stelar
STEM Learning and Research Center

Promising Approaches to Broadening Youth Participation in STEM

Kea Anderson Vogt, Julie Remold, Corinne Singleton, Caroline E. Parker

The National Science Foundation (NSF) views broadening participation in the nation's STEM enterprise as vitally linked to the United States' capacity for innovation. NSF can more readily achieve "major transformational advances" in science and engineering when it draws on the country's full potential, including contributions from those traditionally underrepresented in STEM fields (National Science Foundation [NSF], 2014). Broadening participation is also a central purpose of NSF's ITEST program,

The Innovative Technology Experiences for Students and Teachers (ITEST) program was established by the National Science Foundation (NSF) to help ensure the breadth and depth of the science, technology, engineering, and mathematics (STEM) workforce, in direct response to concerns and projections about the growing demand for and current shortages of STEM professionals in the United States. The STEM Learning and Research (STELAR) Center at Education Development Center, Inc., in partnership with the Goodman Research Group, Inc., assists ITEST principal investigators (PIs) and evaluators to design, refine, and evaluate their ITEST projects and to effectively synthesize and disseminate project findings.

as stated in the solicitation: "The ITEST program is especially interested in broadening participation of students from traditionally underrepresented groups in STEM fields and related education and workforce domains" (NSF, 2015). To prioritize inclusion, the ITEST program has called for reflection on best practices and lessons learned regarding broadening participation with this question: ***"Given the shifting demographics reflected in our current classrooms and in our country, what are effective and productive ways to ensure broadening participation by engaging diverse underrepresented populations in STEM programs and careers?"***

This paper, based on a review of over 200 publications related to approximately 110 ITEST projects, seeks to respond to that question. While all ITEST projects include "broadening participation" as a central goal, we found that publications relating to 43 projects contained specific information on broadening participation. Of those, publications relating to 25 projects had "broadening participation" as the primary focus. Here, we present the range of strategies that project teams employed by highlighting some of those 25 projects.[1]

Projects sought to understand the role of cultural context and cultural connections in maintaining or increasing interest in STEM.

Below, we present outcomes targeted in these projects, and consider the project designs and approaches. We then address promising strategies for recruiting and retaining youth from groups prioritized for inclusion, particularly in projects that take place in out-of-school settings.

1 For overviews of characteristics of all ITEST projects drawn from program monitoring data, see the Data Briefs on the STELAR website (http://stelar.edc.org/resources). The projects included in this and related syntheses are the subset (approximately one-third) of projects with publications available on research.gov and the STELAR website.

Targeted outcomes relate to participants' identities

ITEST projects typically target such outcomes as increases in STEM content knowledge, awareness of STEM careers, and increased interest and engagement in STEM. The publications included for summary here mention a range of additional outcomes tied to participants' identities. Identifying these outcomes helps projects gain insights into characteristics associated with high participation and persistence among students from underrepresented groups.

Outcomes related to participants' identities included participants' perceptions of STEM professionals, motivation in terms of identity (e.g., to identify factors that may motivate girls in particular, or Latinos in particular), and awareness of and attitudes toward stereotypes about STEM studies and careers. Projects also sought to understand the role of cultural context and cultural connections in maintaining or increasing interest in STEM. These included connections to tribal lands in projects designed for Native students and involvement from students' parents and communities in a project designed for Latina middle-schoolers.

Project designs are relevant and accessible, and include specific supports

As projects explored their targeted outcomes, they also sought to maximize their success by using existing research and evaluation findings to inform their project design and approach. Three types of strategies, sometimes used in combination, were common across the 25 projects with publications most centered on broadening participation: (1) design projects around issues important to youth, (2) improve accessibility to STEM experiences, and (3) support participants through mentoring and connections to STEM role models.

Making STEM matter: Focusing on relevance

Many projects strive to engage underrepresented youth by focusing on topics important to the students themselves, to their lives, and to their communities. In a related paper ("Authentic Inquiries into Local Issues: Increasing Engagement and Building a Sense of STEM Identity and Agency"), we present projects that leverage students' interest in locally or personally relevant topics as a strategy for building engagement and a sense of agency in STEM. The projects featured here share the place-based impetus of those projects; in addition, we further explore projects' strategies for emphasizing relevance.

Projects strive to engage underrepresented youth by focusing on topics important to the students themselves.

This paper is based on a review of over 200 publications collected from research.gov and the STEM Learning and Research Center (STELAR) website, and of additional resources related to newer projects. The publications reviewed relate to approximately 110 of the 325 ITEST projects funded from the program's inception in 2003 to 2015. The publications originally appeared in sources from a wide range of disciplines (ranging from maritime technology to women's studies) and an array of formats (research journals, practitioner-focused magazines and newsletters, and conference presentations and posters). The publications reviewed also contain widely ranging levels of detail, and the connection to a given ITEST project may be direct or tenuous. Many include descriptions of project implementation or implementation plans. A smaller portion describe targeted outcomes, evaluation methods, and findings.

The variety of sources reflects the diversity of ITEST grantees' backgrounds, specialties, and professional communities, as well as the diversity of local contexts for which projects are designed. ITEST projects build on the strength found in bringing together diverse professionals in the goal of broadening participation in STEM careers, but this strength also presents challenges; because ITEST PIs come from a range of academic disciplines, the nonprofit sector, or formal or informal learning arenas, their work, and how they report on it, varies widely. By summarizing available publications, STELAR hopes to facilitate learning across the various professional communities that together comprise the ITEST community.

Prevalence of place-based pedagogies. Projects designed around a community issue can help youth understand STEM through real-world applications relevant to their everyday lives. For example, the GET City project (2007–2011) set up a "Green Club" in afterschool programs at Boys and Girls Clubs in a depressed urban area in Michigan. The African American student participants studied the impacts of energy production and consumption in their homes, communities, and cities. The Green Club aimed to support youth in using science to address issues that affect their daily lives and their communities. The project enabled students who had not previously demonstrated high interest or achievement in STEM to become "community science experts" (Birmingham & Calabrese Barton, 2014; Calabrese Barton, Birmingham, Sato, Calabrese Barton, & Tan, 2014; Kissling & Calabrese Barton, 2013, 2015; Rose & Calabrese Barton, 2012).

Students who had not previously demonstrated high interest or achievement in STEM became "community science experts."

Valuing indigenous knowledge. A few projects incorporated traditional knowledge, melding indigenous and "Western scientific" perspectives in STEM investigations. The Back to the Earth project (2012–2016), for example, led by the University of Idaho, involved over 100 students in grades 4–6 in interdisciplinary, place-based activities to study watershed and natural resource management. Participants delved into the historical significance for their Tribes of particular local watersheds. They learned how these watersheds had deteriorated over many decades as Native people struggled to adapt, first to the influx of European settlers and later to U.S. government land and water use policies that conflicted with tribal practices. The students then developed approaches for restoring the watersheds. The project evaluation found that participants had increased positive attitudes about STEM and came to see engineering as relevant to and beneficial for their communities (Navickis-Brasch et al., 2013; Navickis-Brasch et al., 2014).

It was important to the Back to the Earth team to clearly communicate the project's vision of "how improving STEM education can support preservation and restoration of [participants'] aboriginal land" (Navickis-Brasch et al., 2013, p. 2), so they created a Curriculum Framework Flow Chart. The team found that this tool improved communication among researchers and Native partners by providing a focal point for the "community brainstorming sessions" that contributed to the curriculum design (Navickis-Brasch et al., 2013, p. 5).

Building on youth's own interests and preferences. Youth may be more likely to perceive a project as relevant to their own lives when it appeals to their experiences and perspectives. Two projects, Medibotics and COMPUGIRLS, provide concrete examples of how to interest and motivate girls in particular.

The Medibotics project (2006–2009) selected a biomedical engineering focus for its robotics exploration, foregrounding how biomedical technologies can improve people's lives. This aligns with research suggesting that female learners can be motivated when their STEM endeavors can benefit society.[2] The project involved 20 middle and high school teachers and their 112 students (55% girls) in in-school biomedical engineering challenges; it also included mentorship activities to further encourage girls' interest in pursuing STEM in their college majors and subsequent careers (Burr-Alexander, Kimmel, Carpinelli, Hirsch, & Rockland, 2010; Hirsch et al., 2009).

The COMPUGIRLS project (2008–2013) took a similar approach. In an afterschool and summer program in an urban area in the Southwest, 41 African American and Latina girls worked together to use technology as a means of self-expression. Over a period of two years, the girls first identified a social or community issue to research and then undertook the research. The project evaluation found that the girls were motivated by providing useful results for their peers and community and also by disproving stereotypes about their own abilities based on their age, gender, and ethnicity (Scott, Aist, & Hood, 2009; Scott & White, 2013).[3]

2 Hirsch, Carpinelli, Kimmel, Rockland, and Burr-Alexander (2009) cite Conlin (2003), Gibbons (2006), and Koppel, Cano, and Heyman (2002) regarding the appeal for female students of STEM investigations that foreground benefits to society.

3 The COMPUGIRLS team was awarded a scale-up grant, 2012–2017.

Improving access for rural teachers and students

A number of projects use technology to increase access to resources and opportunities, particularly for rural participants. In remote areas of Alaska, great distances—which are perilous to traverse in the long winters—separate teachers from one another and from their schools. The Arctic Climate Modeling Program (2005–2009), a teacher education program for 165 teachers in rural Alaska, focused on giving teachers tools to introduce youth to workforce technologies used in Arctic research. Each year, the professional development was aligned with a different Arctic research theme, and a new suite of curricular resources was created with teacher input. For example, in Year 1, the scientists established weather stations at Bering Strait schools so teachers and students could collaborate with scientists remotely. In Year 2, students compared local weather data with regional 10-day forecasts, 100-year predictions, and

Girls were motivated by providing useful results for their peers and community and also by disproving stereotypes about their own abilities.

200-year modeling projections. In Year 3, scientists installed permafrost-monitoring stations near participating schools so students could collect data for classroom use and scientific research. Each activity connected teachers and participating students to scientific tools, practices, and data that they would not otherwise be able to access (Bertram, 2010).

Scientists installed permafrost-monitoring stations near participating schools so students could collect data for classroom use and scientific research.

In another project, a team from North Carolina State University created a cloud-based Virtual Computer Lab (VCL) to offer high-quality resources for geometry and algebra classes to rural teachers and their students. In the Scaling Up STEM Learning in the VCL project (2009–2014), students in grades 9 and 10 from four rural North Carolina districts used cloud-based versions of the software programs Geometer's Sketchpad and Fathom to create dynamic graphs. By the end of its third year, the project showed positive changes in teaching practices in the classroom, not only with the two software programs but also with cloud-based instructional tools in general (Stein, Ware, Laboy, & Schaffer, 2013).

Shattering stereotypes with STEM role models and mentors

Youth from underserved communities, including urban and rural areas, and youth of color may not have access to role models in STEM careers. Without seeing a reflection of their own communities among STEM professionals, it may be more difficult for these youth to envision pursuing a STEM career. Further, without mentors, they may lack awareness of certain careers and also lack practical guidance on the necessary steps to work toward a STEM career. To address this, a number of ITEST projects connect youth with role models and/or mentors to help nurture their growing STEM interests and promote a sense of identity and ability in STEM.

The STEM Teams project (2010–2014), led by North Carolina State University, sought to improve access to role models and to dispel stereotypes of STEM professionals for youth in rural areas of the state. The team compiled a large video database featuring women and people of color with appealing jobs, such as motorcycle engineers or roller coaster designers, to debunk students' perception that STEM professionals are only white men who work alone in labs. The videos were compiled from sources such as the PBS show *Dragonfly* and from the NASA Women website. In one participating school, 80% of students were African American, and 92% qualified for free or reduced-price lunch (Kier, Blanchard, & Albert, 2014). To further explore the impact of role models on students' STEM interest and pursuits, the team also developed a STEM Career

Interest Survey that included items on access to role models (Kier, Blanchard, Osborne, & Albert, 2014).

In the From Art to STEM project (2009–2013), 215 girls in grades 7 and 8 in an afterschool program in an underserved area of Nashville, Tennessee, were "coached" by teachers and business professionals who volunteered as club leaders. Club activities built on students' existing interests to increase their awareness of how those interests converge with STEM. Students went on field trips to local companies and visited college and university campuses to meet with women in STEM careers. The project team formed a partnership involving a school district, a local collective impact organization, Alignment Nashville, the Adventure Science Center, and Tennessee Tech University to pursue its goal of increasing girls' enrollment in STEM academies within Nashville high schools (Rogers, Harris, & McNeel, 2012).

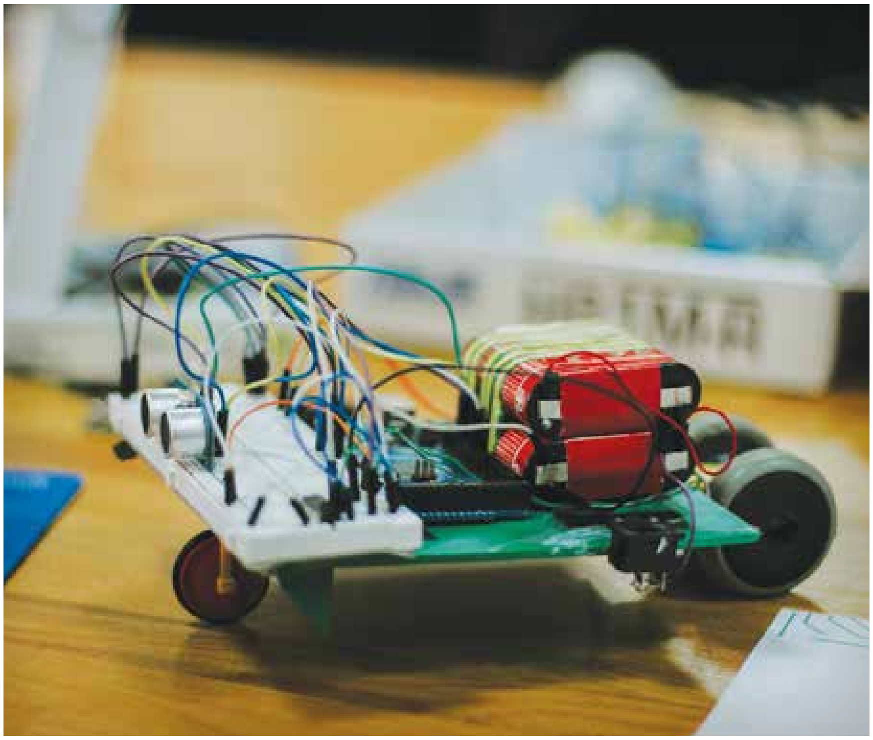
The Enhancing Science and Technology Education and Exploration Mentoring (ESTEEM, 2004–2007) offered a multi-year afterschool and summer camp experience through the University of Maryland–Baltimore County's Center for Women and Information Technology (CWIT). Participants used the TechBridge curriculum from the Chabot Space & Science Center in Oakland, California, to engage in engineering activities, such as powering a toy car by adding solar panels. Participants also visited nearby labs and science museums to see STEM in action. CWIT's efforts to engage and mentor high school girls fed into its core mission of supporting undergraduates who pursue computer science and related degrees (Daukantas, 2005; Hollebrands & Dove, 2011).

Both the From Art to STEM project and the ESTEEM project used afterschool experiences to support girls' interest and persistence in STEM courses in school. In addition, both drew connections for participants between their own STEM interests and their communities by partnering with and visiting the local workplaces of STEM professionals.

Promising recruitment and retention strategies

In projects that take place mainly during the school day, whole classes or grades may participate. These projects do not have to actively recruit participants the way that out-of-school-time (OST) projects do. In projects that occur in OST settings, project teams must be planful in recruiting and retaining participants, especially when the

Club activities built on students' existing interests to increase their awareness of how those interests converge with STEM.



goal is to prioritize participation of students from groups historically underrepresented in STEM fields. Interestingly, while approximately half of all ITEST projects take place in OST settings, a large majority of projects included in this synthesis—those whose publications foreground broadening participation efforts most clearly—are OST-centered. As noted throughout the project descriptions above, these projects prioritize the inclusion of students in particular underrepresented groups, so each project's success hinges on the team's ability to recruit and retain those participants.

Project teams partnered with cultural and community-based organizations.

Three strategies for recruitment and retention emerged in the publications we reviewed: following best practices identified in the literature, establishing partnerships with cultural or community-based organizations, and conducting engagement and outreach campaigns.

Identifying best practices in the research literature

Several publications we reviewed cite research findings in presenting their strategies for recruitment and retention. For example, the Arctic Climate Modeling Program team chose to include student investigations, since, as Hill, Kawagley, and Barnhardt (2004) found, "cooperative learning and community participation [have both been] shown to increase retention for Native students" (as cited in Bertram, 2010, p. 239). Similarly, the Back to the Earth project cited Semken and Freeman (2008) and Gruenewald (2003) to underscore the importance of place-based learning for improving engagement and retention, particularly among Native participants.

Partnering with community-based organizations

To support the participation and persistence of students from prioritized groups and to add to the existing programming at organizations already serving youth in under-resourced communities, project teams partnered with cultural and community-based organizations. The Invention Factory (2005–2008), a Honolulu afterschool project in which youth worked with electronics and microcomputers to improve the accessibility of electronic toys for youth with disabilities, involved instructional aides from The Native Hawaiian Science and Engineering Mentoring program. In addition, the nonprofit organization Women in Technology helped with recruitment from participating schools and in providing mentoring opportunities for girls who participated. The project team reported that 34% of project participants were girls, and 19% were Native Hawaiians (Speitel, Scott, & Gabrielli, 2007).

The GET City project, discussed above, took place in Boys and Girls Clubs primarily serving African American youth in a high-poverty, urban area in Michigan. This partnership reflected the project team's philosophy of inclusion:

> "[We] recognize that many youth possess aptitude and potential that may not yet be realized or observed in standard measures. For example, youth who have not performed well in school in general or in school science, or who are not interested in science, are encouraged to participate in GET City. Within the program, we try to open spaces for youth to leverage the various forms of expertise and interests they bring to studying energy and their environment by incorporating and valuing art, technology, and community concerns." (Birmingham & Calabrese Barton, 2014, p. 293)

The program welcomed attendees of the Boys and Girls Club afterschool programs regardless of in-school achievement or even demonstrated prior interest in STEM.

Involving the community through outreach and engagement events

The Girl Game Company (2006–2010) held a series of engagement and outreach events to attract Latina middle school girls to a rural California district afterschool program that introduced girls to the computing world by teaching them computer game programming, taking them on field trips to tech companies, and connecting them with role models. The team held pizza parties, organized parent nights, and presented information about the program in other student clubs at participating schools. The team also involved the community in identifying interested participants by seeking nominations from girls' teachers and peers. To retain participants, the project continued its family engagement efforts and provided support for English learners in order to obviate any language barrier that could deter participation. In addition, girls worked in pairs throughout the experience, based on literature findings that opportunities to collaborate may encourage persistence in girls (Denner & Werner, 2007). A follow-up project, Animando a Estudiantes con Tecnologia, aimed to integrate outreach and ongoing engagement into the community by developing a Parent Engagement And Leadership (PEAL) model that included parent workshops, parent computer labs, and a community leadership committee (Martinez et al., 2012).

A Parent Engagement And Leadership (PEAL) model included parent workshops, parent computer labs, and a community leadership committee.

Looking Ahead

Consistent with agency and program objectives, "broadening participation" is a key outcome targeted by every ITEST project. The approaches and findings from the projects included here can inform all current and potential ITEST project teams.

Co-designing programs with community members develops a sense of shared ownership.

As these projects show, achieving the goal of broadening participation requires a multi-faceted approach:

- Locally important issues can make for compelling topics of study.
- Project activities and approaches should align with literature findings on motivational factors in the relevant communities.
- Specific supports such as role models and mentors can improve engagement and persistence.
- Engaging the community through partnerships and outreach events can cultivate buy-in. Going further, co-designing programs with community members develops a sense of shared ownership.
- Efforts to reduce barriers, such as distance, transportation, and language, may be necessary.
- Project evaluation can identify outcomes specifically related to broadening participation goals.

The projects described in this paper illustrate the range of project design features, STEM disciplines, and activity types that can be included to maximize appeal to the fullest range of our nation's future STEM innovators, along with supports that can help students from groups underrepresented in STEM fields envision themselves as future scientists and engineers.

Projects included in this synthesis

(listed in order of appearance):

1. GET City
(2007–2011; DRL-0737642)
2. Back to the Earth
(2012–2016; DRL-1139657)
3. Medibotics
(2006–2009; DRL-0624434)
4. COMPUGIRLS
(2008–2013; DRL-0833773)
5. Arctic Climate Modeling Program
(2005–2009; DRL-0525277)
6. Scaling Up STEM Learning in the VCL
(2009–2014; DRL-0929543)
7. STEM Teams
(2010–2014; DRL-1031118)
8. From Art to STEM
(2009–2013; DRL-0833643)
9. Enhancing Science and Technology Education and Exploration Mentoring
(ESTEEM; 2004–2007; DRL-0422703)
10. Invention Factory
(2005–2008; DRL-0525274)
11. Girl Game Company
(2006–2010; DRL-0624549)
12. Animando a Estudiantes con Tecnologia
(2009-2013; DRL-0929676)

The projects described in this paper illustrate the range of project design features, STEM disciplines, and activity types that can be included to maximize appeal to the fullest range of our nation's future STEM innovators, along with supports that can help students from groups underrepresented in STEM fields envision themselves as future scientists and engineers.

References

Bertram, K. B. (2010, April). The Arctic Climate Modeling Program: Professional Development for Rural Teachers. *Journal of Technology and Teacher Education*, *18*(2), 231–262.

Birmingham, D., & Calabrese Barton, A. (2014). Putting on a green carnival: Youth taking educated action on socioscientific issues. *Journal of Research in Science Teaching*, *51*(3), 286–314. doi:10.1002/tea.21127

Burr-Alexander, L., Kimmel, H., Carpinelli, J., Hirsch, L., & Rockland, R. (2010, June). *A Capstone Approach to Exploring Teacher Outcomes.* Professional development paper presented at 2010 Annual Conference & Exposition, Louisville, Kentucky.

Calabrese Barton, A., Birmingham, D., Sato, T., Calabrese Barton, S., & Tan, E. (2014). Youth as Community Science Experts in Green Energy Technologies. *Afterschool Matters*, *18*, 25–33.

Conlin, M. (2003, May 26). The New Gender Gap. *Business Week*, 74–83.

Daukantas, P. (2005, October). OSA Past President Brings Lasers to Summer Camp. *OSA Today.* Retrieved from http://www.umbc.edu/caspr/documents/OSA-OPN-Oct2005.pdf

Denner, J. & Werner, L. (2007). Computer programming in middle school: How pairs respond to challenges. *Journal of Educational Computing Research, 37*(2), 131-150.

Gibbons, M. (2006, October). Women in Engineering. *ASEE Prism*, *15*(5).

Gruenewald, D. A. (2003, May). The Best of Both Worlds: A Critical Pedagogy of Place. *Educational Researcher*, *32*(4), 3–12. Retrieved from http://links.jstor.org/sici?sici=0013-189X%28200305%2932%3A4<3%3ATBOBWA>2.0.CO%3B2-J

Hill, F., Kawagley, O., & Barnhardt, R. (2003). *Alaska Rural Systemic Initiative. Annual report: Phase II, year three, 2002–2003*. Fairbanks, AK: University of Alaska, Alaska Federation of Natives.

Hirsch, L. S., Carpinelli, J. D., Kimmel, H., Rockland, R., & Burr-Alexander, L. (2009, June). *The Impact of Introducing Robotics in Middle and High School Science and Mathematics Classrooms.* Paper presented at the 2009 ASEE Annual Conference, Austin, Texas.

Hollebrands, K., & Dove, A. (2011). Using Technology to Engage in Reasoning and Sense-Making Activities in Geometry: Focus on Reasoning and Sense Making. *Technology*, *1*, 33–52.

Kier, M. W., Blanchard, M. R., & Albert, J. L. (2014, February). Connecting Students to STEM Careers. *Science Scope*, *37*(6), 72.

Kier, M. W., Blanchard, M. R., Osborne, J. W., & Albert, J. L. (2014). The Development of the STEM Career Interest Survey (STEM-CIS). *Research in Science Education*, *44*(3), 461–481.

Kissling, M., & Calabrese Barton, A. (2013). Interdisciplinary Study of the Local Power Plant: Cultivating Ecological Citizens. *Social Studies Research and Practice*, *8*(3), 128–142.

Kissling, M., & Calabrese Barton, A. (2015). Place-Based Education: (Re) Integrating Ecology and Economy. *Bank Street Occasional Paper Series*, 2015 (33), 50–61. Retrieved from http://educate.bankstreet.edu/occasional-paper-series/vol2015/iss33/6

Koppel, N., Cano, R., & Heyman, S. (2002, November 5–7). *An Attractive Engineering Option for Girls.* Presentation at the 32nd ASEE/IEEE Frontiers in Education Conference, Boston, Mass.

Martinez, J., Denner, J., Reyes, S., Rafanan, K., Ructtinger, L., & Sauerteig, D. (2012). *Using Parent Leadership to Engage Latino Families in Informal STEM Education*. Presentation at the American Educational Research Association Annual Meeting, Vancouver, British Columbia.

National Science Foundation. (2014, March). *Investing in Science, Engineering, and Education for the Nation's Future—National Science Foundation Strategic Plan for 2014–2018.* NSF 14-043. Retrieved from https://www.nsf.gov/pubs/2014/nsf14043/nsf14043.pdf

Navickis-Brasch, A. S., Kern, A. L., Cadwell, J. R., Laumatia, L., & Fielder, F. (2013, June 23–26). *How land use change, changed culture.* Presentation at the 120th American Society for Engineering Education Conference and Exposition, Atlanta, GA. Retrieved from https://docs.google.com/file/d/0B2RA0nm-cNhlUFpfLW9vQjJmaTQ/edit

Navickis-Brasch, A. S., Kern, A. L, Fiedler, F., Cadwell, J. R., Laumatia, L., Haynie, K., & Meyer, C. (2014, June). *Restoring Water, Culture, and Relationships: Using a Community Based Participatory Research Methodology for Engineering Education.* Presentation at the American Society for Engineering Education Annual Conference, Indianapolis, Indiana.

Rodger, S. H. (2007, May 7). *An Innovative Approach with Alice for Attracting K–12 Students to Computing.* Presentation at the International Conference on the Virtual Computing Initiative, Research Triangle Park, N.C.

Rogers, S., Harris, S., & McNeel, D. (2012). FROM Art TO STEM—A Creative Journey of Discovery: A Transformational Project for Nashville Middle School Students. In *ITEST Engineering Model: Building a Better Future for STEM Learning* (pp. 17–18). Retrieved from http://stelar.edc.org/sites/stelar.edc.org/files/engineering _model.pdf

Rose, S., & Calabrese Barton, A. (2012). Should Great Lakes City Build a New Power Plant? How Youth Navigate Complex Socioscientific Issues. *Journal of Research in Science Teaching*, *49*(5), 541–567.

Scott, K. A., Aist, G., & Hood, D. (2009). CompuGirls: Designing a Culturally Relevant Technology Program. *Educational Technology*, *49*(6), 34–39.

Scott, K. A., & White, M. (2013, September). COMPUGIRLS Standpoint: Culturally responsive computing and its effect on girls of color. *Urban Education*, *48*(5), 657–681.

Semken, S., & Freeman, C. B. (2008, November). Sense of place in the practice and assessment of place-based science teaching. *Science Education*, *92*(6), 1042–1057.

Speitel, T. W., Scott, N. G., & Gabrielli, S. G. (2007). The Invention Factory: Student inventions aid individuals with disabilities. *The Science Teacher*, *74*(4), 42–46.

Stein, S., Ware, J., Laboy, J., & Schaffer, H. E. (2013). Improving K–12 pedagogy via a cloud designed for education. *International Journal of Information Management*, *33*, 235–241.

Sullivan, S., Hall, C., Kauffmann, P., Batts, D., & Long, J. (2008, September). Influences on female interest in pursuit of STEM fields in higher education. In P. Lari (Ed.), *The impact of information technology on business and education* (pp. 213–222). Atlantic City, NJ: American Institute of Higher Education LLC.

EDC Learning transforms lives.

SRI Education

Suggested reference:

Vogt, K., Remold, J., Singleton, C. &Parker, C. (2016). *Promising Approaches to Broadening Youth Participation in STEM*. STEM Learning and Research Center, Education Development Center, Waltham, MA. Downloaded from https://go.edc.org/ITEST-Broadening-Participation.

This material is based upon work supported by the National Science Foundation under Grant No. DRL-1312022. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.