ±8.1% at 95% confidence level) and alternative methods for establishing representativeness (statistical comparison of apprentice respondents' and participants' demographic information revealed no significant differences) suggest findings from the apprentice questionnaire may be sufficiently generalizable to the apprentice population. |
| | • Statistical reliability calculated for the mentor questionnaire (margin of error = ±20% at 95% confidence level) and lack of available demographic information with which to make alternative determinations suggest mentor respondents may not be representative of the mentor population. Mentors contribute valuable perspective to CQL evaluation and any findings from mentor questionnaires should be cautiously generalized with consideration given to the margin of error and with triangulation of findings with other data. |
| CQL had some success in providing outreach to participants from historically underrepresented and underserved populations. | • Apprentices included female students (35%)—a population that is historically underrepresented in some STEM fields. |
| | • Apprentices identified as Black or African American (9%) and Hispanic or Latino (5%), and American Indian or Alaskan Native (1%)—these populations are among those historically considered underserved and underrepresented in STEM education. |
| | • Mentors identified as predominantly male (67%) and White or Caucasian (57%). Of the 22 mentor respondents, 15% identified as Black or African American (10%) and Hispanic or Latino (5%). |
| CQL serves the Nation's future STEM workforce. | • Most CQL apprentices are pursuing STEM degrees. 95% of apprentices planned to pursue a degree in a STEM field (10% Bachelors, 33% Master's, 52% Doctorate.) |
| | • Most CQL apprentices intend to pursue STEM careers. Most frequently, apprentices reported currently working on engineering degree (48%) and similar intent to pursue an engineering career (48%). Medicine/health was the second most frequent career field listed (17%). Apprentices also intended to pursue careers in life science (9%), chemistry (7%), physical science (6%) and math/computer science (3%), as well as other STEM (6%) and non-STEM (2%) fields. |
| **Actionable Program Evaluation** | |
| CQL marketing and recruitment was largely a site-based endeavor. | • CQL sites marketed CQL to local universities and educators, as well as to participants of other AEOP programs at the site. |
| | • More than one third of apprentice interviewees reported learning about CQL through friends, family, family friends, or university professors with connections to CQL site, program, or mentor. Similarly, 37% of apprentice questionnaire respondents reported having a family member or family friend at the Army research facility where the CQL apprenticeship took place. |
| | • More than one third of apprentice interviewees learned of CQL through GEMS, SEAP, or Near Peers programs at the site. Questionnaire respondents reported past participation in GEMS (10%), SEAP (24%), and Near Peers (3%). |
| | • Many mentors reported selecting apprentices that had been "vetted" by a personal or professional connection of the mentor. |
| CQL apprentices desired repeated engagement at | • Apprentices were motivated to participate in CQL by their desire for repeated engagement at the Army labs after participating in CQL or other AEOP programs at the site (e.g., GEMS, |

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| Army labs and opportunities to advance their STEM pathways. | SEAP, or Near Peers) Apprentices also participate because they generally wish to advance their STEM pathways: build research skills, gain research experience, apply school learning, and their build applications or resumes. |
| CQL mentors sought opportunities to engage with STEM learners in their work. | • Mentors chose to participate in CQL because of positive experiences as CQL, SEAP, or GEMS mentors, for opportunities to re-engage former apprentices in the research project, and to have project needs met by hosting an apprentice. |
| CQL mentors used a team-based approach to engaging their apprentices in STEM research and supporting their educational and career pathways. | • Apprentices and mentors questionnaire respondents reported similar frequencies of mentor activities related to engaging apprentices in STEM research. Similarly, apprentice and mentor interviewees frequently reported activities reviewing apprentice work and giving feedback; grounding laboratory work in scientific principles and practices; and training the apprentice to perform laboratory tasks and procedures. |
| | • Moderately large to very large significant differences were found in apprentices' and mentors' perceptions support for educational and career pathways. Other laboratory personnel contributing to the day-to-day mentoring of apprentices may provide other mechanisms for support of educational and career pathways beyond that provided by Army S&Es. |
| CQL mentors lacked awareness and resources needed for promoting AEOP opportunities and STEM careers. | • Most mentor interviewees had limited awareness of AEOP initiatives. Subsequently, mentors did not consistently educate their apprentices about AEOP programs or encourage apprentices to participate in them. |
| | • Mentors suggested that informational resources provided to mentors or apprentices, mentor training, and clear expectations for promoting other AEOP PROGRAMS were necessary to accomplish this objective. |
| | • Mentors reported a variety of strategies for mentoring apprentices about STEM careers, with a strong emphasis on Army/DoD STEM careers. Some mentors suggested that the experience itself educated apprentices about STEM research and careers with the Army. |
| | • Mentors perceived that furloughs, their own lack of awareness, and lack of resources for educating about STEM careers were challenges to providing career mentorship. Mentors requested resources to share with apprentices and suggested a number of programmatic changes that would increase the visibility of Army/DoD STEM professionals in CQL. |
| CQL benefited apprentices as well as Army S&E mentors and their laboratories. | • Apprentices and mentors perceived that CQL benefits apprentices by providing authentic research opportunities not typically available in school settings, opportunities to expand their STEM competencies and confidence in those competencies, and opportunities to advance their STEM pathway, and access to effective mentorship. |
| | • Mentors also perceived benefits to their laboratories and to themselves. Most notably, mentors indicated that apprentices are low-cost yet highly effective members of the lab, and apprentices have made meaningful contributions to research with near-term impact on Army processes or procedures. |
| CQL's administrative processes and mentee-mentor matching are | • Apprentices and mentors perceived challenges with the "cumbersome" and "time-consuming" administrative tasks associated with the CQL, suggesting they detract from work that can be accomplished during an already short (and furlough-disrupted) summer apprenticeship. Mentors perceived low organization of and support for these tasks. |

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| possible areas for improvement. | • Apprentices suggested processes for mentee-mentor matching could be improved to ensure apprentices have sufficient work to do and can contribute beyond a singular task or procedure. One apprentice suggested professional development is needed for mentors. |
| **Outcomes Evaluation** | |
| CQL engaged apprentices in authentic STEM activities more frequently than their school environment. | • Apprentices reported that CQL provided more frequent opportunities to engage in authentic STEM activities as compared to their school setting, including academic research activities (35%-69% in CQL, 16%-46% in school) and hands-on research activities (29%-71% in CQL, 16%-39% at school). Small to moderately large, significant differences were found for 9 of 12 STEM activities. |
| | • Apprentice and mentor data suggested CQL had a slightly larger effect with respect to providing apprentices opportunities for hands-on research activities than it had providing opportunities for academic (minds-on) research activities. |
| CQL apprentices became more confident in STEM, and mentors rated their research and reporting skills highly. | • A majority of apprentices (68%-85%) perceived growth in their confidence across 7 key STEM skills and abilities: performing literature reviews, formulating hypotheses and designing experiments, using laboratory safely, using laboratory equipment and techniques, analyzing data, generating conclusions, and contributing to a research team. |
| | • Many mentors (53%-91%) rated their apprentices at near expert or expert levels of the development continuum across 6 key STEM skills and abilities: information literacy, scientific reasoning, laboratory, data collection, quantitative literacy, and teamwork and collaboration. Most mentors (92-100%) also rated all 6 components of their apprentices' final research project or presentation as near expert or expert level. |
| CQL apprentices intended to pursue more STEM activities, including serving as STEM role models. | • 73-87% of CQL apprentices intend to pursue STEM activities after participating in CQL, including studying more STEM, learning more about topics they learned about in CQL, and joining professional organizations. |
| | • 57-84% of CQL apprentices intend to serve as a role models by sharing their CQL experiences with friends, recommending CQL to friends, encouraging friends to study more STEM, and mentoring younger STEM learners. |
| CQL apprentices were unaware of the many AEOP initiatives, but showed substantial interest in future AEOP opportunities. | • Many apprentices (29-99%) and mentors (43-84%) were unaware of other AEOP initiatives, with higher proportions lacking awareness for programs occurring outside of the CQL site. |
| | • CQL apprentices are interested in participating in other AEOP opportunities: college apprenticeships (25%), college scholarship programs (22%), and graduate fellowships (8%) offered by AEOP or DoD. This interest could be leveraged for targeted cross-promotion of programs and repeated engagement of apprentices in the AEOP pipeline. |
| | • A small proportion of CQL apprentices (1%-4%) expressed interest in middle and high school programs, presumably as mentors or other volunteers. |
| CQL improves and sustains apprentices' positive attitudes toward the defense community and their interest in potential government service. | • Many apprentices had opportunities to learn about new STEM careers during CQL as reported by apprentices and mentors (50% apprentices, 24% mentors). Army/DoD STEM careers received substantial attention (75% apprentices, 30% mentors). Apprentices clearly have other opportunities to and mechanisms for learning about new STEM and Army/DoD STEM careers beside direct contact with the mentor. |
| | • CQL served to inspire interest in new STEM careers, with 43% of apprentices expressing new interest in Army/DoD STEM careers in particular. Since 83% of apprentices would consider a civilian position in STEM with the Army/DoD because of their valuable contributions to society, suggesting that CQL also sustains existing interest in Army/DoD careers. |

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|---|---|
| | • Most apprentices (85%) credited CQL with improving their understanding Army/DoD STEM contributions. Most mentors (62%) reported that their apprentices expressed a positive attitude toward Army/DoD STEM. |

## Recommendations

1. Coordinated efforts should be made by the Army, ASEE managers, and site coordinators to encourage and improve apprentice and mentor participation in the CQL evaluation efforts. The low response rates to evaluation assessments pose the most significant threat to the validity of findings from those assessments, and, furthermore, prevent any reliable comparisons from those data from year to year. While evaluators can assess representativeness of samples through alternative means, accurate demographic data must be available for the population in order to accomplish these determinations. With respect to the outcomes evaluation, mentors' assessment of apprentice performance are important for triangulating apprentices' perceptions of growing confidence in their STEM competencies. Future evaluation will continue to rely on mentors to provide an authoritative, albeit subjective, assessment of apprentices' performance and *growth* in apprentices' STEM competencies. Mentors reported awareness of and efforts to promote AEOP and Army STEM are important for understanding related apprentice outcomes and identifying site-level programming needs (e.g., resources and/or training for mentors). Evaluators will endeavor to streamline instruments and appropriately incentivize participation in evaluation assessments; however, evaluators necessarily rely on the assistance of Army, ASEE managers, and site coordinators to promote a culture of evaluation among both CQL apprentices and mentors.

2. The number of applications for CQL apprenticeships (588 applications for 260 funded apprenticeships) is indicative of unmet need. Of particular note, rate of participation varied from 0% to 53% at CQL sites having greater than 19 applicants. To the extent allowed by annual budget constraints, CQL should endeavor to engage more Army S&E mentors, thereby creating more apprenticeship positions to populate. CQL programming may benefit from a careful examination of and attention to program- and site-level structures, processes, and resources that both enable and discourage Army S&Es' participation in CQL. Program- and site-level accommodations may be required to further improve Army S&Es' awareness of CQL, feasibility of their participation, and overall motivation to participate in CQL. Mentors noted multiple challenges that they or their apprentices encountered that, if eliminated could provide greater retention of existing mentors and increased recruitment of new mentors. Simultaneous with this effort, ASEE and CQL sites might consider how to effectively recruit a more demographically diverse mentor pool to provide apprentices with greater access to same-demographic role models and mentors.

3. CQL and AEOP objectives include the inclusion and expansion of students from historically underrepresented and underserved populations in programs. While ASEE and local sites conduct targeted marketing of CQL to those populations, assessment data suggests that site-level marketing, recruiting, and selection processes have greater influence in determining CQL apprentices. CQL may benefit from more Army and ASEE oversight and/or guidance of these site-level processes to maximize the inclusion of underrepresented and underserved students. This guidance may include any number of promising marketing and recruitment practices that should be implemented program-wide,

including but not limited to 1) maximizing the recruitment and repeated engagement of female, racial/ethnic minorities, and low income students in GEMS and SEAP programming (where available), 2) subsequent recruitment of those alumni as CQL apprentices, and 3) recruiting new students into the pipeline from historically black colleges and universities and other minority serving institutions. Guidance may also be provided to ensure other "connected" applicants (e.g., those with family, family friends, or school-based connections to the site) are not disproportionately advantaged over qualified but "un-vetted" candidates who may apply at the AEOP website. The Army, ASEE, and CQL sites may need to consider practical solutions to the challenge posed by Army facility locations, as proximity alone is likely to advantage some populations more than others (e.g., students with greater proximity, or students with means for longer distance transportation or temporary relocation near the site).

4. ASEE, CQL sites, and mentors share the responsibility for exposing apprentices to other AEOP initiatives and for encourage continued participation in programs for which apprentices qualify. Evaluation data suggests that CQL apprentices and mentors were largely unaware of other AEOP initiatives, especially those offered outside of the Army research facilities. Yet, apprentices showed interest in university-based apprenticeships and undergraduate scholarships, as well as in AEOP programs offered to younger STEM learners (presumably interested in serving as mentors). This interest would benefit from more robust attention by site coordinators and mentors during CQL program activities. Continued guidance by ASEE is needed for educating CQL site coordinators and mentors about AEOP opportunities, especially beyond the CQL sites. Adequate resources and guidance for using them with apprentices should be provided to all site coordinators and mentors in order that all apprentices leave CQL with an idea of their next steps in AEOP, whether at or outside of the Army site.

5. Most apprentices had opportunities to learn about STEM research and careers during CQL, especially Army/DoD STEM research and careers to which they are exposed daily. However, many mentors reported lack of awareness of STEM careers beyond their own, lack of informational resources, and lack of time for not educating apprentices about other STEM careers. Evaluation findings also suggest that other laboratory personnel contribute substantially to the mentorship of apprentices, and may be providing more support for educational and career pathways than the mentor. Thus, they would benefit from the same supports requested by mentors. We strongly recommend a CQL- or AEOP-wide effort to create a resource that profiles Army STEM interests and the education, on-the-job training, and related research activities of Army S&Es. Such a resource could start the conversation about Army STEM careers and motivate further exploration beyond the resource itself. A repository of public web-based resources (e.g., Army and directorate STEM career webpages, online magazines, federal application guidelines) could be disseminated to each mentor and/or apprentice to help guide their exploration of Army/DoD STEM interests, careers, and available positions.[42]

[42] For example, http://www.goarmy.com/careers-and-jobs/army-civilian-careers.html,http://www.goarmy.com/careers-and-jobs/stem.html, individual directorate STEM webpages and resources such as RDECOM's Army Technology magazine, and usajobs.gov.

## Appendix C: 2013 eCYBERMISSION (eCM) Evaluation

## Executive Summary

In 2012-2013, David Heil and Associates, Inc. (DHA), at the request of the National Science Teachers Association, conducted a comprehensive three-part evaluation and efficacy study of the eCYBERMISSION competition for students in grades six through nine.

The eCYBERMISSION online competition invites students to accept "mission challenges" in one of seven areas. Three to four students work together as a team under the guidance of a Team Advisor to identify and propose a solution to a community problem related to their mission challenge, using scientific methods and/or an engineering design process. Since the program's inception in 2002, more than 100,000 students from across the U.S. and U.S. territories, and DoDEA schools worldwide, have participated in the program.

DHA's evaluation assessed the impact of the program on past and current program participants. Specifically, the evaluation addressed questions related to program strengths and challenges, benefits to the participants, and overall effectiveness in meeting short and long-term program goals.

### Findings

**Part I. Alumni/Past Winner Outcomes**

The data show that eCYBERMISSION contributed to, or in some cases was the primary reason for increased learning and engagement in STEM pursuits. The program primarily serves to enhance existing interest in STEM, and to expand awareness of possible areas of study. In addition, approximately half of the respondents credit their eCYBERMISSION experience as a factor in improved grades and performance in school. Nearly half enrolled in more STEM classes in high school than they had originally planned, and nearly 40% enrolled in AP or IB STEM classes (at least in part) due to their eCYBERMISSION experience.

Participation in eCYBERMISSION also impacted interest in pursuing a STEM career for many of the Past Winners. Following eCYBERMISSION participation, nearly 80% of the survey respondents indicated that their interest in pursuing a STEM career increased, and more than half indicated that eCYBERMISSION contributed to or was the primary reason for the increase. Participants noted that the program strengthened their interest in STEM innovations and provided them with professional insights, reinforcing their desire to follow a STEM career path.

Among those respondents who have completed high school, 89% had been accepted to the college or university of their choice, and 44% credited eCYBERMISSION with contributing to, or being the primary reason for, getting into the college or university of their choice. Participation in eCYBERMISSION also contributed to, or was the primary reason for, earning scholarships for college and, for many alumni, actually having the resources for attending college.

Finally, the eCYBERMISSION experience had a relatively low effect on generating interest and participation in other AEOP opportunities, as well as a moderate effect on increased interest in learning more about the Armed Forces and serving in the military.

**Part II. Actionable Program Evaluation**

Past and current program participants believe that eCYBERMISSION is achieving desired outcomes for students, particularly in terms of building teamwork and fostering innovation. A variety of factors motivate students to participate, and these factors differ for students who reach the national level of the competition and those who participated through a stipend-supported school. The differences in motivation suggest that perhaps eCYBERMISSION should be marketed differently to schools with underserved students who do not have a strong pre-existing interest in STEM.

This evaluation determined that advisors and team members alike underutilize many eCYBERMISSION resources. This is a concern that suggests a need for improving awareness of the resources and defining how they can be utilized. Resources selected by Team Advisors and Past Winners as "most helpful" were those that provide clear communication and timely responses to questions. The eCYBERMISSION website was the resource identified as more helpful than any other, and the reasons included ease of navigation as well as the information and examples that could be found on the site.

While criticism was not as common as praise, the most frequent criticism of eCYBERMISSION resources was that they were difficult to navigate or were not user-friendly. Interface with the website was most frequently mentioned, but several respondents specifically mentioned difficulties in completing the Mission Folder within the constraints of the template. A common theme running through the suggestions for improvement was the need for better communication, particularly in terms of making participants aware of the resources that are available and providing clear criteria and specific guidelines and timelines. There were also some concerns about the clarity and the fairness of judging criteria.

The National Judging & Educational Event (NJ&EE) is viewed positively by Team Advisors and students. Participants agreed that NJ&EE is fun, engaging, motivating, rewarding, exciting and educational. Students used words like "awesome," "amazing," and "uplifting" to describe their experience. Specifically, students were most appreciative of the "Get Up and Speak" workshop, the judging day experience, and the STEM Tech Expo. Team advisors identified several benefits for students, including opportunity for students to recognize what they had accomplished, meeting others from around the country, expanding student horizons, and the exposure to the Tech Expo. Students identified meeting people and making new friends and learning about Army Values and Research conducted by the Military as the main benefits of the NJ&EE. Focus group discussions identified additional benefits, including being inspired to do more, bonding between the teams, and the opportunity to see research in action.

While past participant response to the NJ&EE is overall positive, their ratings of the event show a progressive decline since 2006. The strongest criticisms from past Team Advisors and students are that the event is too regimented, too restrictive, and the schedule is too full and rushed. The students also want more variety, flexibility, and choice in the educational and recreational activities, presentations, and tour events that are offered. The students and their advisors (particularly those who had attended past events) also believe that the NJ&EE should be held in Washington D.C., rather than in Virginia. Finally, several of the advisors questioned the ethics of inviting a Team Advisor to serve as a judge, suggesting that it provided that team with an unfair advantage.

**Part III. Qualitative and Quantitative Data (2012-2013 Competition Year)**

The 2012-13 eCYBERMISSION competitors attributed positive changes in attitudes and behaviors to their participation in eCYBERMISSION, for all of the measured outcomes. The outcomes included attitudes toward STEM disciplines, motivation to study STEM disciplines, career aspirations, STEM self-efficacy, 21st Century Skills, and STEM extracurricular activities.

Students who participated in NJ&EE and those who were from stipend-supported schools reported positive changes in STEM attitudes, motivation, self-efficacy and confidence, and interest in STEM careers as a result of participating in eCYBERMISSION. In addition, both groups increased their confidence regarding 21st Century Skills and participation in STEM extra-curricular activities. Overall, the NJ&EE students had higher levels of pre-existing interest, motivation, and behaviors prior to and after participating in eCYBERMISSION in comparison to stipend-supported school students. However, the changes in interest, motivation, and behavior for Stipend School students were equal to or greater than those found for the NJ&EE students.

## Recommendations

1. We recommend that the program continue to explore and assess the impact of eCYBERMISSION and NJ&EE each year of the program, modeled on Parts II and III of the current evaluation, so that the effectiveness of ongoing improvements to the program may be assessed. In addition, a comprehensive longitudinal study designed to track cohorts of current and future eCYBERMISSION state and regional winners is needed to provide a rigorous and thorough assessment of the long-term impacts of the program.
2. Based on the positive outcomes for students, including those who did not advance beyond the state level of the competition, we recommend that eCYBERMISSION continue to expand its outreach to underserved schools that typically have not participated.
3. When recruiting teachers at stipend-supported schools, encourage teachers to work with just one or a few teams, rather than an entire class. Teachers who worked with entire classes found that it was not possible to provide quality feedback and guidance to every team.
4. Creative and strategic marketing is needed to increase awareness of the program. The eCYBERMISSION staff should determine avenues to reach still more schools and teachers. NSTA is in a unique position to reach science teachers throughout the U.S.

This is particularly important if the program hopes to reach students who are not already strongly interested in STEM. The same recommendation holds true for interesting eCYBERMISSION participants in other Army Education Outreach Programs.

5. To encourage parents to get involved, publicize the advantages that the program provides to their children—the prize incentives (Savings Bonds for college), an expense-paid trip to Washington, D.C. for national finalists, and the now documented increases in student interest, motivation, self-confidence, and expanded opportunities that result, at least in part, from participation in the program.
6. The website is the "face" of eCYBERMISSION, and as such both markets and represents the program, in addition to providing the means for large numbers of students to compete. An evaluation specific to the eCYBERMISSION website and its component resources should be conducted to assess user-friendliness, ease-of-navigation, ease of submitting materials, and the use of innovative and fresh content.
7. Provide teams with timely and specific feedback, including comments, from the Cyber judges. This may require communicating clear and specific expectations to all the volunteer judges. The teams want and need feedback that will help them better understand the strengths and limitations of their projects and their presentation of materials. Students and advisors also called for a clearer communication of judging criteria.

### THE NATIONAL JUDGING AND EDUCATION EVENT (NJ&EE)

8. As the "crown" of the eCYBERMISSION competition, the NJ&EE should be exciting and fun for both the student teams and their team advisors. In addition to the high standards and rigor that NJ&EE provides, participants expect it to be fun and exciting; in essence, a reward for their accomplishments as regional winners. The NJ&EE needs to inject more fun into the experience in order for it to remain one of the key motivating factors of the program.
9. It is recommended that the NJ&EE should be located in Washington D.C., where students, advisors, and parents can take advantage of what for some is a "once in a lifetime" trip, to explore our nation's capitol and its plentiful educational opportunities.
10. The atmosphere at the NJ&EE would benefit from a somewhat less regimented schedule and greater flexibility in how students and advisors are required to spend their time. The program would benefit from lightening up a bit and finding those situations where it is safe to trust the students to adhere to Army Values.
11. Find additional ways to show appreciation to the teachers, parents, and other adults who serve as Team Advisors. They receive intrinsic satisfaction from seeing their students' excitement, growth, and accomplishments, and for some that is enough. However, in many, if not all instances the advisors are making sacrifices to attend the

NJ&EE and would appreciate some free time as well as more time to interact with other advisors.

12. While the Tech Expo content, scheduled activities, guest speakers, and tours are all viewed as excellent, the event could be improved by injecting some new content and choice into the Tech Expo.
13. The overall NJ&EE schedule needs to be expanded or evolve to provide more time for students to interact with students from other teams, to provide more breaks, and more time to explore the stops on the tour of D.C. It is also recommended that travel arrangements be made so that all teams, especially teams who are traveling a great distance, arrive on the same day and that everyone has time to rest, relax, and start to get to know one another before jumping into the NJ&EE program.
14. Notifying the teams that they will be competing in the NJ&EE needs to happen sooner, if possible, in order for teams to complete the necessary paperwork to get approval from their school districts for travel.
15. Perhaps most important, the judging process must not only be fair, but must be *perceived* as fair by all who participate. Allowing a Team Advisor to serve as a judge is inappropriate and raises questions regarding how this may have impacted her own team's performance and ratings. It's a good idea to have one or more teachers serve as judges, but an advisor to one of the teams actively competing at NJ&EE should never participate as a judge.

# Appendix D: Gains in the Education of Mathematics & Science (GEMS) Evaluation Executive Summary

Gains in the Education of Mathematics & Science (GEMS), managed in FY13 by the American Society for Engineering Education (ASEE) on behalf of the Army Educational Outreach Program's (AEOP), is a non-residential summer STEM enrichment program for elementary, middle, and high school students (herein referred to as students). GEMS is hosted by Army laboratories and takes place at Army research laboratories (herein referred to as GEMS sites). GEMS is driven by the overarching mission: to interest youth in STEM through a hands-on Army laboratory experience that utilizes inquiry based learning and near-peer mentoring. GEMS is the entry point for a pipeline of AEOP opportunities affiliated with the US Army Research Laboratories. The various GEMS sites are run independently, with ASEE providing support and guidance in program execution to local lab coordinators. Although they operate under a shared mission, GEMS sites are free to include different topics in their curricula that highlight the mission of the laboratory and they may set, in addition to the overall program Priorities and individual laboratory goals. Instead of having a specific model and curriculum prescribed to GEMS sites, they are able to design curricula (using the hands-on, experiment-based model) and procedures that make sense considering the specialties of their facility and available resources. GEMS programs run from one to four weeks in length with Army Scientists and Engineers (S&Es), college-level near-peer mentors (NPMs), and/or in-service resource teachers (RTs), facilitating educational activities, exposing students to Army STEM research and careers, and providing adaptive mentorship to students.

In 2013, GEMS provided outreach to 2,038 students at 13 different sites, representing a 26% increase in enrollment from 1,614 student participants in 2012. Consistent with historical data, many of the GEMS sites received applications from more qualified students than they could serve.

This report documents the evaluation of the FY13 GEMS program. The evaluation addressed questions related to program strengths and challenges, benefits to participants, and overall effectiveness in meeting AEOP and program objectives. The assessment strategy for GEMS included pre- and post-GEMS questionnaires for students and on-site focus groups with students and mentors at four sites.

| Table 1. 2013 GEMS Fast Facts | |
|---|---|
| Major Participant Group | Elementary, middle, and high school students |
| Participating Students | 2,038 |
| Participating K-12 Teachers | 45 |
| Represented K-12 Schools | 628 (28 Title-I schools) |
| Participating Army Agencies | 13 |
| Participating Army S&Es | Not available |
| Total Cost | $730,070 |
| Participant Stipends | $618,875 |
| **Cost Per Participant** | $358 |

## Summary of Findings

The FY13 evaluation of GEMS collected data about participants, their perceptions of program processes, resources, and activities, and indicators of achievement related to AEOP's and GEMS objectives and intended outcomes. A summary of findings is provided in Table 2.

| Table 2. 2013 GEMS Evaluation Findings | |
|---|---|
| **Participant Profiles** | |
| GEMS student participation in evaluation yields high level of confidence in the findings. | • The statistical reliability achieved for the pre- and post-GEMS student questionnaires, as well as the pre- to post-GEMS matched cases (all <±2%) allow us to sufficiently generalize findings of the evaluation sample to the population. Three case studies for which pre- to post-GEMs statistical analyses were conducted further illustrate the potential effects of the simplest unit of a single GEMS program. Cases included beginner/I, intermediate/II, and advanced/III levels of GEMS and a range of topics. |
| | • Additional evaluation data contribute to the overall narrative of GEMS's efforts and impact, and highlight areas for future exploration in programming and evaluation, though findings from these data are not intended to be generalized to all GEMS sites and participants. |
| GEMS serves students of historically underrepresented and underserved populations. | • GEMS attracted participation from female students—a population that is historically underrepresented in engineering fields; however, student questionnaire respondents included more males (52%) than females (47%). |
| | • GEMS provided outreach to students from historically underserved minority race/ethnicity and low-income groups. Student questionnaire respondents included minority students identifying as Black or African American (23%), American Indian or Alaskan Native (1%), and Hispanic or Latino (7%). A small proportion (12%) of students reported qualifying for free or reduced lunch. |
| | • GEMS served students across a range of school contexts. Most student questionnaire respondents attended public schools (79%) and suburban settings (64%). |
| GEMS engages a diverse group of adult participants as STEM mentors. | • GEMS engaged Army Scientists and Engineers (S&Es, number unknown), college-level near-peer mentors (NPMs, 69), and in-service resource teachers (RTs, 45), who facilitated educational activities, exposed students to Army STEM research and careers, and mentored students. |
| | • At all GEMS sites visited by evaluators, students had access to mentors belonging to either the same gender (female) and/or the same race and ethnicity group. |
| **Actionable Program Evaluation** | |
| GEMS is strongly marketed to schools and teachers serving historically underserved groups. | • ASEE and GEMS sites employed multi-pronged efforts to market programs to and recruit students from populations of historically underserved students. Efforts included partnerships with minority-serving community organizations (e.g., Boys and Girls Clubs, 100 Black Men) and targeted marketing to on-post schools, rural schools, and schools in districts serving high proportions of low-income students. |
| | • Students most frequently learned about the local GEMS program from parents and family members (more than 50%) and from teachers and others at school (more than 20%). |

| | |
|---|---|
| GEMS students are motivated by positive past experiences and opportunities provided by GEMS. | • Students were most frequently motivated to participate in GEMS this year because of overall satisfaction with previous GEMS participation. Students also sought opportunities to explore or advance their STEM pathways, such as new or deeper learning about topics, developing STEM skills, engaging in hands-on activities, and clarifying future education or career goals. |
| GEMS mentors engage students in meaningful STEM learning, through team-based and hands-on activities. | • Mentors used a variety of mentor and/or instructional activities for productively engaging students in STEM learning, including: supporting student experimentation and exploration, facilitating small group and partner work, and using one-on-one teaching and peer-to-peer teaching to ensuring student understanding. |
| | • Most students (74%-93%) found their GEMS mentors to be excited about STEM, accessible to learners, and having impacted their learning. Students perceived that mentors cared about their learning (93%), were excited to do hands-on activities (87%), and were easy to learn from (81%). |
| GEMS mentors promote AEOP initiatives and Army STEM careers available at Army research laboratories. | • Most mentor interviewees had no awareness of or past participation in an AEOP initiative beyond GEMS or the AEOP's at the site, such as SEAP and CQL. Subsequently, students reported limited exposure and encouragement to pursue AEOP opportunities other than SEAP and CQL. |
| | • GEMS programs engaged Army S&Es as leaders of educational activities and as invited career speakers, in an effort to expose students to Army STEM research and careers. |
| | • Mentors at one site reported that their lessons culminate with information that helps them connect Army/DoD jobs and careers with the activities just completed by students in the GEMS program. These curricular supports were considered particularly useful to the NPMs and RTs at the site who were less familiar with the work conducted by the Army/DoD. |
| GEMS benefits participants over typical school STEM offerings. | • Mentors perceived that GEMS provides students with opportunities to explore and advance their STEM pathways and provides learning opportunities (e.g., environments, resources, and activities) not available typical school settings. |
| | • Mentors perceived that GEMS benefits mentors, by expanding their STEM networks, their teaching and mentoring skills, and their instructional resources. GEMS is highly motivating environment. |
| | • Mentors suggest expanding GEMS' to address unmet need and to extend its geographic and demographic reach. Mentors also suggested that educators would benefit from outreach. |
| **Outcomes Evaluation** | |
| GEMS students have more frequent opportunities for students to engage in STEM activities than they have in school. | • Most students (75-90%) reported engaging in the various STEM activities multiple times per week during GEMS. Fewer students (26%-45%) reported participating in various activities at the same frequency in school. |
| | • The in school vs. in GEMS difference is statistically significant with a moderately strong to very strong effect across all GEMS program data. The strongest effects are relate to students having opportunities to participate in hands on activities and to decide how to carry out experiment or activity to answer ones' own question. Strength of effects generally diminish with the advanced GEMS case. |
| | • Students suggested that hands-on activities during GEMS provided more meaningful learning than could be obtained through lectures and reading typical in school and were more engaging to students. |

| | |
|---|---|
| GEMS students have higher opinion of their STEM knowledge, skills, and abilities after GEMS. | • Greater proportions of students reported seven STEM skills and/or abilities post-GEMS (63%-81%) as compared to pre-GEMS (41%-72%). |
| | • While the pre- to post-GEMS comparison reveals significant changes in all items, those differences are generally weak in effect. A strong effect is observed with students pre- to post-GEMS assessments of their knowledge of laboratory techniques. The number of significant differences and the strength of the effects generally diminish with the advanced GEMS case. |
| GEMS students have higher confidence to use their STEM knowledge, skills, and abilities after GEMS. | • Greater proportions of students reported confidence to use seven STEM skills and/or abilities post-GEMS (64%-76%) as compared to pre-GEMS (52%-67%). |
| | • While the pre- to post-GEMS comparison reveals significant changes in all items, those differences are generally weak in effect. The strongest effect, and still considered weak, is observed with students pre- to post-GEMS confidence to communicate science and engineering concepts. The number of significant differences and strength of their effects generally diminish as the level of GEMS increases. |
| GEMS inspires and sustains students' interest in STEM. | • Greater proportions of students reported positive interest in STEM after GEMS (53%-90%) than reported positive interest after their school STEM experiences (44%-86%). |
| | • Across all items, the after school vs. after GEMS differences in attitudes or interest are statistically significant, but with weak effects. The largest effect was observed for interest level in learning from STEM classes (in school) vs. GEMS. Students participating in the advanced GEMS case exhibit no significant differences. |
| GEMS inspires and sustains students' intent to engage in future STEM. | • Greater proportions of students reported intent to engage in future STEM activities, education, and careers post-GEMS (58%-80%), as compared to pre-GEMS (55%-78%). |
| | • Across all items, the pre- to post-GEMS differences in intentions are statistically significant, but with very weak effects. Only students' intentions to work as a STEM intern or apprentice are considered "substantively important." Each case study revealed significant differences in one or more items that may relate to specific features of programming or to other program offerings at the site: STEM summer programs, STEM fair/competition, and STEM apprenticeships. |
| GEMS students may be unaware of the full portfolio of AEOP initiatives, but students show substantial interest in future AEOP opportunities. | • Most students (71%-80%) expressed interest in participating in the pipeline of programs available at the Army laboratories which hosted or sponsored their GEMS program (e.g., GEMS, SEAP, CQL). |
| | • Fewer students (43%-49%) expressed interest in the competitions (eCYBERMISSION, West Point Bridge Design Contest, and Junior Science & Humanities Symposium), and summer programs (UNITE) that are available outside of Army laboratories. Most student interviewees generally could not name, or recognize when named, AEOP initiatives outside of the Army laboratory GEMS-SEAP-CQL pipeline. |
| GEMS increases students' awareness of Army STEM jobs. | • Most students (87%) learned about multiple STEM jobs, and on average, students learned about 4 STEM jobs. Army/DoD STEM jobs received less attention that STEM jobs, with students exposed to an average of 3 Army/DoD STEM jobs. |

## Recommendations

1. The number of applications for GEMS (4231 applications for 2038 funded apprenticeships) is indicative of considerable unmet need and interest. The evaluation provides evidence of program success in support of expansion to accommodate this unmet need and interest. Expanding geographically to more GEMS sites alone may simply generate new or more need in new communities. Expanding the capacity of existing GEMS sites to serve more students would be needed to accommodate existing need in those communities. To expand the capacity of existing GEMS sites, greater investment may be required to expand site administrative staff, physical infrastructure needs, and mentor participation, most specifically Army S&E participation.

2. GEMS and AEOP objectives include expanding participation of historically underrepresented and underserved populations. While ASEE conducts targeted marketing of GEMS to those populations, assessment data suggests that site-level marketing, recruiting, and selection processes have greater influence in reaching and determining GEMS participants. GEMS may benefit from more Army and ASEE oversight and/or guidance of these site-level processes to maximize the inclusion of underrepresented and underserved students. This guidance may include any number of promising marketing and recruitment practices that should be implemented program-wide, including but not limited to targeted marketing to and partnership with low-income and minority-serving schools, educational networks, community organizations, and professional associations that serve these populations. Guidance may also be provided to ensure other "connected" applicants (e.g., those with family, family friends, or school-based connections to the site) are not disproportionately advantaged over qualified but "un-vetted" candidates who may apply at the AEOP website. The Army, ASEE, and GEMS sites may need to consider practical solutions to the challenge posed by Army facility locations, as proximity alone is likely to advantage some populations more than others (e.g., students with greater proximity, or students with means for longer distance transportation or temporary relocation near the site). In-residence programs, travel accommodations (e.g., bus transportation from schools) may be needed to recruit and make participation feasible for underserved populations living at greater distances from the GEMS sites.

3. Mentors play important roles in GEMS. Mentors design and facilitate learning activities, deliver content through instruction, supervise and support collaboration and teamwork, provide one-on-one support to students, chaperone students, advise students on educational and career paths, and generally serve as STEM role models for GEMS students. The FY13 mentor focus groups served as a baseline effort to collect information from this participant group, but a more systemic assessment of mentors is required to evaluate their engagement as STEM-Savvy Educators in AEOP programs. Any future survey of mentors should at a minimum gather information how mentors become aware of GEMS, motivating factors for participation in GEMS, satisfaction with and suggestions for improving GEMS programs, perceived benefits to participants, and mentor activities, including those relating to exposing students to AEOP opportunities and Army STEM careers.

4. As a whole, students began and ended GEMS with high opinions of and confidence in their STEM competencies, and ambitious STEM extracurricular, education, and career aspirations. The evaluation provides evidence of perceived growth in these outcomes across all program data, albeit with weak effects. Site-level data provides clearer evidence of GEMS' variable impact on students STEM confidence and ambitions: the GEMS-I and II cases showed moderately strong to strong, significant effects across more indicators while the GEMS-III case showed

fewer points of growth that were significant or with strong effect. These findings may indeed be specific to those cases; however, they may also provide evidence that beginning GEMS programs (often those targeted to upper elementary and middle school students) improve outcomes whereas advanced levels of GEMS sustain outcomes. Future evaluation should continue to explore cases to uncover differential effects that are masked when data is averaged across all sites, levels, and curricular topics. Where adequately powered, these case studies may also investigate whether differential effects across different demographic populations.

5. Data suggests that GEMS apprentices have more opportunities to do the *hands-on* aspects of STEM activity and fewer opportunities to engage in the *minds-on* aspects. Minds-on aspects of STEM activity have been linked to greater student affective and achievement outcomes than hands-on activities alone.[43] [44] Programs might consider how to expand students' opportunities to engage in challenging minds-on STEM activities such as generating questions, designing experiments, analyzing and interpreting data, and formulating conclusions for their questions during their GEMS programs. For example, one site required that students work in teams to apply their new learning to solving a case. Another AEOP, the UNITE program, had several sites that used weekly challenges or competitions to engage students in student-directed application of learning. Assessment data also suggest that students value opportunities to apply school learning to real world situations and in collaborative settings, as these are less common in typical school settings. Minds-on experiences may also continue to challenge and inspire older GEMS students and returning GEMS alumni who exhibited less change in outcomes related to STEM competencies and ambitions.

6. Mentor and student interviewees across the focus group samples reported limited awareness of and participation in any given AEOP initiative beyond the Army research lab GEMS-SEAP-CQL pipeline. Mentor interviewees reported spending little or no time educating students about AEOP initiatives for which students qualify during daily program activities, aside from distributing AEOP brochures and highlighting the website. Student interviewees generally could not name, or recognize when named, AEOP initiatives except for GEMS, SEAP, and CQL. However, substantial student interest exists in AEOP opportunities when vaguely described. This interest, especially from students of underserved populations, would benefit from more robust attention by program coordinators and mentors during GEMS program activities, especially since the existing GEMS-SEAP-CQL pipeline cannot accommodate the considerable unmet need. Other AEOP programs may be able to provide greater geographical and demographic reach where GEMS sites are simply unable. Continued guidance by ASEE is needed to ensure coordinators and mentors alike are knowledgeable of AEOP opportunities at and beyond the Army research labs, and have reasonable plans and strategies for exposing students to these opportunities before, during, and after program activities.

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

[44] Maltese, A.V. & Tai, R. H. (2011) Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education Policy* 98, 877-906

# Appendix E: 2013 High School Apprenticeship Program (HSAP) Evaluation Executive Summary

The High School Apprenticeship Program (HSAP), managed by 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 science, technology, engineering, or mathematics (STEM) to work as an apprentice in an Army-funded university research laboratory. HSAP is designed so that students (herein called apprentices) can apprentice in fields of their choice with experienced scientists and engineers (herein called mentors) full-time during the summer or part-time during the school year.

Students receive an educational stipend equivalent to $10 per hour, and are allowed to work up to 300 hours total. The students contribute to the research of the laboratory while learning research techniques in the process. This "hands-on" experience gives students a broader view of their fields of interest and shows students what kind of work awaits them in their future career. At the end of the program, the students prepare final reports for submission to the US Army Research Office Youth Science programs office.

In 2013, HSAP provided outreach to 24 apprentices and their mentors at 12 Army-sponsored university or college laboratory sites (herein called HSAP sites).

This report documents the evaluation of the 2013 HSAP program. The evaluation addressed questions related to program strengths and challenges, benefits to participants, and overall effectiveness in meeting AEOP and program objectives. The assessment strategy for HSAP included: in-person focus groups with apprentices and mentors at 3 HSAP sites, individual phone interviews with apprentices and mentors from 10 additional HSAP sites, and online post-program questionnaires distributed to all apprentices and mentors.

| Table 1. 2013 HSAP Fast Facts | |
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| Major Participant Group | High School Students |
| Participating Students | 24 |
| Participating University Personnel | 16[45] (11 Faculty, 5 Graduate Mentoring Fellows) |
| Participating Universities | 12 |
| Total Cost | $80,594 |
| Total Stipends | $70,985 |
| Cost Per Student Participant | $2,779[46] |

[45] This number reflects university faculty members serving as the primary mentor and Graduate Mentoring Fellows (GMFs) that may have assisted with mentoring the HSAP apprentice.
[46] GMFs were included in the calculation of Cost Per Student Participant.

## Summary of Findings

The 2013 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 2.

| Table 2. 2013 HSAP Evaluation Findings | |
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| **Participant Profiles** | |
| Low participation of HSAP apprentices and mentors in evaluation assessments limit the reliability of findings. | • Statistical reliabilities achieved for the apprentice questionnaire sample (±15.8% margin of error) suggest limited representativeness of the samples. Geographically, the current sample of apprentices represents a limited proportion (75%) of the distribution of HSAP sites nationally<br>• Mentor respondents did not systematically identify themselves in the questionnaire and, as a result, the representativeness of this sample is not discernable.<br>• Alternative methods for establishing representativeness of the current samples were difficult to employ; demographic information for the population of apprentice and mentor participants was not available. |
| | • Findings from mentor and apprentice questionnaires should be cautiously generalized with consideration given to the calculated margin of error and with triangulation of findings with other data. |
| HSAP had limited success in providing outreach to participants from historically underrepresented and underserved populations. | • More apprentices identified themselves as racial or ethnic minorities in 2013 than in 2012. Black or African American (2012 = 0%, 2013 = 15%) and Hispanic or Latino (2012 = 0%, 2013 = 15%) populations are among those historically considered underserved and underrepresented in STEM education. |
| | • In 2012 and 2013, HSAP struggled to reach female high school students (2012 = 14%, 2013 = 8%), a population that is historically underrepresented in certain STEM fields. |
| | • In 2012 and 2013, most apprentices did not qualify for free/reduced lunch at school (86% and 73%, respectively). Free and reduced lunch recipients are generally considered an underserved population. |
| | • Mentors identified as predominantly male (78%) and either White or Caucasian (50%) or Asian or Other Pacific Islander (44%). Only 6% identified as Black or African American, and no mentors identified as Hispanic or Latino (0%) or American Indian or Alaskan Native (0%). |
| HSAP apprentices intend to pursue advanced STEM degrees in STEM. | • 100% of apprentices planned to pursue a master's degree or higher, 85% of whom intend to pursue that degree in a STEM field (38% STEM Master's, and 46% STEM Doctorate) |
| | • Large proportions of apprentices planned to pursue engineering (31%) and medicine/health-related fields (31%). Apprentices also intended to pursue physical science (15%), chemistry (15%), and social science (8%). |
| **Actionable Program Evaluation** | |
| HSAP marketing and recruitment is a bottom-up phenomenon | • HSAP's marketing and advertising campaigns target the very specific population of Army-funded university and college researchers. |
| | • Apprentices most frequently learned about HSAP through individuals who are connected with HSAP sites. Apprentices reported that personnel from their high school (31%) or family or friends (15%) informed them about the program. |

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| occurring at the site-level. | • Most mentors recruited apprentices through connections with local high school staff (45%) and other informal programs (27%).<br>• A majority of mentors (75%) selected apprentices from the AEOP applicant pool with assistance from ARO, and 25% knew students prior to their participation as an HSAP apprentice. |
| HSAP apprentices seek opportunities to clarify and advance their STEM pathways. | • Apprentices received encouragement to participate in HSAP from others who have connections to the HSAP program, such as high school staff or staff from other programs that they are already involved in. But many apprentices were motivated to participate in HSAP because it offered them an opportunity to clarify and advance their STEM pathways through experiences that are not available in school. |
| HSAP mentors seek opportunities to engage with STEM learners in their work. | • Mentors were motivated to participate in HSAP through their desire to outreach to youth, which was encouraged by their colleagues, departments, and universities. HSAP also provided mentors with an opportunity to advance their research through the funding of apprenticeships. |
| HSAP mentors engaged their apprentices in STEM research and provided guidance about educational and career pathways during the HSAP apprenticeship. | • HSAP mentors engaged their apprentices in STEM research and provided them with guidance about educational and career pathways. Apprentices and mentors reported similar engagement in mentor activities related to STEM research experiences, educational goals, and career goals<br>• Apprentice and mentor accounts of educational and career advising differed. Mentors may have conflated their responses with interactions that they had with HSAP and URAP apprentices simultaneously. |
| HSAP mentors lacked awareness and resources needed for promoting AEOP opportunities and STEM careers. | • Mentor interviewees had limited awareness of or direction from ARO to educate their apprentices about AEOP initiatives. Subsequently, mentors did not consistently educate their apprentices or encourage their participation in AEOP initiatives.<br>• Mentors suggested that informational resources, mentor training, and an emphasis from ARO were necessary to accomplish this objective.<br>• Mentors reported using a variety of strategies for mentoring apprentices about STEM careers, through few emphasized Army/DoD STEM careers.<br>• Mentors perceived high school students are not advanced enough to engage in career discussions, that they lacked information about many aspects of Army/DoD STEM careers, and that they program was too short to initiate career conversations. |
| HSAP benefited apprentices as well as university and college S&E mentors and their laboratories. | • Apprentices and mentors perceived that HSAP benefits apprentices by providing authentic research opportunities not available typical school settings, opportunities to clarify or advance their STEM pathway, and opportunities to develop and expand research skills.<br>• Mentors also perceived that HSAP helped them develop their own mentorship capacity, that the work of apprentices helped advance the work of the laboratory, and that it was rewarding to serve in a community service capacity. |
| HSAPs lack of visibility and programmatic processes are possible areas for improvement. | • Apprentices and mentors would like to see HSAP expand through increased funding and reach additional students by increasing its visibility.<br>• Mentors invest significant time in the program and recommend streamlined and more efficient programmatic processes. |
| **Outcomes Evaluation** | |
| HSAP engaged apprentices in authentic STEM activities more | • Apprentices reported that HSAP provides more frequent opportunities to engage in authentic STEM activities as compared to their school setting, including academic research activities (42%-58% in HSAP, 23-46% in school) and hands-on research activities (25%-75% in HSAP, 8%-33% at school). |

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| frequently than their school environment. | • Moderate to very strong significant differences were found in apprentices perceptions of how frequently they did the following in HSAP as compared to school: used, cared for, and calibrated equipment; employed advanced measurement techniques; and defined research questions. |
| | • Apprentice and mentor data suggested HSAP had a larger effect with respect to providing apprentices opportunities for hands-on research activities than it had providing opportunities for academic (minds-on) research activities. |
| HSAP apprentices become more confident in STEM, and mentors rate their research skills highly. | • Many apprentices (42%-75%) perceived growth in their confidence across 7 key STEM skills and abilities: performing literature reviews, formulating hypotheses and designing experiments, using laboratory safely, using laboratory equipment and techniques, analyzing data, generating conclusions, and contributing to a research team. |
| | • The majority of mentors (58%-74%) rated their apprentices at near expert or expert levels of the development continuum across 6 key STEM skills and abilities: information literacy, scientific reasoning, laboratory, data collection, quantitative literacy, and teamwork and collaboration. Most mentors (73%-86%) also rated all 6 components of their apprentices' final research project or presentation in the near expert or expert levels. |
| HSAP apprentices were unaware of the many AEOP initiatives, but showed substantial interest in future AEOP opportunities. | • Many apprentices (42%-92%) and mentors (42-65%) were unaware of other AEOP initiatives. For example, most mentors (88%) did not educate apprentices about the AEOP's high school STEM research competition, JSHS. Most apprentices (90%) were not intent on pursuing JSHS; however, 30% of apprentices expressed an interest in submitting their research to other science fairs or competitions including sponsored events such as INTEL-ISEF. |
| Mentoring HSAP apprentices about STEM and Army/DoD STEM careers varies by HSAP site but apprentices hold positive attitudes toward Army research and researchers | • Students and mentors provided conflicting accounts of the extent to which teaching and learning about STEM and Army/DoD STEM careers occurred during HSAP. It is likely that the amount of information provided to apprentices varies highly from site to site. |
| | • Most apprentices (72%) credited HSAP with improving their understanding Army/DoD STEM contributions and 81% would consider a civilian position in STEM with the Army/DoD. Most mentors (67%) reported that their apprentices' expressed a positive attitude toward Army/DoD STEM. |

## Recommendations

1. A commitment should be made to producing more reliable and valid evaluation of HSAP activities and benefits to participants. The 2013 evaluation provides valuable information regarding how HSAP is perceived by a proportion of participants, and begins to provide evidence for how the program has impacted HSAP apprentices. However, the low response rate from HSAP apprentices, the inability of mentors to correctly identify their role in the program, as well as the limited demographic information regarding the population of apprentice and mentor participants, all pose significant threats to the reliability and validity of these findings. In other words, we have limited confidence that the findings of questionnaire respondents are representative of or can be generalized to the full population of participants. Mentors provide an authoritative, albeit subjective, assessment of apprentices' performance (STEM competencies) at the end of the program that is otherwise not possible; future evaluation will further rely on mentors to assess *growth* in apprentices' STEM competencies. Mentor participation in HSAP's evaluation is vital. Coordinated efforts should be made by the Army, and ARO to encourage and improve apprentice and mentor participation in HSAP's evaluation

efforts. Subsequently, evaluators should endeavor to streamline instruments and appropriately incentivize participation in evaluation assessments to further maximize participation.

2. AEOP objectives include expanding participation of historically underrepresented and underserved populations. In HSAP, recruitment of apprentices is largely a bottom-up phenomenon that occurs at the site-level using connections or mechanisms available to the university or college site and community in which they lie. As a result, the ability of HSAP to recruit underserved or underrepresented populations of students depends upon the diversity of the local communities, and especially high schools, in which recruitment takes place. Guidance that ensures that "connected" applicants (e.g., those with family, family friends, or school-based connections to the site) are not disproportionately advantaged over qualified but "un-vetted" candidates who apply through the AEOP website is likely to help in recruitment efforts. Additionally, the AEOP and ARO may need to consider practical solutions to the challenge posed by HSAP locations, as proximity alone is likely to advantage some populations more than others (e.g., students with greater proximity, or students with means for longer distance transportation or temporary relocation near the site).

3. Apprentice and mentor data suggested that HSAP apprentices have more opportunities to participate in the hands-on aspects of research and fewer opportunities to participate in the academic (minds-on) aspects of research, including technical writing. ARO should endeavor to provide HSAP mentors with strategies that appropriately and meaningfully expand apprentices' opportunities to engage in all aspects of the research under the tutelage of their mentor, including opportunities to generate research questions, design experiments, analyze and interpret data, formulate conclusions, and contribute to technical writing about the research in which they are engaged. Whether these strategies include mentors modeling such practices for apprentices, scaffolding "thought exercises" to be completed by apprentices, or coaching apprentices through making real contributions in these areas, such efforts will maximize apprentices' professional development as STEM apprentices, better mirror the day to day practices of scientists and engineers, and more closely align with current research and best practices identified for effective STEM learning.

4. ARO, universities, and mentors share the responsibility for exposing apprentices to other AEOP initiatives and for encouraging continued participation in programs for which apprentices qualify. Evaluation data suggests that HSAP apprentices and mentors were largely unaware of other AEOP initiatives and that HSAP serves as an entry point into the AEOP for students who have not yet been exposed the Army STEM outreach. Yet, substantial apprentice interest exists in participating in AEOP moving forward. This interest would benefit from more robust attention by ARO and mentors during HSAP program activities. Continued guidance by ARO is needed for educating mentors about AEOP opportunities nationwide. Adequate resources and guidance for using them with apprentices should be provided to all mentors in order that all apprentices leave HSAP with an idea of their next steps in AEOP.

5. Depending upon the university or college site in which they worked, apprentices had varying opportunities to learn about STEM research and careers during HSAP, especially Army/DoD STEM research and careers. Many mentors reported lack of awareness of Army/DoD STEM careers generally, lack of informational resources, and lack of direction to provide such information to their apprentices. This is of concern given HSAP mentors are Army-sponsored S&Es who are receiving "add-on" funding for their HSAP apprentices. In an effort to standardize the information provided to apprentices we strongly recommend an HSAP- or AEOP-wide effort to create a resource that profile Army STEM interests and the education, on-the-job training, and related research activities of Army S&Es. Such a resource could

start the conversation about Army STEM careers and motivate further exploration beyond the resource itself. A repository of public web-based resources (e.g., Army and directorate STEM career webpages, online magazines, federal application guidelines) could also be disseminated to each mentor and/or apprentice to help guide their exploration of Army/DoD STEM interests, careers, and available positions. [47] Furthermore, ARO might consider a requirement, similar to that of the AEOP's high school UNITE program, through which HSAP sites connect participants with local Army research laboratories so that apprentices have first-hand opportunities to connect their university-based research to the Army's broader STEM interest and network with Army STEM professionals.

6. The Graduate Mentoring Fellows (GMF) Data Brief (Appendix E) suggests that the eWorkshop had varying degrees of success with teaching GMFs about the critical components of effective mentorships. The low frequencies with which GMFs reported employing these strategies suggest that awareness is insufficient for implementation. Further, GMFs did not feel well-supported by the program activities. GMF's offer insightful recommendations for programmatic revisions that would potentially improve the experience of GMFs and the apprentices they mentor. If the GMF program is to be implemented in FY14 and/or scaled up in future, substantial programmatic revision is needed, including increased communication between ARO, faculty mentors, and GMFs about expectations and objectives of mentorship, enhanced training and ongoing support of GMFs, and access to resources to enable GMFs to provide mentorship about AEOP offerings and Army STEM careers.

# Appendix F: 2013 Junior Science & Humanities Symposium (JSHS) Evaluation Executive Summary

The Junior Science & Humanities Symposium (JSHS), managed by the Academy of Applied Science (AAS), is an Army Educational Outreach Program (AEOP) with tri-service sponsorship from the Army, Navy, and Air Force to provide enrichment to high school students throughout the US, Puerto Rico, and Department of Defense Dependent Schools (DoDDS) in Europe and the Pacific. In 2013, JSHS engaged 8,700 students and teachers in 47 Regional Symposia (R-JSHS)

[47] For example, http://www.goarmy.com/careers-and-jobs/army-civilian-careers.html,http://www.goarmy.com/careers-and-jobs/stem.html, individual directorate STEM webpages and resources such as RDECOM's Army Technology magazine, and usajobs.gov.

and a National Symposium (N-JSHS). Student participants orally present their original research in an area of science, technology, engineering, and mathematics (STEM) before a panel of expert judges and compete for scholarships and the opportunity to advance to the N-JSHS event.

This report documents the evaluation of JSHS at the levels of the Regional Symposia (R-JSHS) and National Symposium (N-JSHS). The evaluation addressed questions related to the program's strengths and challenges, benefits to participants, and its overall effectiveness in meeting AEOP and program objectives. The assessment strategy for R-JSHS included at-event focus groups with regional directors/representatives attending N-JSHS and post-event questionnaires for R-JSHS students and regional directors/representatives. N-JSHS assessments included at-event focus groups with N-JSHS students and post-event questionnaires for N-JSHS students and judges.

| Table 1. 2013 JSHS Fast Facts | |
|---|---|
| Major Participant Group | High school students from US, Puerto Rico, and DoD Dependent Schools in Europe and the Pacific |
| Participating Students | 7,600 |
| Participating Teachers | 1,100 |
| Participating Schools | 1,000 |
| Participating Universities | 47 |
| Participating DoD Agencies | 23 in R-JSHS; 17 in N-JSHS |
| Participating Army S&Es | Not available |
| Total Cost | $1,941,415 |
| Total Scholarships/Awards | $384,000 to 144 student finalists, $23,500 to 47 outstanding teachers |
| Cost Per Student Participant | Average cost $55 per person/day, R-JSHS; Average cost $1,000 per student, N-JSHS |

## Summary of Findings

The FY13 evaluation of JSHS collected data that provided information about the participant pool, participants' perceptions of program processes, resources, and activities, and indicators of achievement. A summary of findings is provided in Table 2.

| Table 2. 2013 JSHS Evaluation Findings | |
|---|---|
| **Participant Profiles** | |
| All evaluation data contribute to the overall narrative of JSHS's efforts and impact, and highlight areas for future exploration in programming and evaluation. However, confidence in evaluation findings varies by participant group. | • The statistical reliability achieved for the N-JSHS students and R-JSHS regional directors/representatives suggest adequate representativeness of the respective participant group populations. Low participation of R-JSHS students in evaluation assessments limit reliability of findings. Only 1% (87) of 7600 R-JSHS participants responded to the R-JSHS student questionnaire. Statistical reliability achieved with the sample (±10.6% margin of error at 95% confidence level) and alternative means of establishing representativeness of the sample, through known respondent and participant characteristics, suggest limited confidence that the R-JSHS student respondents are representative of the larger population of R-JSHS student participants. Findings from R-JSHS students' data should be cautiously generalized, with consideration given to the margins of error and with triangulation of findings from other data sources. |
| JSHS is successful in attracting participation from females—a population that is historically underrepresented in some STEM fields. JSHS has had limited success with providing outreach to students from historically underserved groups—low socioeconomic and minority race/ethnic groups. | • More females than males completed R-JSHS and N-JSHS student questionnaires, and the majority of students (82% R-JSHS, 86% N-JSHS) identified with race/ethnicity categories of Caucasian (54% R-JSHS, 49% N-JSHS) or Asian (28% R-JSHS, 37% N-JSHS). Less than 15% of students identified as either American Indian or Alaskan Native, Black or African American, Hispanic/Latino at both levels of JSHS. However, this is an improvement from last year where only 1% of questionnaire respondents identified as Black or African American with no other minority race/ethnicities represented. |
| | • Most R-JSHS and N-JSHS students report they do not qualify for free or reduced lunch—a common indicator of low income or low socioeconomic status. A statistically lower proportion of N-JSHS students (69%) received free or reduced lunch than R-JSHS students (85%). |
| | • The average age of R-JSHS and N-JSHS students is ~16.5. Statistically higher proportions of $11^{th}$ graders participated in R-JSHS (52%) as compared to N-JSHS (34%), and higher proportions of $12^{th}$ graders participated in N-JSHS (43%) as compared to R-JSHS (21%) |
| JSHS provides outreach to the Nation's future STEM workforce. | • 100% of R-JSHS and N-JSHS students reported intent to pursue a college degree. 87% of R-JSHS and N-JSHS students intend to pursue a STEM degree, with a majority (56% R-JSHS, 65% N-JSHS) intending to pursue a doctoral STEM degree. A statistically higher proportion of R-JSHS students intended to stop with the Bachelor's STEM degree as compared to N-JSHS students. |
| | • 98% of R-JSHS students indicated their intent to pursue a career in a STEM field. Medicine/Health (48%), Chemistry (11%), Engineering (10%) and Life Science (10%) were chosen most frequently. |
| **Actionable Program Evaluation** | |
| JSHS students are motivated by opportunities that JSHS and other STEM competitions provide them to grow critical skills for STEM research. | • Most students (60% R-JSHS, 89% N-JSHS) participated in one or more science competitions besides JSHS. Statistically higher proportions of N-JSHS students participated in these national, sponsored events as compared to R-JSHS students: Intel Talent Search (17%, 13% R-JSHS) and Intel Science & Engineering Fair (50%, 8% R-JSHS). |
| | • Students reported participating in STEM competitions for opportunities to engage in and learn from academic research activities (65% R-JSHS, 97% N-JSHS); to advance STEM pathways (11% R-JSHS, 25% N-JSHS); and because of school-based associations that recommend or require their participation in such competitions (21% R-JSHS, 18% N-JSHS). |
| | • Students most frequently (45% R-JSHS, 43% N-JSHS) reported one or more features of JSHS programming that motivate their participation in JSHS, including JSHS symposia format, |

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| | oral and poster presentation options, the breadth of competition categories, and the prestige of JSHS. |
| JSHS is largely marketed to schools and teachers, but teachers serve as the primary conduit through which many students come to participate in JSHS. | • Most students (84% R-JSHS, 72% N-JSHS) credited school-based associations—teachers, academic coursework or programs, science departments, and school nominations—for their awareness of JSHS. Of those associations, teachers (58% R-JSHS, 47% N-JSHS) were most frequently cited as the means by which students were attracted to JSHS. |
| | • Most regional directors employed multi-pronged efforts to reach teachers. Their self-identified "best practices" for outreach, recruitment, and retention strategies for teachers hinged upon establishing and maintaining personal relationships with teachers and ensuring reasonable incentives to facilitate initial and continued involvement. However, regional directors more frequently focused their efforts on teacher outreach and recruitment (74%) rather than on facilitating participation (29%) once teachers are recruited. |
| | • The majority of regional directors generally agreed that funding to support regional director travel to schools for outreach and recruitment (65%) and for student and teacher travel to events (57%) are necessary to expand participation in JSHS. In many regions, teacher participation is also limited by schools' ability to fund substitute teachers (42%). |
| JSHS's key elements are regarded highly by students. | • The oral presentations (86% R-JSHS, 91% N-JSHS) and invited speakers (78% R-JSHS, 77% N-JSHS) were especially held in high regard. At both R-JSHS and N-JSHS, fewer poster presenters are satisfied with poster sessions than are oral participants. In particular, statistically fewer N-JSHS poster presenters are satisfied with the specific poster sessions in which they participated (i.e. non-competitive or competitive.) |
| | • Students considered student research presentations (57% R-JSHS, 49% N-JSHS) and invited speakers (17% R-JSHS, 14% N-JSHS) the two most valuable activities. N-JSHS students also strongly valued peer interactions (17%). The reasons students gave for assigning value to each of the various elements emphasized the nature and breadth of learning experiences and the opportunities JSHS provides to interact with others around STEM. |
| JSHS presentation and judging processes are enjoyable; however, students want more and useful feedback and fair judging processes. | • Most students enjoyed presenting at JSHS; however, poster presenters (88% R-JSHS, 64% N-JSHS) expressed statistically less enjoyment than oral presenters (91% R-JSHS, 91% N-JSHS). R-JSHS oral presenters (58%) perceived statistically more utility in feedback than do R-JSHS poster presenters (24%) and N-JSHS oral presenters (17%). |
| | • At R-JSHS, feedback students received from judges depended upon whether students presented research in the oral or poster formats. Poster presenters received less feedback and fewer types of feedback than oral presenters. The only type of feedback reported by N-JSHS presenters is oral feedback. Importantly, a substantial portion of all presenters at R-JSHS and N-JSHS reported receiving no feedback from the judges (22% R-JSHS-Oral, 62% R-JSHS-Poster, ~75% N-JSHS-Oral and NJSHS-Poster). |
| | • Students' suggestions for improvement most frequently included requests for receiving more feedback from the judges. Concerns were also offered regarding judge qualifications and potential judging bias, suggesting that a number of students at both R-JSHS and N-JSHS perceive that the judging process was not fair. |
| JSHS feedback mechanisms from judges to students vary considerably across R-JSHS. | • Regional directors employ a range of formal and informal feedback mechanisms from judges, executive committee, or peers; written and oral forms of feedback; at- or post-event feedback; and feedback provided to all, some, or none of the student presenters. No single feedback mechanism described was used by more than 34% of regional directors. |

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| JSHS online and at-event resources for N-JSHS judges are not consistent in preparing judges for their work. | • Nearly all N-JSHS judges found the online guidance (96%) and online access to abstracts and papers (100%) to be useful for preparing them for judging at N-JSHS. A majority of judges (65%) did not find the online scoring system to be useful, and one third of judges requested clarification of the relationship between online scoring and at-event judging. |
| | • A majority of N-JSHS judges felt prepared to judge presentations (65%) and question presenters (65%). Most judges reported that their judging was on-time (90%) and went smoothly (90%). However, more than 40% of judges did not feel prepared to provide feedback or to deliberate winners, or did not perceive that judges in the competition room had shared understandings of the judging process and tools. |
| JSHS Student mentorship varies. R-JSHS students are less likely to have mentors and especially, STEM professionals as mentors. | • More than two thirds of R-JSHS and N-JSHS students reported having mentors, consisting of parents, teachers, professors and graduate students, and industry researchers. Statistically higher proportions of N-JSHS students (51%, 25% R-JSHS) reported university professors or graduate students as mentors, while statistically higher proportions of R-JSHS students (35%, 10% N-JSHS) reported that they did not have a research mentor. |
| **Outcomes Evaluation** | |
| JSHS is successful at fostering development in critical STEM competencies. However, growth varies by presentation format and mentorship. | • Most oral presenters at both R-JSHS and N-JSHS agreed or strongly agreed that presenting their research at JSHS helped them become a better speaker or presenter (91% R-JSHS, 91% N-JSHS) and that they are more confident in their ability to communicate science after presentation and judging process (83% R-JSHS, 91% N-JSHS). However, fewer of these same students reported that JSHS helped them become better writers (60% R-JSHS, 63% N-JSHS) or that judges' feedback will improve their research (73% R-JSHS, 65% N-JSHS). |
| | • Participants who presented research posters reported statistically lower perceptions of growth than their oral presentation counterparts at R-JSHS and N-JSHS. They did indicate that the poster process helped improve their presentation skills (88% R-JSHS, 52% N-JSHS) and confidence (88% R-JSHS, 65% N-JSHS). |
| | • 28% of 32 R-JSHS respondents reported improvement in STEM competencies from working with a mentor, including: development of laboratory skills (16%), writing/presenting skills (9%), and critical thinking skills (3%). In contrast, 79% of 71 N-JSHS respondents—who had a statistically higher proportion of university faculty and graduate students mentors—reported growth in STEM competencies: mentors taught them the fundamental knowledge or practices of research (31%) and exposed them to new ideas in the discipline (28%), in addition to those STEM competencies reported by R-JSHS students. |
| JSHS inspires and motivates students' further achievement through engagement with a scientific community of peers and STEM professionals from academia, industry and government. | • Key elements of JSHS exposed students to new information/knowledge in STEM (77-84% R-JSHS, 66-90% N-JSHS) and motivated them to achieve more in STEM (52%-65% R-JSHS, 49%-81% N-JSHS). Fewer students felt their current assumptions of STEM were challenged (51%-58% R-JSHS, 34-56% N-JSHS). Oral presenters and invited speakers had the most influence, while poster presentations had the least. |
| | • N-JSHS students exchanged research ideas with their peers (64%) and found motivation from that exchange (73%). Additionally, N- JSHS students were inspired by their peers (89%) and believed that their peers help them become better scientists (65%). Statistically lower proportions of R-JSHS students, though still the majority, reported that they were inspired by their peers (65%) and motivated to continue STEM research (73%). |
| | • When asked what activities were most inspirational or motivational, students most frequently reported invited speakers (58% R-JSHS, 57% N-JSHS) and student presentations (18% R-JSHS, 25% N-JSHS). Reasons given suggested that other student participants (peers) inspire more immediate achievement in STEM, but STEM professionals at JSHS |

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| | events serve an important role in motivating students' future and long-term participation in STEM. |
| JSHS has limited success in educating students about other AEOP programs in ways that generate lasting awareness and interest. | • Many students (43% R-JSHS, 53% N-JSHS) agreed that JSHS activities or exhibits educated them about AEOP. Yet, the majority of students (85% - 93% R-JSHS, 75% - 94% N-JSHS) indicated that they have never heard about the individual AEOP initiatives. Very few students indicated that they have participated in other AEOP programs in the past (<2% in Research and Engineering Apprenticeship Program, eCYBERMISSION, West Point Bridge Design Competition, Gains in the Education of Mathematics and Science, <3% Junior Solar Sprint). |
| JSHS has limited success in educating students about DoD STEM careers in ways that generate considerable interest or illustrate alignment to students' existing career goals and aspirations. | • JSHS programming exposed students to new career options (64% R-JSHS, 68% N-JSHS) but has less success inspiring and motivating students to pursue DoD/Government service careers (24-27% R-JSHS, 37-44% N-JSHS). Both R-JSHS and N-JSHS events motivated a substantial number of students to explore DoD/Government service careers, but N-JSHS students perceive statistically higher motivation to explore DoD/Government service careers after participating in JSHS activities/exhibits than do R-JSHS students. |
| | • A majority of students (66-67% R-JSHS, 69-74% N-JSHS) were certain that they will pursue jobs or build careers in STEM. A majority of students (72-75% R-JSHS, 62-65% N-JSHS) expressed low levels of certainty about pursuing Army STEM jobs and careers. Most N-JSHS students reported in focus groups that the DoD does not offer jobs in the fields they are interested in, or admitted to being unaware of DoD STEM careers. |

## Recommendations

1. Given that JSHS's reach is through the R-JSHS, a commitment should be made to producing more reliable and valid evaluation of the R-JSHS and benefits to students. The FY13 evaluation provides valuable information regarding how R-JSHS are perceived by a small number of participants, and begins to provide evidence for how the program has impacted R-JSHS students in comparison to N-JSHS students. The low response rate from R-JSHS students poses the most significant threat to the validity of these findings—in other words, we have limited confidence that these findings of 87 respondents are representative of the full population of 7600 participants. Coordinated efforts should be made by the Army, AAS managers, and regional directors (who are provided Army funding for these activities), to encourage and improve student participation in the R-JSHS evaluation efforts. Subsequently, evaluators should endeavor to streamline instruments and appropriately incentivize student participation.

2. Creative and strategic marketing is needed to increase awareness of the program. Schools and teachers play a vital role in attracting participation to JSHS, with the majority of students learning about JSHS through school (i.e. 84% R-JSHS level, 72% N-JSHS). Regional directors report that reaching new teachers and schools is critical for reaching new students. The evaluators and AAS collected regional directors' "best practices" for marketing, outreach, recruitment. AAS should devise and implement a plan for sharing findings with regional directors, and supporting them in prioritizing and enacting the most robust marketing, outreach, and recruitment mechanisms possible for their region.

3. As part of this marketing effort, JSHS should continue to expand its outreach to underserved schools that typically have not participated in JSHS or other STEM competitions. Because many students in these schools may not be as invested

in STEM or have strong STEM supports as traditional competitors, strategies to engage these students should tap into their motivations. Furthermore, adequate supports to ensure successful participation in JSHS are needed. "Best practices" reported by regional directors for facilitating these students' successful participation include inviting new teachers and students to participate in regional symposia as observers, engaging middle school students in high school or similar middle school programs, and professional development for teachers to more effectively support student research.

4. A substantial number of students at both levels do not receive feedback from JSHS judges, and many receiving feedback do not find it useful. Student presenters need timely and specific feedback from judges that will help them understand the strengths and limitations of their presentation materials and delivery, and feedback that can be used to support them in improving their presentations and their future research. Regional directors are employing a variety of different mechanisms for sharing judges' feedback, suggesting that AAS guidelines for feedback are not interpreted or employed consistently. Systemic changes to regional judging and feedback practices may require strong collaboration between AAS, regional directors, and N-JSHS judges to establish clear and specific expectations and feedback tools for judges to ensure feedback is consistently provided to all students.

5. The judging process must not only be fair, but must be perceived as fair by all who participate at the regional and national symposia. Evaluation findings suggest there is room for improvement in the selection, training, and retention of judges as well as in the quantity and quality of feedback provided to presenters. Efforts to expand the pool of national event judges are clearly successful, and military STEM personnel represent a major portion of the newly recruited judges. However, of significant concern are the findings that so few judges do return to participate in other N-JSHS or R-JSHS events and those that participate are less likely to recommend the provision of feedback to student presenters. Considering that all participant groups surveyed suggested that the engagement and quality of judges are areas for future improvement, future programming should consider how to expand capacity not only in terms of numbers of STEM professionals participating, but also work to increase the quality of judging through deeper knowledge and continued engagement of judges in JSHS programs. Furthermore, both R-JSHS and N-JSHS should give careful thought to feedback mechanisms that are useful for all students but that balance the concerns of judges who would be providing the feedback. Both R-JSHS and N-JSHS programs will benefit from strong partnership between AAS and regional directors in establishing robust mechanisms for training judges about the judging process and providing feedback to students. This collaboration could have significant impact of providing consistency across R-JSHS and N-JSHS programs and improving the experience of all competitors.

6. JSHS's position in the pipeline of AEOP initiatives is an area with significant growth potential and should continue to be a program priority. While many students (43% R-JSHS, 53% N-JSHS) report that activities or exhibits educated them about educational opportunities offered by DoD, an overwhelming majority of students do not recognize AEOP programs. Approximately 4-17% of JSHS participants at both R-JSHS and N-JSHS expressed interest in in each of the other AEOP initiatives for which they may qualify. A similar percentage of students participating in other AEOP initiatives this summer (and greater in the AEOP apprenticeship programs) expressed interest in submitting their research projects and papers to JSHS. JSHS and AEOP initiatives should consider a deliberate cross-marketing effort to actively recruit these now-past participants of FY13 programs, increasing JSHS's position as a key component of the pipeline.

7. JSHS should carefully review current practices for generating awareness of and interest in Army/DoD STEM careers and, if possible, recommend that R-JSHS employ best practices identified within its current efforts (e.g., STEM Showcase at N-JSHS) and in other AEOP initiatives that seem to have great success. This is clearly another area with significant growth potential and should be a program priority, as students who have greater awareness of and positive attitudes toward DoD STEM careers are more likely to seek them out in the future. Many regional directors reported in focus groups and questionnaires a strong desire for more "military presence" in their R-JSHS programming. R-JSHS programs in particular would benefit from stronger partnership between regional directors, AAS, and CAMs in connecting with regional DoD and other government agencies conducting STEM research, not just recruiting "military and ROTC personnel," in an effort to better highlight cutting edge, exciting, and impactful STEM research programs and careers offered by DoD and beyond.

# Appendix G: 2013 Junior Solar Sprint (JSS) Evaluation Executive Summary

Junior Solar Sprint (JSS) is a science, technology, engineering, and mathematics (STEM) education activity where $4^{th}$- $8^{th}$ grade students apply scientific understanding, creativity, experimentation, and teamwork to design, build, and race a model solar car. Junior Solar Sprint activities occur nationwide, in classrooms and schools, through extracurricular clubs and student associations, and as community-based events that are independently hosted and sponsored. The Army Educational Outreach Program's (AEOP's) investment in JSS-based programming is managed by Technology Student Association (TSA). The AEOP's JSS programming (herein called AEOP's JSS) is intended to complement, support, and extend existing classroom, extracurricular, and community-based JSS activities that occur nationwide. In FY13 AEOP's JSS included the management of a JSS online resource center, consisting of a repository of JSS-related material for students, educators, and local event hosts (herein called hosts), as well as an online national competition for students. A dedicated website (jrsolarsprint.org) provided educators and hosts with access to course syllabi, lesson plans, alignment of JSS curricula to established STEM standards, guidelines and resources for hosting local race events, and fundraising information for local race events. AEOP's JSS also provided free advertising for non-AEOP sponsored local events through the jrsolarsprint.org Calendar of Events; for this service event hosts registered their event with the jrsolarsprint.org website. In 2013, AEOP's JSS provided students without access to local race events an opportunity to design, build, and test their model solar cars at home, then register their designs and time trials in an online national competition through the jrsolarsprint.org website.

The AEOP's JSS investment has experienced substantial transition over the last three years; this report documents the developmental evaluation of the AEOP's JSS online resource center and the national online competition. The evaluation focused on the usefulness and potential impact of the JSS online resources and national competition, and established a baseline and limited feedback to inform future programming and evaluation. Evaluators used website analytics in an attempt to capture current levels of use for the AEOP's JSS online resource center and online national competition, and to identify areas of possible improvement for the jrsolarsprint.org website. Evaluators gathered information from local event hosts and educators who registered at jrsolarsprint.org about their use and perceived effectiveness of AEOP's JSS online resource center and online national competition. These data informed recommendations about the AEOP's JSS online resources and online national competition, and AEOP's JSS- programming more broadly (e.g., marketing, partnerships, formats).

| Table 1. 2013 JSS Fast Facts | |
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| **AEOP Element** | **Junior Solar Sprint** |
| Major Participant Groups | 4th – 8th grade students, educators, and local event hosts registered with the AEOP at jrsolarsprint.org |
| Students | 20 |
| Teachers | 80 |
| Event Hosts and Volunteers | 21 event hosts, 19 volunteers |
| Local Events | 17 local events (1 local TSA chapter event) |
| Total Cost | $70,736.63 |
| Total Awards | $150.00 (1 student competitor awarded) |

## Summary of Findings

The FY13 evaluation collected data that is useful for a developmental evaluation of AEOP's JSS online resource center and online competition. The findings contained in Table 2 are meant to assess developmental milestones and inform future iterations of AEOP's JSS program.

| Table 2. 2013 JSS Evaluation Findings | |
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| **Study Sample** | |
| Evaluation data inform further development of AEOP's JSS online resource center and provide a baseline for measuring the impact of any future programming that aims to incorporate the JSS resource center. | • A small number of hosts and educators within a restricted geographic distribution of the local JSS events responded to evaluation surveys. It is not appropriate to generalize findings to the larger population of individuals and organizations that host local JSS events or educators that currently use JSS resources. Respondents provided information about their use and perceived effectiveness of AEOP's JSS online resource center and the online national competition, and whether, through the use of these resources, they successfully identified with the AEOP and contributed to the achievement of AEOP priorities. |
| **Actionable Program Evaluation** | |
| AEOP's efforts to establish a nationwide network of JSS events and educators may benefit from and be challenged by hosts' and educators' longstanding relationships with local, independently organized JSS programming. | • When hosts and educators were asked to report how many years they have been involved in JSS, most hosts (57%) reported more than five years of involvement and approximately 10 years on average while half of educators (50%) reported more than five years of involvement and approximately 9 years on average. |
| AEOP may benefit from partnerships with non-profit organizations currently hosting and/or sponsoring JSS events. | • Six of seven hosts (86%) and two of seven educators (29%) reported that they became involved in JSS through an affiliation with a non-profit organization. Five of eight educators (63%) reported working with students in other STEM competitions, all of which are sponsored by non-profit organizations. |

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| AEOP is poised to provide a strong model for JSS programming that reaches populations that are historically underserved and underrepresented in STEM. | • Hosts estimated that very small number of Title-I schools (less than one per event) are served by their JSS events; no educators reported serving Title-I schools. Small proportions of female students (37%) participate in their local events as compared to male participants. |
| AEOP's JSS online resource center currently attracts limited web-traffic, considering the nationwide reach of other non-AEOP JSS programming in communities and schools. | • In FY13, a total of 140 individuals registered with AEOP's JSS online resource center; the majority of whom are educators (80%). A total of 17 hosts registered and posted their competition on AEOP's Calendar of Events, most of which were located in the North East region of the United States. |
| | • The jrsolarsprint.org website received a total of 3740 unique visitors in FY13. Most of whom viewed, explored, or downloaded content from the Educational Resources and Build a Car levels including lesson plans and video tutorials. |
| AEOP's JSS online resources have the potential to be useful and valuable resources for hosts and educators; future efforts to align with the Next Generation Science Standards and attention to user feedback may facilitate greater integration in classroom and school settings. | • 60% of event hosts and 67% of educators report that AEOP's lesson plans and course syllabi are "Useful" or "Very Useful." Educators also report that JSS terminology and video tutorials were useful (87% and 87%, respectively). Large proportions of hosts and educators report that they did not use fundraising information (80% and 83%, respectively). |
| | • Hosts and educators reported that AEOP's JSS online resources are valuable. 67% of hosts agreed that their students responded well to the material from JSS's online resources and that these resources helped them become a better teacher. 50% of educators believe that their students responded well to the material from JSS's online resources while 100% of educators reported that they are valuable teaching and learning resources. |
| | • Hosts and educators suggested that including related content from NASA would improve the online JSS content offered by AEOP as well as alignment with Next Generation Science Standards. Hosts and educators requested more information and resources to help procure sponsorship for local events. |
| AEOP's JSS online national competition received limited interest in 2013; hosts, educators, and students were largely unaware of its existence. | • The online national competition received 161 page views, 5 letters of intent, and 1 submission during FY13. 57% of educators were unaware of the online national competition. |
| AEOP's JSS online resource center is not currently raising Army STEM and AEOP awareness but is likely to do so with strategic improvements to the website and broader JSS programming. | • Although hosts were aware of the AEOP (86%), only 29% were aware of eCYBERMISSION, and very few encouraged their students to participate in AEOP programming.<br>• Only 25% of educators reported that they were aware of the AEOP but 50% reported that they were aware of eCYBERMISSION meaning that they do not associate the two together. Very few educators reported encouraging their students to participate in AEOP programming. |
| | • AEOP's JSS online resource center attempts to raise awareness of Army STEM and AEOP: AEOP logo is visible and provides an outbound like to www.usaeop.com; |

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| | dedicated AEOP page in About JSS level; Army link in the STEM careers page; and outbound link to an AEOP .pdf flyer.<br>• Only the usaeop.com outbound link was used with any frequency in FY13 (85 links). |

## Recommendations

1. Motivating and recruiting existing event hosts and educators to use AEOP's JSS resource center will require significant interaction and integration with very well-established implementers of JSS. If AEOP's JSS-related efforts are to be successful moving forward, non-profit organizations that host local events may be important points of contact and/or potential partners. In order to reach educators, AEOP will need to clearly demonstrate the value of JSS as a teaching tool, and the value of AEOP's JSS online resources for supporting educators in integrating JSS with school STEM curriculum. Alignment of JSS educational resources to the three dimensions of the Next Generation Science Standards—core disciplinary ideas, cross-cutting themes, and science and engineering practices--and robust professional development (e.g., online webinars, face-to-face professional development offerings at local events) will ensure resources are both relevant and feasible for integration with school STEM education nationwide. AEOP JSS might consider whether and how to leverage lessons learned and promising practices of AEOP's eCYBERMISSION (eCM) in improving use of the JSS online resource center to support broader uptake of resources by local events and by educators in schools. eCM managers, ambassadors and event hosts, and team advisors (mostly educators) could provide valuable insight regarding a range of issues unique to AEOP's competition programs, including: maximizing potential use of online resources, marketing to existing users and potential event hosts, and initiating teacher and school partnerships to expand and study the participation of underserved populations.

2. AEOP should remain cognizant that attempts to perform outreach primarily through the jrsolarsprint.org website and existing school- and community-based JSS programming may constrain the diversity of the population that it attracts, according to data we collected from hosts and educators. We acknowledge that outreach to underserved and underrepresented populations may not be a key objective of JSS hosts and educators nationwide. However, outreach to these populations is an Army priority, and therefore AEOP's JSS programming in FY14 should incorporate explicit efforts to market to and recruit these populations, and to support them in successfully participating in JSS. In an effort to engage underserved and underrepresented populations, AEOP's JSS may need to identify and directly engage educators and students that have not been exposed to JSS-based programming to date. For example, these efforts might include a) promoting JSS to TSA's nationwide and diverse membership base, support and volunteer network, and local chapters, and supporting TSA-affiliated local and national competition options for students; b) initiating unique partnerships with educators at Title 1 schools, including the provision of low or no-cost kits for students, professional development for educators, and support for school-based communities of practice to help educator teams integrate JSS activities with their classroom STEM curricula; and c) strategically cross-promoting and forging initiating partnerships with Army and university sites that host other AEOP pipelines (e.g., GEMS-SEAP-CQL and UNITE-REAP) to expand outreach to diverse populations when they are younger, and prepare them for future engagement in GEMS and UNITE.

3. AEOP's JSS online resource center currently attracts limited web traffic and registrants considering the nationwide reach of other non-AEOP JSS programming. In FY13, a total of 140 teachers, hosts, students, and volunteers registered with AEOP's JSS online resource center while only 17 local events registered with AEOP's system (most in the North East region of the US). We expect that efforts to expand the number and geographic representation of events that register with the JSS resource center, and further development of relationships with those events that have already registered with the resource center will necessarily increase traffic at and use of the website moving forward. Continued efforts to promote existing local events in areas outside of the North East US, may also help establish a national network for JSS information sharing and generate additional registrants and website traffic. The previous recommendations (1 and 2) will undoubtedly increase website traffic and expand the use of the JSS online resource center as well. Ongoing study of website traffic and registration numbers will be critical moving forward to provide information about the use of jrsolarsprint.org in FY14.

4. Hosts and educators that used the online resources provide by AEOP indicated that they are valuable for teaching and learning. Website analytics support these findings; lesson plans and video tutorials were the most viewed content in AEOP's JSS online resource center. Suggestions for improving these resources include the following: additional content such as information from NASA, virtual simulations, and providing variations on the base car model for younger students. Evaluators would like to highlight and recommend one respondents' suggestion to align educational resources with the Next Generation Science Standards. This suggestion aligns with both the AEOP objective and the national call for shared standards across formal and informal education settings. Evaluators also advise improving the visibility of existing resources and adding new resources to meet current and potential users' needs, as reported from the evaluation assessments. Examples from the current study include a list of resources that local hosts would need to start a new event as well as a list of companies that may be contacted to sponsor local events.

5. AEOP's online JSS competition showed limited efficacy in FY13. The information contained in AEOP's online national competition web page received very limited traffic and extremely limited participation (5 letters of intent and 1 official submission). When event hosts and educators that registered with AEOP's JSS online resource center were asked how the online competition could be improved, most stated that they were unaware of the competition entirely. Strategic promotion of the online competition to TSA's membership base may be needed for the success of this programming component. If such promotion is unlikely to produce the desired interest, and/or provide outreach to underserved populations, AEOP should consider live event programming for a JSS national competition, consistent with the format of other successful AEOP national competitions (e.g., eCYBERMISSION, WPBDC, JSHS).

6. Currently, AEOP's JSS online resource center has limited, if any, success at raising AEOP and Army STEM awareness. It has the capacity to do so with strategic changes to the website and to other AEOP JSS marketing. The visibility of information related to AEOP and Army STEM will, in part, determine the extent to which this program successfully raises awareness through the website. AEOP's JSS online resource center has dedicated content to AEOP, and analytics from outbound links demonstrate that they are used by those who visit the website. Additionally, AEOP's JSS resource center has dedicated a page to STEM careers, including Army STEM careers. However, this page is difficult to find (embedded in About JSS) and only contains external links to resources and information. Placement of STEM career information at

a location in the website with higher traffic (e.g., placing a button or tab on the main page) and providing short text descriptions of each linked resource may improve the use of and awareness generated by these resources. Other suggestions for improving the visibility of AEOP and Army STEM offerings through TSA's other JSS-related efforts include offering AEOP and Army STEM career promotional materials to local event hosts and educators registered with the jrsolarsprint.org website, to schools, educators, and other AEOP program sites with which TSA partners, and to educators who participate in JSS-related professional development at TSA conferences. These strategic website revisions and marketing efforts are likely to strengthen the visibility and participant awareness of Army STEM and the AEOP.

7. AEOP's investment in JSS is likely to see another year of transition, in FY2014. Most of the recommendations provided are likely to necessitate greater investment to support costs associated accomplishing them. In addition, the LO evaluators, Army, and TSA will need to prioritize evaluation to reflect where the most resources and effort are being expended in FY14, and thus, where the most impact is likely to be detected. To the extent possible, evaluation should include continued monitoring of the jrsolarsprint.org website as a measure of nationwide reach, but evaluation assessments should primarily focus on experiences of and potential impact on educators and students who are *directly* engaged by AEOP's JSS programming.

# Appendix H: 2013 Research & Engineering Apprenticeship Program (REAP) Evaluation Executive Summary

The Research Engineering & Apprenticeship Program (REAP), managed by the Academy of Applied Science (AAS), is an Army Educational Outreach Program (AEOP) that places high school students from historically underserved and underrepresented populations in summer research apprenticeships at colleges and universities throughout the nation. Each REAP student (herein referred to as apprentice) works under the direct supervision of a university scientist or engineer (herein referred to as mentor) on a hands-on research project. Through the five to eight week REAP experience, apprentices are exposed to the real world of research, they gain valuable mentorship, and they learn about education and career opportunities in STEM.

In 2013, REAP provided outreach to 101 participants at 54 hosting college or university laboratories. According to AAS, more than 1,500 applications were received from students interested in REAP.

This report documents the evaluation of the 2013 REAP program. The evaluation addressed questions related to program strengths and challenges, benefits to participants, and overall effectiveness in meeting AEOP and program objectives. The assessment strategy for REAP included: in-person focus groups with apprentices and mentors at 4 REAP sites, phone interviews with apprentices and mentors representing 10 additional REAP sites, and online post-program questionnaires distributed to all apprentices and mentors.

| Table 1. 2013 REAP Fast Facts | |
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| Major Participant Group | High School Students |
| Participating Students | 101 |
| Participating University Faculty | 95 |
| Participating Universities | 54 |
| Total Cost | $349,690 |
| Total Stipends | $216,400 |
| Cost Per Student Participant | $3,462 |

## Summary of Findings

The 2013 evaluation of REAP 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 2.

| Table 2. 2013 REAP Evaluation Findings | |
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| **Participant Profiles** | |
| REAP apprentice and mentor participation in evaluation yielded sufficient confidence in the findings. | • The statistical reliability achieved for the REAP apprentice questionnaires allow us to sufficiently generalize findings of the evaluation sample to the population. Findings from mentor questionnaires can be cautiously generalized with consideration given to the margin of error and triangulation of findings with mentor focus group and interview data. Expanded participation in 2013 evaluation assessments is a success for REAP. |
| REAP had some success in serving historically underrepresented and underserved populations. | • REAP was successful in attracting participation of female students (60%)—a population that is historically underrepresented in engineering fields. |
| | • REAP had some success in providing outreach to students from historically underserved minority race/ethnicity and low-income groups. Questionnaire respondents included apprentices identifying as Black or African American (33%), American Indian or Alaskan Native (2%), and Hispanic or Latino (15%), as well as apprentices who qualify for free or reduced lunch (27%). |
| REAP's mentor diversity did not mirror the diversity of apprentices. | • Mentors identified as predominantly male (75%) and White or Caucasian (67%). |
| | • A comparison of apprentice and mentor demographics suggested that many apprentices of underserved or underrepresented populations are not likely to have mentors sharing the same gender or race/ethnicity characteristics—a potential motivator for reducing stereotypes and increasing students' performance and persistence in STEM. |
| REAP provides outreach to the Nation's future STEM workforce. | • 91% of the 86 respondents indicated their intent to pursue a career in a STEM-related field. More respondents intended to pursue careers in Medicine/Health (36%) than any other field, with Engineering (26%), Chemistry (9%), and non-STEM fields (8%) being the next most frequently reported fields. |
| **Actionable Program Evaluation** | |
| REAP marketing and recruitment was largely a site-based endeavor. | • 54% of mentors reported actively recruiting apprentices through connections with local high schools, 13% through other programs for high school students, and 4% through on-campus recruiting events. University- and faculty-led advertising, social media, and word of mouth are also used to recruit apprentices. |
| | • Apprentices most frequently learned about REAP from high school personnel (25%) or through family or family friends (22%). 30% of apprentices reported having a family member or family friend at the university where the REAP apprenticeship took place. |
| | • 52% of mentors learned about REAP from a colleague and 33% from a superior, such as a Department Chair, Center Director, or Dean. |
| REAP apprentices participate to clarify and advance their STEM pathways. | • Apprentices received encouragement to participate from others, including friends, family members, and school staff, often who have current or past connections to the REAP program. Additionally, apprentices participated to clarify and advance their STEM pathways. A small number were motivated by their own positive experiences in REAP or other AEOP programs. |
| REAP mentors participate to serve as university and STEM ambassadors. | • Mentors received encouragement to participate from other colleagues, including peers, more senior faculty, and superiors, often who have current or past connections to the REAP program. Additionally, mentors participated in REAP to serve as university and/or STEM ambassadors. |
| REAP mentors used a team-based approach to engaging their REAP | • Apprentices and mentors reported similar frequencies and types of mentor activities related to engaging apprentices in STEM research, with more focus on laboratory-based work than on academic or scientific writing. |

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| apprentices in STEM research. | • Apprentices and mentors suggested that other students and laboratory personnel contributed significantly to the day-to-day mentoring and guidance about STEM educational and career pathways, sometimes more than the designated REAP faculty mentor. |
| | • Mentors suggested a number of ways that REAP can improve its impact on underserved students, including efforts to establish or expand site-based and REAP-wide community-building and support for post-REAP educational and career opportunities. |
| REAP mentors lacked awareness and resources for promoting AEOP opportunities and Army/STEM careers. | • Most mentors had limited awareness of or past participation in an AEOP initiative beyond REAP or the AEOP UNITE program on their campus. Most mentors suggested that more resources were necessary to educate apprentices about AEOP opportunities. A small number of mentors reported that educating apprentices about other AEOP opportunities is the responsibility of the AEOP and REAP administrator, AAS, and could be accomplished through an improved AEOP website. |
| | • Many mentors educated apprentices about STEM majors, programs, and funding sources for their educational pursuits. Some mentors educated apprentices about STEM careers, but few of those were Army/DoD STEM careers. Most mentors suggested that more resources are necessary to allow them to comfortably educate apprentices about Army/DoD STEM careers, in particular. |
| REAP benefited apprentices, mentors, and laboratories. | • Apprentices and mentors perceived that REAP benefits apprentices by providing authentic and deeper learning opportunities not available typical school settings. Mentors suggested establishing program features to engage apprentices in a larger community of REAP and AEOP alumni after during and after their apprenticeship. |
| | • Mentors also perceived benefit to their laboratories and to themselves, most notably that apprentices made meaningful contributions to the work of the lab. |
| **Outcomes Evaluation** | |
| REAP engaged apprentices in authentic STEM activities and improved their STEM competencies. | • Apprentices perceived that REAP provides significantly more opportunities to engage in authentic STEM activities as compared to their school setting, including academic (42%-68% in REAP, 17-42% in school) and hands-on (47%-75% in REAP, 12%-44% at school) research activities. Apprentice and mentor data suggested REAP has a larger effect with providing apprentices opportunities for hands-on research activities (using equipment safely, following procedures) than it does academic research activities (generating questions, designing experiments, analyzing and interpreting data, formulating conclusions). |
| | • Most apprentices (63%-87%) perceived growth in their confidence across 7 STEM skills and abilities. A majority of mentors (52%-72%) rated their apprentices at near expert or expert levels of the development continuum across 6 skills and abilities. The majority of mentors (64%-77%) also rated all 6 components of their apprentices' final research project or presentation in the near expert or expert levels. |
| REAP apprentices were largely unaware of AEOP initiatives, but showed substantial interest in future AEOP opportunities. | • Apprentices (57%-96%) and mentors (50-66%) were largely unaware of other AEOP initiatives. Yet, substantial apprentice interest exists in AEOP opportunities: 27-29% of apprentices expressed interest in high school, college apprenticeship programs, and college scholarship program and 10% expressed interest in JSHS, a research competition program. |

| | |
|---|---|
| REAP had some success in increasing apprentices' awareness of, interest in, and attitudes toward Army/DoD STEM careers. | • Apprentice and mentor data suggested that a majority of apprentices had opportunities to learn about new STEM careers during REAP (54% apprentices, 57% mentors), but Army STEM careers received less attention (29% apprentices, 23% mentors). |
| | • REAP served to inspire interest in new STEM careers, with 21% of apprentices expressing new interest in Army/DoD STEM careers in particular. |
| | • 51% of apprentices credited REAP with improving their understanding Army/DoD STEM contributions, and 57% of apprentices would consider a civilian position in STEM with the Army/DoD because of their valuable contributions to society. 35% of mentors perceived their apprentices expressed a positive attitude toward the Army/DoD. |

## Recommendations

1. Based on the demographic data collected in evaluation assessments, REAP had some success in providing outreach to students from historically underserved minority race/ethnicity and low-income groups. Future evaluation and annual program reporting may provide a clearer picture of REAP's success in this area. However, additional program-level efforts and stronger collaboration between AAS and university sites may be required to fully realize this objective. For example, program level efforts such as AAS' competitive 2-year selection process, continued marketing to HBCUs and MSIs, and strengthening and expanding of the UNITE-REAP pipeline provide some assurance that universities receiving REAP awards are poised to serve minority and low-income populations. Further collaboration between AAS and universities are needed during the recruiting and selection processes for both apprentices and mentors. AAS and universities should consider
    a. How to mitigate underserved students' resource and educational gaps (identified by mentors), to ensure their participation is both feasible and successful;
    b. How to recruit and select apprentices in ways that do not unwittingly privilege certain students over others (e.g., those with personal connections to the university site, coordinator, or mentor); and
    c. How to recruit a more diverse yet highly qualified pool mentors that reflect the gender and race/ethnicity characteristics of apprentices. Access to mentors of the same gender and/or race/ethnicity have been suggested as a potential factor for reducing stereotypes and increasing students' performance and persistence in STEM.

2. Data suggests that REAP apprentices have more opportunities to do the *hands-on* aspects of research and fewer opportunities to contribute to the *minds-on* aspects. AAS, in collaboration with university sites, should explore creative strategies for supporting all apprentices in having opportunities to contribute to generating questions, designing experiments, analyzing and interpreting data, and formulating conclusions for research in which they are engaged. For example, sites may reproduce the daily written summary described in one of the REAP focus groups, or promising practices occurring at other sites or in the research literature pertaining to apprenticeship. In light of challenges expressed by mentors, including gaps in underserved students' education (lack of conceptual understanding and writing skills) and finding age- or ability-level appropriate projects for them to do, program level scaffolds may be needed, including any of the following: REAP apprentices participate in other AEOP programs before REAP, REAP apprenticeships extend beyond 5-8 weeks and include an apprentice-directed research project (though not necessarily

paid beyond summer months), and/or REAP apprenticeships are awarded with a commitment of two summers from each apprentice.

3. REAP appears to serve as largely an entry and exit point to participation in AEOP. Only a small percentage of apprentices reported past participation in other AEOP initiatives before REAP, and data from REAP and other AEOP evaluations suggest few REAP apprentices participate in other AEOP initiatives after REAP. Subsequently, REAP apprentices and mentors were largely unaware of other AEOP initiatives. In light of these findings, we first recommend that both training and resources be provided to mentors to educate them about AEOP programs, with clear expectations that they educate apprentices about and encourage participation in other AEOP initiatives. Every REAP apprentice should at least know possible next steps to take in AEOP at the conclusion of their REAP apprenticeship. Second, we recommend that AAS be strategic in its cross-marketing of other AEOP initiatives to mentors and apprentices to better position itself within a pipeline and to support successful participation of underserved populations. For example, REAP will benefit from strengthening and expanding the UNITE-REAP bridge, ensuring readiness of REAP apprentices by mitigating any educational gaps before they arrive in REAP. REAP will also benefit from establishing a REAP-JSHS bridge, ensuring that REAP apprentices have opportunities to network and build community with other REAP apprentices (and non-REAP students), to present their research in a STEM-supportive environment, and to compete for college scholarships through their research.

4. Most apprentices had opportunities to learn about STEM careers during REAP. Army/DoD STEM careers received less attention than STEM careers in general. Apprentices are interested in an array of career fields that are of potential interest to the Army/DoD, but perhaps they do not recognize them as such. The majority of mentors interviewed cited their lack of awareness of Army/DoD STEM careers as the primary reason for not educating apprentices about them. AAS might consider a requirement, similar to that of the UNITE program, that REAP sites connect (either virtually or in-person) with local Army scientists, engineer, and/or research facilities. In addition, REAP and/or AEOP should consider developing a resource that profiles the research, educational pathway, and on-the-job training of one or more Army/DoD STEM professionals (or Army/DoD-sponsored researchers in private industry and academia) engaged in the fields of interest listed by apprentices. This evolving resource can assist mentors and apprentices in learning about Army/DoD STEM interests more broadly without the need for firsthand experience or professional connections with Army/DoD scientists and engineers.

# Appendix I: 2013 Science & Engineering Apprenticeship Program (SEAP) Evaluation Executive Summary

The Science & Engineering Apprenticeship Program (SEAP), managed by the American Society for Engineering Education (ASEE), is an Army Educational Outreach Program (AEOP) that matches talented high school students (herein referred to as apprentices) with practicing Army Scientists and Engineers (Army S&Es, herein referred to as mentors), creating a direct apprentice-mentor relationship that provides apprentice training that is unparalleled at most high schools. SEAP apprentices receive firsthand research experience and exposure to Army research laboratories. The intent of the program is that apprentices will return in future summers and continue their association with their original laboratory and mentor and upon graduation from high school participate in the College Qualified Leaders (CQL) program or other AEOP or Army programs to continue their relationship with the laboratory. Through their SEAP experience, apprentices are exposed to the real world of research, they gain valuable mentorship, and they learn about education and career opportunities in STEM. SEAP apprentices learn how their research can benefit the Army as well as the civilian community.

In 2013, SEAP provided outreach to 101 apprentices and their mentors at 11 Army laboratory sites (herein called SEAP sites). This is a decline of 34% from the 154 apprentices in 2012. In 2013, 814 students submitted applications to the program, up 2% from 796 student applicants in 2012.

This report documents the evaluation of the 2013 SEAP program. The evaluation addressed questions related to program strengths and challenges, benefits to participants, and overall effectiveness in meeting AEOP and program objectives. The assessment strategy for SEAP included: in-person focus groups with apprentices and mentors at 4 SEAP sites and online post-program questionnaires distributed to all apprentices and mentors.

| Table 1. 2013 SEAP Fast Facts | |
|---|---|
| Major Participant Group | High School Students |
| Participating Students | 101 |
| Represented K-12 Schools | 59 (5 'Title 1' Schools) |
| Participating Army S&Es | 101 |
| Participating Army Agencies | 11 |
| Total Administrative Cost | $66,644 |
| Total Stipends | $250,888 |
| Cost Per Student Participant | $3,144 |

## Summary of Findings

The 2013 evaluation of SEAP 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 2.

| Table 2. 2013 SEAP Evaluation Findings | |
|---|---|
| **Participant Profiles** | |
| Low participation of SEAP apprentices and mentors in evaluation assessments limit the reliability of findings. | • Statistical reliabilities achieved for questionnaire samples (±11.7% margin of error for apprentices, ±23.5% margin of error for mentors) suggest limited representativeness of samples. However, alternate methods for establishing representativeness suggest we may sufficiently generalize findings from the apprentice questionnaire respondents to the apprentice population. |
| | • Findings from mentor questionnaires should be cautiously generalized with consideration given to the calculated margins of error and with triangulation of findings with other data. |
| SEAP had some success in providing outreach to participants from historically underrepresented and underserved populations. | • Apprentices included female students (30%)—a population that is historically underrepresented in some STEM fields. |
| | • Apprentices included students who identified as Black or African American (3%) or Hispanic or Latino (3%)—these populations are among those historically considered underserved and underrepresented in STEM education. |
| | • While apprentices attended schools in urban (10%) and rural (13%) settings, no apprentices reported qualifying for free or reduced lunch at school, a common indicator of low-income status. |
| | • Mentors identified as predominantly male (67%) and White or Caucasian (67%). Less than 10% identified as Black or African American (3%) and Hispanic or Latino (3%). |
| SEAP apprentices intend to pursue post-secondary education in STEM. | • 97% of apprentices planned to pursue a degree in a STEM field (10% Bachelors, 31% Masters, and 56% Doctorate) |
| | • Large proportions of apprentices planned to pursue engineering (39%) and medicine/health-related fields (26%). Apprentices also intended to pursue math/computer science (16%), chemistry (11%), physical science (3%) and life science (3%). |
| **Actionable Program Evaluation** | |
| SEAP marketing and recruitment was largely a site-based endeavor. | • SEAP sites market SEAP to local schools and universities, to local educators, and to participants of their GEMS programs. |
| | • Apprentices most frequently reported learning about SEAP through family, family friends, or school staff with connections to the SEAP mentor and/or Army research facility. 30% of apprentices reported having a family member or family friend at the Army research facility where the SEAP apprenticeship took place. |
| | • Apprentices who identified as GEMS alumni reported learning about SEAP through GEMS activities and staff. |
| | • Many mentors reported selecting apprentices that had been "vetted" by a personal or professional connection of the mentor. |
| SEAP apprentices seek opportunities to clarify and advance their STEM pathways. | • Apprentices were motivated to participate in SEAP by encouragement they received from others who have connections to the SEAP program, by their own positive experiences in GEMS programs, and by opportunities SEAP could provide to clarify and advance their STEM pathways. |
| SEAP mentors seek opportunities to engage with STEM learners in their work. | • Mentors were motivated to participate in SEAP because of positive experiences as CQL, SEAP, or GEMS mentors, by opportunities to re-engage former apprentices in the research project, and by opportunities to have project needs met by hosting an apprentice. |

| | |
|---|---|
| SEAP mentors engaged their apprentices in STEM research and provided limited guidance about educational and career pathways during the SEAP apprenticeship. | • Apprentices and mentors reported similar types and frequencies of mentor activities related to engaging apprentices in STEM research. Most frequently they reported training the apprentice to perform laboratory tasks and procedures; providing apprentices with constructive feedback; and efforts to ground the apprentices' laboratory-based work in scientific principles (e.g., assigning readings, teaching sessions, participation in journal club). |
| | • A large significant difference was found in proportions of apprentices and mentors reporting mentorship around careers (apprentices = 67%, mentors = 100%). Mentor interviewee comments possibly clarify this finding, suggesting that career-related guidance is more frequently provided to CQL apprentices than to SEAP apprentices, or is provided after the apprenticeship through ongoing communication with SEAP apprentices. |
| SEAP mentors lacked awareness and resources needed for promoting AEOP opportunities and STEM careers outside of the SEAP site. | • Most mentor interviewees had limited awareness of AEOP initiatives beyond the GEMS, SEAP, and CQL programs running at their Army research facility. Subsequently, mentors did not consistently educate their apprentices or encourage their participation in those AEOP initiatives. |
| | • Mentors suggested that informational resources, mentor training, and a command-level emphasis on promoting other AEOP PROGRAMS were necessary to accomplish this objective. |
| | • Mentors reported a variety of strategies for mentoring apprentices about STEM careers, with a strong emphasis on Army/DoD STEM careers. |
| | • Mentors perceived that furloughs, their own lack of awareness about STEM careers (beyond their own), lack of resources, and apprentice disinterest in STEM or Army STEM careers were challenges to providing career mentorship. |
| SEAP benefited apprentices as well as Army S&E mentors and their laboratories. | • Apprentices and mentors perceived that SEAP benefits apprentices by providing authentic research opportunities not available typical school settings, opportunities to clarify or advance their STEM pathway, and opportunities to develop and expand research skills. |
| | • Mentors also perceived benefits of SEAP to their laboratories and to themselves. Most notably, mentors indicated that apprentices are low-cost yet highly effective members of the lab, and apprentices have made meaningful contributions to research with near-term impact on Army processes or procedures. |
| SEAP's administrative processes and support are a possible area for improvement. | • Apprentices and mentors alike perceived challenges with the "cumbersome" and "time-consuming" administrative tasks associated with the SEAP program, suggesting they detract from work that can be accomplished during an already short (and furlough-disrupted) summer apprenticeship. Mentors perceived low organization of and support for these tasks. |
| **Outcomes Evaluation** | |
| SEAP engaged apprentices in authentic STEM activities more frequently than their school environment. | • Apprentices reported that SEAP provides more frequent opportunities to engage in authentic STEM activities as compared to their school setting, including academic research activities (32%-66% in SEAP, 17-39% in school) and hands-on research activities (35%-62% in SEAP, 8%-39% at school). |
| | • Moderate to large significant differences were found in apprentices perceptions of how frequently they did the following in SEAP as compared to school: used, cared for, and calibrated equipment; employed advanced measurement techniques; defined research questions; and worked as part of a research team. |

| | |
|---|---|
| | • Apprentice and mentor data suggested SEAP had a larger effect with respect to providing apprentices opportunities for hands-on research activities than it had providing opportunities for academic (minds-on) research activities. |
| SEAP apprentices become more confident in STEM, and mentors rate their research skills highly. | • A majority of apprentices (58%-79%) perceived growth in their confidence across 7 key STEM skills and abilities: performing literature reviews, formulating hypotheses and designing experiments, using laboratory safely, using laboratory equipment and techniques, analyzing data, generating conclusions, and contributing to a research team. |
| | • Many mentors (48%-59%) rated their apprentices at near expert or expert levels of the development continuum across 6 key STEM skills and abilities: information literacy, scientific reasoning, laboratory, data collection, quantitative literacy, and teamwork and collaboration. Most mentors (57%-79%) also rated all 6 components of their apprentices' final research project or presentation in the near expert or expert levels. |
| SEAP apprentices will serve as STEM role models for their peers | • 50-81% of SEAP apprentices intend to serve as a role models by sharing their SEAP experiences with friends, recommending SEAP to friends, encouraging friends to study more STEM, and mentoring younger STEM learners. |
| SEAP apprentices were unaware of the many AEOP initiatives, but showed substantial interest in future AEOP opportunities. | • Many apprentices (32%-97%) and mentors (13-78%) were unaware of other AEOP initiatives, with higher proportions lacking awareness for programs occurring outside of the Army research facility. |
| | • SEAP apprentices are interested in participating in other AEOP opportunities: high school STEM competitions (5-21%), high school apprenticeships (36%), college apprenticeships (60%), and college scholarship programs (60%). This interest could be leveraged for targeted cross-promotion of programs and repeated engagement of apprentices in the AEOP pipeline. |
| SEAP apprentices have positive attitudes toward the defense community and a view toward potential government service. | • A majority of apprentices had opportunities to learn about new STEM careers during SEAP as reported by apprentices and mentors (64% apprentices, 53% mentors). Army/DoD STEM careers received substantial attention (69% apprentices, 54% mentors). |
| | • SEAP served to inspire interest in new STEM careers, with 44% of apprentices expressing new interest in Army/DoD STEM careers in particular. 85% of apprentices would consider a civilian position in STEM with the Army/DoD because of their valuable contributions to society. |
| | • Most apprentices (87%) credited SEAP with improving their understanding Army/DoD STEM contributions. Most mentors (73%) reported that their apprentices expressed a positive attitude toward Army/DoD STEM. |

## Recommendations

1. Greater commitment should be made to producing more reliable and valid evaluation of SEAP activities and benefits to participants. The 2013 evaluation provides valuable information regarding how SEAP is perceived by less than half of participants, and begins to provide evidence for how the program has impacted SEAP apprentices. However, the low response rate from both SEAP apprentices and mentors poses the most significant threat to the validity of these findings. In other words, we have limited confidence that these findings of questionnaire respondents are representative of or can be generalized to the full population of participants. Mentors provide an authoritative, albeit subjective, assessment of apprentices' performance (STEM competencies) at the end of the program that is otherwise not possible; future evaluation will further rely on mentors to assess *growth* in apprentices' STEM competencies. Their

participation in SEAP's evaluation is vital. Coordinated efforts should be made by the Army, ASEE managers, and site coordinators to encourage and improve apprentice and mentor participation in the SEAP evaluation efforts. Subsequently, evaluators should endeavor to streamline instruments and appropriately incentivize participation in evaluation assessments to further maximize participation.

2. The number of applications for SEAP apprenticeships (814 applications for 101 funded apprenticeships) is indicative of unmet need. Of particular note, the rate of participation varied from 0% to 35% at SEAP sites having greater than 4 applicants. To the extent allowed by annual budget constraints, SEAP should endeavor to engage more Army S&E mentors, thereby creating more apprenticeship positions to populate. SEAP programming may benefit from a careful examination of and attention to program- and site-level structures, processes, and resources that both enable and discourage Army S&Es' participation in SEAP. Program- and site-level accommodations may be required to further improve Army S&Es' awareness of SEAP, feasibility of their participation, and overall motivation to participate in SEAP. Simultaneous with this effort, ASEE and SEAP sites should consider how to effectively recruit a more demographically diverse mentor pool to provide apprentices with greater access to same-demographic role models and mentors.

3. SEAP and AEOP objectives include expanding participation of historically underrepresented and underserved populations. While ASEE conducts targeted marketing of SEAP to those populations, assessment data suggests that site-level marketing, recruiting, and selection processes have greater influence in determining SEAP apprentices. SEAP may benefit from more Army and ASEE oversight and/or guidance of these site-level processes to maximize the inclusion of underrepresented and underserved students. This guidance may include any number of promising marketing and recruitment practices that should be implemented program-wide, including but not limited to maximizing the recruitment and repeated engagement of female, racial/ethnic minorities, and low- income students in GEMS programming, and subsequent recruitment of those individual GEMS alumni as SEAP apprentices. Guidance may also be provided to ensure other "connected" applicants (e.g., those with family, family friends, or school-based connections to the site) are not disproportionately advantaged over qualified but "un-vetted" candidates who may apply at the AEOP website. The Army, ASEE, and SEAP sites may need to consider practical solutions to the challenge posed by Army facility locations, as proximity alone is likely to advantage some populations more than others (e.g., students with greater proximity, or students with means for longer distance transportation or temporary relocation near the site).

4. Apprentice and mentor data suggested that SEAP apprentices have more opportunities to participate in the hands-on aspects of research and fewer opportunities to participate in the academic (minds-on) aspects of research, including technical writing. Site coordinators and mentors might explore strategies that appropriately and meaningfully expand apprentices' opportunities to engage in all aspects of the research under the tutelage of their mentor, including opportunities to generate research questions, design experiments, analyze and interpret data, formulate conclusions, and contribute to technical writing about the research in which they are engaged. Whether these strategies are mentors modeling such practices for apprentices, scaffolding "thought exercises" to be completed by apprentices, or coaching apprentices through making real contributions in these areas, such efforts will maximize apprentices' professional development as STEM apprentices, better mirror the day to day practices of scientists and engineers, and more closely align with current research and best practices identified for effective STEM learning.

5. ASEE, SEAP sites, and mentors share the responsibility for exposing apprentices to other AEOP initiatives and for encouraging continued participation in programs for which apprentices qualify. Evaluation data suggests that SEAP apprentices and mentors were largely unaware of other AEOP initiatives, especially those offered outside of the Army research facilities. Yet, substantial apprentice interest exists in AEOP programs. This interest would benefit from more robust attention by site coordinators and mentors during SEAP program activities. Continued guidance by ASEE is needed for educating SEAP site coordinators and mentors about AEOP opportunities, especially beyond the SEAP sites. Adequate resources and guidance for using them with apprentices should be provided to all site coordinators and mentors in order that all apprentices leave SEAP with an idea of their next steps in AEOP, whether at or outside of the Army site.

6. Most apprentices had opportunities to learn about STEM research and careers during SEAP, especially Army/DoD STEM research and careers to which they are exposed daily. However, many mentors reported lack of awareness of STEM careers beyond their own, lack of informational resources, and lack of time for educating apprentices about other STEM careers. We strongly recommend a SEAP- or AEOP-wide effort to create a resource that profiles Army STEM interests and the education, on-the-job training, and related research activities of Army S&Es. Such a resource could start the conversation about Army STEM careers and motivate further exploration beyond the resource itself. A repository of public web-based resources (e.g., Army and directorate STEM career webpages, online magazines, federal application guidelines) could also be disseminated to each mentor and/or apprentice to help guide their exploration of Army/DoD STEM interests, careers, and available positions.[48]

7. As reflected in the apprentice respondent profile Table 9 (and footnote 6), the evaluation assessments revealed that a number of college students were supported through SEAP apprenticeships, rather than through CQL apprenticeships that are expressly intended for college students. Support of college students in SEAP programming does not align with the intent or objectives of the program, and may impact other aspects of programming, including discrepancy in program budget versus expenditures due to different pay scales offered to high school and college students, as well as lack of consistency or coherence in the SEAP experiences of apprentices. During the summer 2013 evaluators communicated these findings to ASEE and to the Army, and the development of a standard operating procedure (SOP) has since been initiated. It will be important for ASEE and the Army to closely monitor and support SEAP sites for compliance of the SOP during FY14 programing and beyond.

[48] For example, http://www.goarmy.com/careers-and-jobs/army-civilian-careers.html,http://www.goarmy.com/careers-and-jobs/stem.html, individual directorate STEM webpages and resources such as RDECOM's Army Technology magazine, and usajobs.gov.

# Appendix K: 2013 STEM Teacher Program Initiative (STPI) Evaluation Executive Summary

The STEM Teacher Program Initiative (STPI), managed by the University of New Hampshire (UNH), is an Army Educational Outreach Program (AEOP) that supports and empowers educators with Army research and technology resources. In partnership with Harford Community College (HCC) and Army Research Laboratory at Aberdeen Proving Ground (ARL-APG), STPI provides STEM content-based professional development and experiential learning environments for STEM teachers. Additionally, STPI develops relationships between STEM teachers and active/retired Army scientists and engineers (S&Es). STPI programming is focused on the STEM Teachers Academy (STA), a one-week summer STEM course, with sessions from Army S&Es.

In 2013, STA activities engaged Harford County and Cecil County teachers ranging from middle school to high school (6th-12th grades). During STA, teachers received instruction from HCC faculty, Army S&Es, and other local STEM experts in one of three disciplinary track themes—Biology/Chemistry, Engineering, or Earth/Environmental Science. 2013 STA activities also included a lesson planning strand that attended to pedagogical strategies of teaching science through levels of inquiry and engaging students in Scientific and Engineering Practices.[49] STA developers assume that after having an opportunity to apply their new learning in a team-based lesson planning project during STA, teachers will individually apply these learnings to their everyday lesson planning and teaching in their own classroom, as well as serve as leaders in their schools through collaboration with STEM professionals and teachers, offering professional development activities for their peers related to their STA learning, and contributing to school STEM literacy efforts. University of New Hampshire provides 2.0 Continuing Education Units to STA teachers.

This report documents the evaluation of STPI's primary activity, the STEM Teachers Academy. The evaluation addressed questions related to the program's strengths and challenges, perceived benefits to participants, and its overall effectiveness in meeting AEOP and program objectives. The assessment strategy for STPI included post-program questionnaire administered to 2013 STA teachers. A 9-month follow up questionnaire will be administered to 2013 STA teachers in the March-April timeframe. For the purposes of addressing teachers use of STA learning in their classrooms, the 9-month follow up questionnaire administered to 2012 STA teachers is reported here.

| Table 1. 2013 STPI Fast Facts | |
|---|---|
| Major Participant Groups | Middle and high school STEM teachers |
| Teachers | 43 |
| Schools Served | 17 |
| Army S&Es | 6 |
| Army Research Laboratories | 2 |
| Univesity Partners | 2 |
| Total Cost | $38,375 |
| Total Awards/Stipends | $12,114 |

[49] NGSS Lead States (2013) *Next Generation Science Standards*. Washington, D.C.,: National Academies Press; National Research Council (2011) *A Framework for K-12 Science Education*. Washington, D.C.,: National Academies Press

## Summary of Findings

The FY13 evaluation of STPI collected data that provided information about STA teachers, their perceptions of program activities, benefits to teachers, and utility of STA learning and materials in their teaching context. The 9-month post-STA follow-up questionnaire for 2012 STA teachers provides additional information about teachers' actual use of STA learning in their teaching contexts. The findings summarized Table 2 are intended to highlight the overall effectiveness of STPI in meeting AEOP and program objectives and inform recommendations future programming.

| Table 2. 2013 STPI Evaluation Findings | |
|---|---|
| **Study Sample and Respondent Profiles** | |
| Teacher participation in STA evaluation yielded variable confidence in the findings. | • The statistical reliability achieved for 2013 STA teachers approach an acceptable level and suggest adequate representativeness of the population. The larger margin of error for 2012 STA teachers suggests less representativeness. The 2012 STA teacher data contributes valuable perspective to understanding the impact of STA beyond the one-week summer institute, however, any findings should be cautiously generalized with consideration given to the margin of error. |
| STA attracts teachers with varied teaching contexts. | • STA teachers serve a range of middle and high school grade levels, teach courses across the fields of science, technology, and mathematics, and include beginning/early-, mid-, and late-career teachers. |
| STA has limited success with providing outreach to teachers that serve populations historically underserved in STEM. | • All teachers (100%) reported that they do not teach in Title-I schools. Historically, Title-I schools serve more students who are historically underserved and underrepresented in STEM (e.g., low-income and racial and ethnic minority groups) as compared to non-Title-I schools. |
| **Actionable Evaluation Findings** | |
| STA teachers value opportunities to collaborate with and learn from STEM professionals and teachers; STA topics such as incorporating inquiry, science and engineering practices, hands-on, and real-life applications of STEM are important issues for STEM literacy in schools. | • Teachers listed a number of program structures, resources, and activities with which they were most satisfied. Most frequently, teachers reported satisfaction with Aquaponics, collaborative work (e.g., lesson planning) with their peers, and expert presentations. |
| | • Teachers described a range of topics, tools, and strategies that would be most adaptable to their classroom lessons. Aquaponics (40%) and iTree (20%) were the most frequently cited. |
| | • Teachers most frequently reported that STA materials supporting the incorporation of inquiry lessons, scientific and engineering practices, and hands-on activities were most suitable and important for professional development activities and for supporting STEM literacy efforts at their school. Similarly, teachers also perceived that utilizing STEM professionals to better connect classroom learning to real-life STEM applications was important. |
| | • Teachers reported that the most valuable part of the lesson planning project/presentation were the opportunities to collaborate with other teachers (and across different grade levers) and STEM professionals. |

<table>
<tr><th colspan="2">Outcomes Evaluation Findings</th></tr>
<tr><td rowspan="2">STA teachers perceived growth in their STEM literacy.</td><td>• Teachers' retrospective pre-post self-assessments suggest that teachers generally felt they gained understanding in concepts and practices, current research, and everyday issues and applications of the disciplines they studied in STA.</td></tr>
<tr><td>• Most 2012 STA teachers (92-100%) credit STA with improving their knowledge, learning, or confidence in energy and environmental literacy.</td></tr>
<tr><td>STA teachers perceived growth in their understanding and confidence to engage students in inquiry and practices through STEM lessons and teaching.</td><td>• Teachers' retrospective pre-post self-assessments suggest that teachers generally felt they gained understanding of and confidence to apply discipline-specific laboratory activities and research projects, levels of inquiry, Scientific and Engineering practices to their teaching.</td></tr>
<tr><td rowspan="2">STA teachers intended to adapt their STA learning for their classroom contexts; some 2012 STA teachers reported doing so.</td><td>• The majority of teachers (80-91%) intended to apply their learning across the broad categories targeted in STA in their everyday lesson planning and teaching: teachers intend to incorporate concepts (88%), Scientific and Engineering Practices (82%), levels of inquiry (91%), and suggested laboratory activities and research projects (82%).</td></tr>
<tr><td>• Many 2012 STA teachers applied their STA learning of energy and environmental literacy to their own teaching practice: teachers developed (energy, 84%; environmental, 85%) and implemented (environmental, 69%; energy, 84%) in the classroom.</td></tr>
<tr><td rowspan="2">STA teachers are encouraged to and have identified potential collaborations with STEM professionals; some 2012 STA teachers reported doing so.</td><td>• The majority of teachers (82%) reported that STA encouraged them to collaborate with STEM professionals. Three teachers identified possible collaborations with Harford County Government, Harford Science Society, and Senior Engineers.</td></tr>
<tr><td>• Many 2012 STA teachers (54%) felt STA encouraged them to seek collaborative opportunities with STEM professionals; four teachers described working with scientists or engineers at Battelle, Aberdeen Proving Grounds, and the local college.</td></tr>
<tr><td rowspan="3">Fewer STA teachers intended to use their STA learning as teacher leaders in their schools; some 2012 STA teachers did collaborate across subjects and grades, provide PD activities, and advance STEM literacy at their schools.</td><td>• Many teachers (53-62%) intend to collaborate with other teachers at the school in their lesson planning endeavors. However, only 34% of teachers intend to share their learning with other teachers by providing professional development (PD) based on their experiences in STA.</td></tr>
<tr><td>• While many teachers reported that STA provided them with materials to motivate STEM literacy (70%), fewer intend to analyze (35%) and/or lead (35%) STEM literacy efforts at their school.</td></tr>
<tr><td>• Fewer 2012 STA teachers engaged other teachers in collaborative lesson planning (23-38%). Only 16% (2 teachers) reported planning and providing professional development activities to others.</td></tr>
<tr><td rowspan="2">STA teachers' awareness of AEOP opportunities varies; most teachers intend to encourage their students to participate in AEOP, but do not intend to incorporate them into lessons or extracurricular programs.</td><td>• Most STA teachers (59-84%, avg. 68%) reported receiving information about other AEOP initiatives during STA, but a significant proportion report having never heard of the individual AEOP programs.</td></tr>
<tr><td>• Only 3-7% of STA teachers intended to incorporate AEOP programming and resources into either their class lessons or their extracurricular activities, though a majority of teachers expressed their intent to encourage student participation.</td></tr>
</table>

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| 2012 STA teachers did not consistently recognize or promote AEOP opportunities to their students in their schools. | • Most 2012 STA teachers did not encourage their school students to pursue AEOP opportunities. Of the teachers that did encourage student participation, 50% recommended GEMS, 25% recommended eCYBERMISSION, up to 18% recommended one of the high school apprenticeship programs, and 8% recommended JSHS. More notable is that many FY12 teachers claim to be unaware of individual AEOP programs after STA (25%-83%, avg. 56%). |

## Recommendations

1. STPI's programming (the STEM Teachers Academy, STA) reaches communities in and around Harford Community College (Bel Air, MD). There is, however, an apparent dearth of Title 1 secondary schools in those communities. A teachers-in-residence program model should be considered in an effort to provide outreach to teachers (and ultimately impact underserved students) from Title 1 or other schools serving high proportions of underserved populations that are not within daily commuting distance from Harford Community College.

2. STPI supports the critical role that teachers assume in the mentoring STEM talent in-school. As such, it is poised to expand the AEOP mission of outreach to the classrooms and schools of participating teachers. STA content offerings focus on engaging teachers in current research and everyday applications of the field. As the STPI expands its reach to teachers outside of MD, it should endeavor to align these experiences with the realities of the classrooms, most notably, the dimensions of learning envisioned in the *Next Generation Science Standards (NGSS)*. The call for shared standards is evident in AEOP's Priority 2 objectives, and advances federal policy recommendations calling for widespread support of the NGSS standards movement by K-12 agencies, and by academic, non-profit, business and other sectors providing outreach to K-12 students and teachers (PCAST 2010). Such alignment would provide inspiring opportunities for students to learn about recent STEM advancement, and would attend to federal recommendations and those offered by teachers (e.g., recommendations for more careful attention to relevance of content to their teaching contexts, in terms of the scope of the subject matter selected and support in translation for grade level appropriateness.)

3. To provide the greatest return on an investment that aims to enhance K-12 teaching and learning through professional development, STPI programming should include an expectation of and a mechanism for supporting teachers' transfer of new STA learning to their classrooms and schools. In order to accomplish this goal, STA activities must ensure that
    - STEM content is relevant to participants' classroom and school contexts;
    - Teachers are provided with sufficient guidance—through content experts and through collaboration with teacher participants—for translating adult level STA learning to grade-level ideas and activities that align with standards teachers are held accountable to teaching;
    - Teachers are provided with scaffolds to support transfer of STA learning to the classroom—exemplary models of planning and instruction that intertwines the important dimensions of science and engineering they studied in STA with grade-appropriate expectations;
    - Academic year follow up that supports teachers in applying their STA learning to their classroom teaching and contributing to organizational change in their schools. Academic year activities might include collaborative lesson planning, collaborative study of student outcomes from enacted lessons, and opportunities to develop professional development or other activities to advance STEM literacy beyond teachers' own classrooms.

4. Thus far, STPI's efforts have only endeavored to inform teachers, and through them, students of AEOP offerings. STPI is well positioned to address the Army's objectives of integration of AEOP elements and resources in classrooms. The

Army might consider a shift in STPI programming that focus STA activities on helping teachers understand the potential contributions of AEOP programs to their teaching contexts, and supporting the integration of AEOP elements and resources in classrooms and schools. Such a shift would potentially advance the AEOP objectives of shared standards for STEM, the integration of AEOP elements and resources with classroom curriculum, and attract more teachers and students to other AEOP programs. The following vignette provides an illustration for such a model:

*STA exists as a resident program during the summer institute, and leverages regional and/or national science teacher association meetings as opportunities for academic year activities with teachers. STPI markets STA programming to teachers and schools that serve underserved populations, nationwide or regionally. STPI ultimately serves students of those populations in their school-based learning through engagement with AEOP elements and resources. These experiences generate further interest and engagement in AEOP programs beyond the classroom.*

*STA teachers learn about a NGSS-aligned AEOP element and its resources during the summer institute, and, through academic year activities, are supported in incorporating that AEOP element or its resources into their classroom STEM lessons or extracurricular activities, and collaboratively studying the results of those efforts. For example, in the Junior Solar Sprint (JSS)-related track, teachers would participate in*

1. *A Summer Institute during which teachers are provided with*
    - *Opportunities to work with and learn from Army STEM professionals engage teachers in learning about foundational principles and cutting edge Army research around solar energy, electrical and mechanical engineering, and the engineering design process;*
    - *Opportunities to work with and learn from AEOP educators (who have successfully incorporated JSS into their classroom and extracurricular activities) engage teachers in exploring the JSS curricular materials as learners, relating NGSS dimensions to those curricular materials (e.g., either identifying and/or adapting lessons for improved alignment to NGSS), learning about common student ideas related to the curricular materials, and identifying challenges of and possible solutions for implementing curricular materials in teachers' own contexts;*
    - *Opportunities to work with other STA teachers to initiate their capstone project, consisting of plans for implementing the AEOP element, including necessary adaptations of lessons to align with district curricula, supplies and materials needed (costs and source of funding), dates of proposed implementation, and how the implementation will be assessed.*
2. *Academic year sessions which would include*
    - *Opportunities to work with other STA teachers to finalize preparations for their enactment of the AEOP element or resource; and*
    - *Opportunities to collaboratively study their enactments of the AEOP resource or element through video clips of their classroom teaching and student work artifacts produced by the assessment proposed in their capstone.*
    - *Opportunities to volunteer for and/or participate with students in regional or national JSS events.*

5. The current evaluation of STPI primarily relies on teacher self-assessments of teacher outcomes (e.g., learning from STA, and intended and actual use of that learning in the classroom and school.) Currently, no objective measures of teacher and student outcomes are employed or measures that triangulate teacher reports with those of others in their schools; without such measures, the evaluation cannot make conclusive claims about the extent to which STA activities have effected teacher learning or practice, or, in turn, student learning. UNH and Army should consider how to establish

and employ objective measures of teacher performance that align with AEOP and program priorities. Guskey[50] provides a hierarchical framework for the evaluation of teacher professional development, which includes assessing: 1) teacher reactions, 2) teacher learning, 3) organization support and change, 4) teacher use of new knowledge and skills, and 5) student learning outcomes. Also embedded in framework is a hierarchy of measures ranging from subjective self-report assessments to objective measures. STPI might consider, at a minimum, establishing objective measures of teacher learning (e.g., pre-post test of content or pedagogical content knowledge) associated with the STA content, resources, and activities. Ideally, the evaluation would also include teacher use (e.g., video/direct observation, or submission of lesson plans), and student outcomes (e.g., learning and affective outcomes aligned with AEOP and Army STEM objectives), especially if programming shifts to incorporate academic year follow-up that focuses on the implementation and study of classroom based interventions.

[50] Guskey, T. (1999) *Evaluating Professional Development*. Thousand Oaks, CA: Corwin Press.

# Appendix L: 2013 UNITE Evaluation Executive Summary

UNITE, managed by the Technology Student Association (TSA), is an Army Educational Outreach Program (AEOP) pre-collegiate initiative for talented high school students from historically underserved and underrepresented groups in science, technology, engineering, and mathematics (STEM). UNITE encourages and helps prepare high school students to pursue a college education and career in engineering. In a four- to six-week summer program, hosted at nine competitively selected university sites throughout the country, UNITE provides academic and social support to participants so that they have the ability and confidence to become successful engineers.

This report documents the evaluation of the FY13 UNITE program. The evaluation addressed questions related to program strengths and challenges, benefits to participants, and overall effectiveness in meeting AEOP and program objectives. The assessment strategy for UNITE included pre- and post-UNITE questionnaires for students and on-site focus groups with students and mentors at three sites. In addition, TSA collected a final report from each UNITE site, which were provided to evaluators as an additional source of data.

UNITE sites included Alabama State University (ASU), City College of New York (CCNY), Jackson State University (JSU), Miami Dade College (MDC), Michigan Technological University (MTU), New Jersey Institute of Technology (NJIT), South Dakota School of Mines and Technology (SDSMT), Texas Southern University (TSU), and University of Colorado-Colorado Springs (UCCS).

| Table 1. 2013 UNITE Fast Facts | |
|---|---|
| Major Participant Group | Current and rising high school students |
| Participating Students | 188 |
| Participating K-12 Teachers | 32 |
| Represented K-12 Schools | Not available |
| Participating Universities | 9 |
| Participating Army Agencies | 7+ |
| Participating Army S&Es | 8+ |
| Total Cost | $300,954 |
| Total Stipends | $82,900 |
| Cost Per Student Participant | $1601 |

## Summary of Findings

The FY13 evaluation of UNITE collected data about participants, their perceptions of program processes, resources, and activities, and indicators of achievement related to AEOP's and UNITE's objectives and intended outcomes. A summary of findings is provided in Table 2.

| Table 2. 2013 UNITE Evaluation Findings | |
|---|---|
| **Participant Profiles** | |
| UNITE student participation in evaluation yields high level of confidence in the findings. | • The statistical reliability achieved for the pre- and post-UNITE student questionnaires, as well as the pre- to post-UNITE matched cases, allow us to sufficiently generalize findings of the evaluation sample to the population. Additional evaluation data contribute to the overall narrative of UNITE's efforts and impact, and highlight areas for future exploration in programming and evaluation, though findings from these data are not intended to be generalized to all UNITE sites and participants. |
| UNITE serves students of historically underrepresented and underserved populations. | • UNITE was successful in attracting participation from female students—a population that is historically underrepresented in engineering fields. Student questionnaire respondents included more females (61%) than males (37%). |
| | • UNITE had success in providing outreach to students from historically underserved minority race/ethnicity and low-income groups. Student questionnaire respondents included minority students identifying as Black or African American (47%), American Indian or Alaskan Native (19%), and Hispanic or Latino (15%). Respondents most frequently reported qualifying for free or reduced lunch (47%). |
| | • UNITE served students across a range of school contexts. Most student questionnaire respondents attended public schools (85%) and schools in urban (36%) and rural (28%) settings, which tend to have higher numbers or proportions of underserved groups. |
| UNITE engages a diverse group of adult participants as STEM mentors. | • In total, 167 adults, including university faculty (39), high school and university students (84), local teachers (32), and industry STEM professionals (2), served as program mentors. Additional STEM professionals from a range of business sectors participated in career day activities. |
| | • At two of the sites visited by evaluators, students had access to mentors belonging to the same gender (female) and/or race/ethnicity group. In program reports, additional UNITE sites described efforts to achieve gender and race/ethnicity group diversity among program and career day mentors. |
| **Actionable Program Evaluation** | |
| UNITE is strongly marketed to schools and teachers serving historically underserved groups. | • Many UNITE sites employed multi-pronged efforts to market programs to and recruit students from schools and school networks identified as serving large populations of traditionally underserved students. Most frequently, UNITE sites sent a combination of email communications, printed promotional materials, and application packages to target schools, as well as participated in a variety of at-school events directed to students, parents, and STEM teachers. |
| | • Students most frequently learned about the local UNITE program from parents and family members (more than 28%) and from teachers and guidance counselors at school (more than 22%). UNITE generally found students, rather than students finding UNITE. |
| UNITE students are motivated by opportunities to clarify and advance their STEM pathways. | • Students were most frequently motivated to participate in UNITE to clarify and advance their STEM pathways, including: to expand understanding of a STEM field or a potential career, to develop STEM skills or gain experience with processes and tools of a STEM field, to clarify future STEM education or career goals, and to prepare for college. |

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| UNITE mentors engage students in meaningful STEM learning, through team-based and hands-on activities. | • Mentors used a variety of mentor and/or instructional activities for productively engaging students in STEM learning. |
| | • Most students (61-87%) had opportunities to engage in collaborative or team-based activities at least 2-3 times per week. Differences in students' perceptions of these opportunities were detectable across the sites and plausibly relate to differences in key mentor and/or instructional activities identified from program reports. |
| | • Students contrasted "theoretical" and textbook-focused school STEM learning with opportunities to learn by "touching," "seeing," or "applying" STEM to real world contexts in UNITE. Students suggested that hands-on activities during UNITE provided positive experiences to learn about working on teams. |
| UNITE promotes Army STEM careers but can improve marketing of other AEOP opportunities. | • Most mentors had no awareness of or past participation in an AEOP initiative beyond UNITE or the AEOP's Research and Engineering Apprenticeship Program on their campus. Subsequently, students reported limited exposure and encouragement to pursue AEOP opportunities by mentors. |
| | • UNITE sites offered a variety of activities for promoting STEM careers, including interactive expert panels, off- and on-campus STEM expos, and field trips to Army, university, and other research labs and facilities. Six of the nine UNITE sites engaged Army engineers and/or Army research facilities in career day events. |
| | • Mentors described efforts to educate students about STEM majors, STEM programs, and funding sources for their educational pursuits, but suggested that more resources are necessary to allow them to comfortably educate students about STEM careers and Army/DoD STEM careers, in particular. |
| UNITE benefits participants over typical school STEM offerings. | • Students and mentors perceived that UNITE benefits students by clarifying and advancing their STEM pathways and providing learning opportunities (e.g., environments, resources, and activities) not available typical school settings. Mentors also perceived benefit to themselves and to students' communities. |
| | • Students offered a range of recommendations for improvement, focused on mentorship and instructional activities, differentiating learning to better accommodate students' readiness, and expanding opportunities for students to engage with STEM professionals. |
| **Outcomes Evaluation** | |
| UNITE's limited effect on students' already high confidence in STEM competencies appears specific to site program activities. | • Students entered and left UNITE with high levels of confidence in their skills and abilities, with limited evidence of significant growth across the UNITE program. Significant growth was evident for each of six different confidence items for at no more than one or two sites: ability to apply engineering principles to solve real world problems (ASU and CCNY); identifying, formulating, and solving engineering problems (across program, CCNY); sketching/drafting skills (across program, ASU); computer programming skills (ASU and CCNY); social abilities (program, TSU); and abilities to work on teams (CCNY). Most often, this change appeared to relate to a major feature of sites' specific program activities that targets that particular skill or ability. |
| UNITE generally maintains students' positive attitudes toward engineering. After UNITE some students perceive | • Students started UNITE with positive attitudes toward engineering and, while some students' exhibited growth and others decline on certain items, generally students' motivation, perceptions of importance, and engagement were maintained across the UNITE program. Students at JSU showed moderately large to very large |

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| less importance in their mathematics and science abilities. | significant growth in motivations to pursue engineering and in perceived importance of working on teams. Some students showed moderately large to very large decline in their perceptions of the importance of mathematics abilities (NJIT), science abilities (MTU, NJIT, and SDSMT), and applying science and mathematics to solving real work problems (across program, SDSMT). |
| UNITE exposes students to engineering pathways but students' aspirations for future pursuit of STEM education and careers show limited change. | • UNITE exposed students to engineering pathways, with significant improvement in some students' knowledge of engineering students (JSU and MTU), professionals (across program, JSU and TSU), majors (across program, CCNY), and professional societies (across program, ASU) and intent to join a professional engineering society (ASU and JSU) and work in engineering (ASU and MTU). |
| | • Students began and ended UNITE with relatively high educational goals and confidence to achieve those goals. High percentages of UNITE students intend to pursue and achieve STEM-related degrees, and their intentions were sustained throughout the UNITE program (64.8% pre, 68.4% post). Students entered UNITE with an idea of the field that they intend to pursue, and UNITE served to sustain existing interests rather than inspiring interest in new fields about which they have learned. Most frequently, students had interest in engineering (33.6% pre, 34.4% post) and medicine (29.5% pre, 25.4% post). |
| UNITE students are largely unaware of AEOP initiatives, but students show substantial interest in future AEOP opportunities. | • Student and mentors were largely unaware of other AEOP initiatives. Yet, substantial student interest exists in AEOP opportunities. 39-42% of students were interested in competition programs, 74-79% of students were interested in high school and college apprenticeship programs. In particular, 83% of students would pursue a REAP apprenticeship at the UNITE host site. |
| UNITE increases students' intent to pursue Army STEM careers. | • Most students learned about multiple STEM jobs during UNITE (94% learn about 3 or more jobs), but Army STEM careers received less attention (59% learn about 3 or more jobs). Despite this, students' interest and intent to pursue Army STEM careers showed large, significant growth through participation in UNITE (program, ASU, CCNY, JSU, MTU, and TSU), while more limited change (across program, ASU and, CCNY) were evident in students' intent to pursue STEM jobs and careers generally. |

## Recommendations

1. Mentors play important roles in UNITE. Mentors design and facilitate learning activities, deliver content through instruction, supervise and support collaboration and teamwork, provide one-on-one support to students, chaperone students, advise students on educational and career paths, and generally serve as STEM role models for UNITE students. The FY13 mentor focus groups served as a baseline effort to collect information from this participant group, but a more systemic assessment of mentors is required to evaluate their engagement as STEM-Savvy Educators in AEOP programs. Any future survey of mentors should at a minimum gather information how mentors become aware of UNITE, motivating factors for participation in UNITE, satisfaction with and suggestions for improving UNITE programs, perceived benefits to participants, and mentor activities, including those relating to exposing students to AEOP opportunities and Army STEM careers.

2. As a whole, students began and ended UNITE with high levels of confidence in their STEM competencies, positive attitudes about STEM, and ambitious education and career aspirations, with limited evidence of growth across the UNITE program. Lack of significant growth, and even observations of decline, should not be regarded as UNITE having no or negative effect on students. Sustaining students' high levels of confidence, positive attitudes, and ambitious aspirations during rigorous programs should be considered a success of UNITE. Particular to students' confidence around STEM competencies, these observations could suggest that students become less confident (though arguably more competent) during UNITE as they are challenged to use their STEM skills and abilities in ways that go beyond what is typically expected of them in school activities. In other words, perhaps through their UNITE experience students realize the limitations of their skills and abilities, that they have much to learn, and for that reason become less confident. Employing a retrospective pre-post evaluation design in subsequent evaluations may help to determine if this is the case, by allowing students to reflect on pre- and post-UNITE status with the same internal standard. In addition, site-based efforts to employ objective measures of learning would provide even clearer understanding of site programs' effects on students' STEM competencies.

3. Students at several UNITE sites showed moderately large to very large decline in their perceptions of the importance of mathematics and science principles and their application to solving problems. UNITE sites should consider the extent to which students are learning and applying science and mathematics principles in service of to their engineering-focused learning in an effort to further explore these findings. If opportunities to learn and apply scientific and mathematics principles and skills are relatively disconnected from the engineering-focused learning, we might expect such declines in perceptions of importance of mathematics and science. In this case, helping students see the underlying necessity and contributions of scientific and mathematic principles in engineering disciplines and in the engineering design process would be an area of potential improvement for programs. For example, the mathematics portion of NJIT's curriculum appears to focus more on reinforcing and extending ability to do school math—learning concepts, solving problems, and test preparation—rather than connecting math to the site's biomedical engineering focus or to other real world problems. NJIT might consider how key concepts learned in the math course could be applied to solving problems in the biomedical engineering

course, or at a minimum, highlighted in vignettes of STEM professionals who have used these or similar mathematical concepts to solve engineering problems.

4. Mentor and student interviewees across the focus group samples reported limited or no awareness of any given AEOP initiative, except for the pipeline initiative, Research in Engineering Apprenticeship Program (REAP), being piloted at the UNITE sites. Mentor interviewees reported spending little or no time educating students about AEOP initiatives for which students qualify during daily program activities, aside from distributing AEOP brochures. Student interviewees received AEOP promotional materials, such as the AEOP brochure or the Rite in the Rain notebooks, but generally could not name, or recognize when named, AEOP initiatives. Yet, from what little students know about AEOP initiatives substantial student interest exists in AEOP opportunities when broadly described. This interest, especially from students of underserved populations, would benefit from more robust attention by program coordinators and mentors during UNITE program activities. Continued guidance by TSA is needed for educating UNITE site coordinators and staff to AEOP opportunities, including the possible provision of TSA-led information sessions.

5. Most UNITE sites were successful in exposing students to Army STEM careers through career day activities in meaningful ways that generated significant interest in Army STEM jobs and careers. Creative solutions and continued collaboration among TSA, Army Cooperative Agreement Managers, and UNITE sites may be necessary for providing and expanding engagement of Army STEM professionals and research facilities at each UNITE site. UNITE sites that are unable to benefit from proximity of Army research facilities might consider other alternatives that would provide for direct interactions between students and Army STEM professionals, such as videoconferencing and/or virtual tours of research facilities. Furthermore, deliberate connections of UNITE sites' curricula to related Army STEM research and careers may provide alternative or additional exposure; these connections could be made by Army STEM professionals or by UNITE mentors. Some GEMS sites have formalized efforts to educate students about Army/DoD STEM careers through their curricular materials, which make explicit connections between subject matter or skills being learned in GEMS and the Army/DoD STEM jobs or careers that apply those subject matter or skills. GEMS mentors, many of whom are university students and local teachers, reported that these curricular materials are helpful in their work to expose students to Army/DoD STEM careers, especially given the mentors' own limited awareness of Army/DoD STEM careers. UNITE programs may benefit from similar efforts to connect UNITE curricula with Army/DoD STEM careers.

# Appendix M: 2013 Undergraduate Research Apprenticeship Program (URAP) Evaluation Executive Summary

The Undergraduate Research Apprenticeship Program (URAP), managed by the U.S. Army Research Office (ARO), is an Army Educational Outreach Program (AEOP) commuter program for undergraduate students who demonstrate an interest in science, technology, engineering, or mathematics (STEM) to work as an apprentice in an Army-funded university or college research laboratory. URAP is designed so that students (herein called apprentices) can apprentice in fields of their choice with experienced Army-funded scientists and engineers (S&Es, herein called mentors) full-time during the summer or part-time during the school year.

Students receive an educational stipend equivalent to $10 per hour, and are allowed to work up to 300 hours total. The students contribute to the research of the laboratory while learning research techniques in the process. This "hands-on" experience gives students a broader view of their fields of interest and shows students what kind of work awaits them in their future career. At the end of the program, the students prepare final reports for submission to the US Army Research Office Youth Science programs office.

In 2013, URAP provided outreach to 47 apprentices and their mentors at 29 Army-sponsored university or college laboratory sites (herein called URAP sites).

This report documents the evaluation of the 2013 URAP program. The evaluation addressed questions related to program strengths and challenges, benefits to participants, and overall effectiveness in meeting AEOP and program objectives. The assessment strategy for URAP included: in-person focus groups with apprentices and mentors at 3 URAP sites, individual phone interviews with apprentices and mentors from 10 additional URAP sites, and online post-program questionnaires distributed to all apprentices and mentors.

| Table 1. 2013 URAP Fast Facts | |
|---|---|
| Major Participant Group | College Students |
| Participating Students | 47 |
| Participating University Personnel | 32[51] (18 Faculty, 14 Graduate Mentoring Fellows) |
| Participating Universities | 29 |
| Total Cost | $209,887 |
| Total Stipends | $163,647 |
| Cost Per Student Participant | $3,440[52] |

[51] This number reflects university faculty members serving as the primary mentor and Graduate Mentoring Fellows that may have assisted with mentoring the URAP apprentices.
[52] GMFs were included in the calculation of Cost Per Student Participant.

## Summary of Findings

The 2013 evaluation of URAP 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 2.

| Table 2. 2013 URAP Evaluation Findings | |
|---|---|
| **Participant Profiles** | |
| All evaluation data contribute to the overall narrative of URAP's efforts and impact, and highlight areas for future exploration in programming and evaluation. However, confidence in evaluation findings varies by participant group. | • Statistical reliability calculated for the apprentice questionnaire (margin of error = ±8.0% at 95% confidence level) and alternative methods for establishing representativeness (statistical comparison of apprentice respondents' and participants' demographic information revealed no significant differences) suggest findings from the apprentice questionnaire may be sufficiently generalizable to the apprentice population. |
| | • Statistical reliability calculated for the mentor questionnaire (margin of error = ±14.5% at 95% confidence level) and lack of available demographic information with which to make alternative determinations suggest mentor respondents may not be representative of the mentor population. Mentors contribute valuable perspective to URAP evaluation and any findings from mentor questionnaires should be cautiously generalized with consideration given to the margin of error and with triangulation of findings with other data. |
| URAP had difficulty providing outreach to participants from historically underrepresented and underserved populations. | • Apprentice participants included a small proportion of female students (14%)—a population that is historically underrepresented in some STEM fields. |
| | • 11% of apprentices identified as populations among those historically considered underserved and underrepresented in STEM education; Black or African American (3%), Hispanic or Latino (8%), and American Indian or Alaskan Native (0%). |
| | • Mentors identified as predominantly male (73%), White or Caucasian (50%), or Asian or Other Pacific Islander 38%). Of the 26 mentor respondents, 0% identified as Black or African American, 0% as American Indian or Alaskan Native, and 4% as Hispanic or Latino. |
| URAP serves the Nation's future STEM workforce. | • Most URAP apprentices (94%) planned to pursue a degree in a STEM field (14% Bachelors, 29% Master's, 57% Doctorate). |
| | • Most URAP apprentices intended to pursue STEM careers. Most frequently, apprentices reported currently working on an engineering degree (39%) and having similar intentions to pursue an engineering career (43%). Physical science was the second most frequently listed career field (17%). Apprentices also intended to pursue careers in math or computer science (14%), medicine or health (11%), environmental science (3%), chemistry (3%), social science (3%), or another STEM field (3%). |
| **Actionable Program Evaluation** | |
| Marketing and recruitment of URAP apprentices and mentors depends almost entirely on the universities or colleges that host URAP | • ARO successfully marketed and recruited URAP mentors from university or college laboratories that conduct Army-sponsored research. Subsequently, university or college researchers marketed and recruited URAP apprentices using university or college channels. |
| | • Apprentices learned about URAP through university personnel, advertisements, classes, or other acquaintances associated with URAP site. Many apprentices had previous associations with their mentor prior to working as a URAP apprentice. Only 10% of URAP apprentices found out about the program through their own searches. |

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|---|---|
| | • Most mentors reported recruiting apprentices within the university or college context. Some mentors had a previous association with the apprentice prior to URAP through a course or previous research. |
| | • Although many apprentices and mentors had previous associations prior to URAP, most mentors selected apprentices from the AEOP applicant pool. This pattern of responses suggests that apprentices are first recruited within universities and colleges and subsequently directed to the AEOP application as a formality. |
| URAP apprentices desired opportunities to engage in authentic research experiences and advance their STEM pathways. | • Apprentices were motivated to participate in URAP because the program offered opportunities to experience research in a lab setting and to advance their STEM pathways: experiencing research first hand, developing academically, building applications or resumes, and gaining new knowledge in their desired field of study. |
| URAP mentors sought an opportunity to outreach to STEM learners or develop professionally. | • Most mentors participated in URAP to satisfy their desire to mentor students and/or perform community service that benefitted youth. Less often, mentors mentioned that URAP offered them the opportunity to develop their mentorship or supervisory skills and abilities. A few mentors used URAP to expand their research laboratories with extra funding for undergraduate apprenticeships. |
| URAP mentors used team-based and one-on-one approaches to engage apprentices in STEM research activities but supported their educational and career pathways to a lesser extent. | • Apprentice and mentor questionnaire respondents reported similar frequencies of mentor activities related to engaging apprentices in hands-on STEM research and academic and career advising. Apprentices and mentors also generally agreed that mentorship focused more on productively engaging in STEM research and less on educational and career pathways. |
| | • Approximately the same proportions of mentors used team-based approaches as used one-on-one approaches to engage apprentices in STEM research activities. Data also suggests that mentors focus more on engaging and training apprentices about STEM research than on supporting educational and career pathways. |
| URAP mentors lacked awareness of or directives to promote AEOP opportunities and STEM careers during the program. | • Most mentor interviewees had limited awareness of AEOP initiatives and did not receive or perceive any direction from ARO to educate apprentices about AEOP. Subsequently, mentors did not consistently educate their apprentices about AEOP programs or encourage apprentices to participate in them. |
| | • Mentors suggested that informational resources provided to mentors or apprentices, mentor training, and clear expectations for promoting other AEOP programs were necessary to accomplish this objective. |
| | • Mentors reported using a variety of strategies for mentoring apprentices about STEM careers, some with an implied emphasis on Army/DoD STEM careers. In other words, most mentors believe that the experience itself educated apprentices about STEM research and working within Army-funded laboratories. |
| | • Mentors cited a lack of necessary knowledge about Army/DoD STEM careers and that the duration of the program was too short to facilitate career mentorship. Suggestions for improving included the provision of information resources for distribution to apprentices and facilitation of visits or tours to Army/DoD research laboratories. |
| URAP benefited apprentices as well as | • Apprentices and mentors perceived that URAP benefits apprentices by providing authentic research opportunities not typically available in school settings, opportunities to expand their STEM competencies and confidence, opportunities to advance their STEM pathway, and access to effective mentorship in a civilian Army research setting. |

| | |
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| Army S&E mentors and their laboratories. | • Mentors also perceived benefits to their own professional development, an opportunity to engage in community service, and an opportunity to expand the impact of their research laboratory through funded apprenticeships. |
| URAP funding is not transparent and the 8-week duration presents challenges to apprentices and mentors. | • Some mentors had a difficult time tracking funding coming from ARO to their university and felt that funding is not sufficient for the time commitment involved for apprentices and mentors. |
| | • Mentors suggested that URAP's 8-week duration is too short, making it difficult to meet apprentice expectations while trying to complete research project in a compressed time period. |
| **Outcomes Evaluation** | |
| URAP engaged apprentices in authentic STEM activities more frequently than their undergraduate courses. | • Apprentices reported that URAP provided more frequent opportunities to engage in authentic STEM activities as compared to their undergraduate courses, including academic research activities (24%-68% in URAP, 12%-39% in classes) and hands-on research activities (32%-63% in URAP, 9%-32% it classes). Small to large, significant differences were found between in-URAP and in-school engagement for 9 of 12 STEM activities. |
| | • Apprentice and mentor data suggested URAP had a slightly larger effect with respect to providing apprentices opportunities for hands-on research activities than it had providing opportunities for academic (minds-on) research activities. |
| URAP apprentices became more confident in STEM, and mentors rated their research and reporting skills highly. | • A majority of apprentices (63%-80%) perceived growth in their confidence across 7 key STEM skills and abilities: performing literature reviews, formulating hypotheses and designing experiments, using laboratory safely, using laboratory equipment and techniques, analyzing data, generating conclusions, and contributing to a research team. |
| | • Many mentors (66%-79%) rated their apprentices at near expert or expert levels of the development continuum across 6 key STEM skills and abilities: information literacy, scientific reasoning, laboratory, data collection, quantitative literacy, and teamwork and collaboration. Most mentors (77-90%) also rated all 6 components of their apprentices' final research project or presentation as near expert or expert level. |
| URAP apprentices believe that serving as STEM mentor is an implicit part of STEM careers. | • Apprentice interviewees were interested in mentoring students in the future because it is an important part of the career of a STEM researcher. Others cited positive impacts that mentors have played in their STEM pursuits which motivates them to pursue opportunities to mentor other students in the future. |
| URAP apprentices were unaware of the many AEOP initiatives, but showed interest in future AEOP opportunities. | • Many apprentices (58-97%) and mentors (48-64%) were unaware of other AEOP initiatives. |
| | • URAP apprentices are interested in participating in other AEOP opportunities: college apprenticeships (21%), college scholarship programs (21%), and graduate fellowships (27%) offered by AEOP or DoD. This interest could be leveraged for targeted cross-promotion of programs and repeated engagement of apprentices in the AEOP pipeline. |
| URAP improved and sustained apprentices' positive attitudes toward the defense community but does not systematically impact their interest or intent to | • Apprentices and mentors disagree about the extent to which apprentices were given opportunities to learn about new STEM careers (apprentice=24%, mentor=46%) and Army/DoD STEM careers (apprentice=21%, mentor=31%). |
| | • URAP had limited success inspiring interest in new STEM careers (15%) or in Army/DoD STEM careers (24%). Data suggest that URAP apprentices enter URAP with well-established career intentions that do not change over the course of the program. However, 74% of apprentices would consider a civilian position in STEM with the Army/DoD because of their valuable contributions to society, suggesting that URAP sustained any existing interest in Army/DoD civilian careers. |

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| pursue STEM or Army/DoD STEM careers. | • Most apprentices (66%) credited URAP with improving their understanding Army/DoD STEM contributions. Most mentors (69%) reported that their apprentices expressed a positive attitude toward Army/DoD STEM. |

## Recommendations

1. Coordinated efforts should be made by the Army, ARO, and selected URAP PIs to encourage and improve apprentice and mentor participation in evaluation efforts. Low response rates to evaluation assessments, especially for programs that reach small populations, pose the most significant threat to the validity of findings from those assessments. Furthermore, low response rates prevent reliable comparisons of data year to year. While evaluators can assess representativeness of samples through alternative means, accurate demographic data must be available for the population in order to accomplish these determinations. With respect to the outcomes evaluation, mentors' assessment of apprentice performance are important for triangulating apprentices' perceptions of growing confidence in their STEM competencies. Future evaluation will continue to rely on mentors to provide an authoritative, albeit subjective, assessment of apprentices' performance and *growth* in apprentices' STEM competencies. Mentor-reported awareness of and efforts to promote AEOP and Army STEM are important for understanding related apprentice outcomes and identifying site-level programming needs (e.g., resources and/or training for mentors). Evaluators will endeavor to streamline instruments and appropriately incentivize participation in evaluation assessments; however, evaluators necessarily rely on assistance from Army, ARO, and selected URAP PIs to promote a culture of evaluation among URAP apprentices and mentors.

2. AEOP objectives include expanding participation of historically underrepresented and underserved populations. In URAP, recruitment of apprentices is largely a bottom-up phenomenon that occurs at the site-level using connections or mechanisms available to the university or college site. As a result, the ability of URAP to recruit underserved or underrepresented populations of students depends upon the diversity of the universities or colleges in which recruitment takes place. Indications are that many URAP apprentices are informally selected by mentors and subsequently sent to the AEOP application site as a mere formality. Guidance ensuring that "connected" applicants (e.g., those with family, family friends, or school-based connections to the site) are not disproportionately advantaged over qualified but "un-vetted" candidates who apply through the AEOP website is likely to help in recruitment efforts. Additionally, the Army and ARO may need to consider practical solutions to the challenge posed by URAP locations, as the student population of some universities and colleges is likely to advantage some groups of students more than others.

3. Apprentice and mentor data suggested that URAP apprentices have more opportunities to participate in the hands-on aspects of research and fewer opportunities to participate in the academic (minds-on) aspects of research. At the undergraduate level, students are more capable of and should have frequent opportunities to make conceptual contributions to their research: generate research questions, design experiments, analyze and interpret data, formulate conclusions, and contribute to technical writing about the research in which they are engaged. ARO should encourage mentors to use strategies that productively engage apprentices in these critical aspects of work, ensuring that

apprentices are more than simply laboratory assistants. Whether these strategies include mentors modeling such practices for apprentices, scaffolding "thought exercises" to be completed by apprentices, or coaching apprentices through making real contributions in these areas, such efforts will maximize apprentices' professional development as STEM apprentices, better mirror the day to day practices of scientists and engineers, and more closely align with current research and best practices identified for effective STEM learning.

4. ARO and mentors share the responsibility for exposing apprentices to other AEOP initiatives and for encouraging continued participation (even as a mentor or volunteer) in programs which are available. Evaluation data suggests that URAP apprentices and mentors were largely unaware of other AEOP initiatives and that URAP served as an entry point into the AEOP for students who have not yet been exposed the Army STEM outreach. Yet, substantial apprentice interest exists in participating in AEOP moving forward. This interest would benefit from more robust attention by ARO and mentors during URAP program activities. Continued guidance by ARO is needed for educating mentors about AEOP opportunities nationwide. Adequate resources and guidance for using them with apprentices should be provided to all mentors in order that all apprentices leave URAP with an idea of their next steps in AEOP and/or the capability to serve as an AEOP ambassador.

5. Depending upon the university or college site and/or mentor for which they worked, apprentices had varying opportunities to learn about STEM research and careers during URAP, especially Army/DoD STEM research and careers. Many mentors reported lack of awareness of Army/DoD STEM careers generally, lack of informational resources, and lack of direction to provide such information to their apprentices. In an effort to standardize the information provided to apprentices we strongly recommend a URAP- or AEOP-wide effort to create a resource that profiles Army STEM interests and the education, on-the-job training, and related research activities of Army S&Es. Such a resource could start the conversation about Army STEM careers and motivate further exploration beyond the resource itself. A repository of public, web-based, resources (e.g., Army and directorate STEM career webpages, online magazines, federal application guidelines) could also be disseminated to each mentor and/or apprentice to help guide their exploration of Army/DoD STEM interests, careers, and available positions.[53]

[53] For example, http://www.goarmy.com/careers-and-jobs/army-civilian-careers.html,http://www.goarmy.com/careers-and-jobs/stem.html, individual directorate STEM webpages and resources such as RDECOM's Army Technology magazine, and usajobs.gov.