ITEST Learning Resource Center

September 2010 **Information Brief**

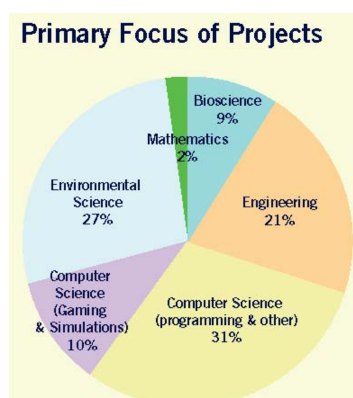
ITEST: Meeting the Needs of STEM Workforce Development

Funded by the National Science Foundation, the Innovative Technology Experiences for Students and Teachers (ITEST) program strives to connect workforce development needs and K–12 learning in and out of school. To understand that connection, we need to consider how the skills, knowledge, and attributes developed over time through formal and informal learning shape students' career development and therefore, development of our STEM workforce.

ITEST Projects Increase STEM Learning and Career Exploration

Now in its seventh year, the ITEST program funds a variety of innovative projects aimed at supporting the STEM career development of youth and building the next generation of scientists, engineers, mathematicians and technologists. **Strategies** projects design, implement, and evaluate models that engage youth, educators, and often other community members in STEM-rich, contextual learning experiences. **Scale-Up** projects take proven practices and expand them to engage larger populations of learners. **Research** projects enrich our understanding of how to enlarge the country's STEM workforce. **Conferences and workshops** contribute to the development of a research agenda on K–12 STEM workforce preparation and development issues, workforce participation, and cyberlearning.

In 37 states across the U.S., the ITEST experience is helping young people and teachers in urban, suburban, and rural communities build the skills, knowledge and abilities needed to succeed in a technologically-rich society. ITEST provides opportunities for populations traditionally underrepresented in the STEM workforce including: African-Americans, Hispanics and Latinos, Native Americans and females. Participants are involved at a level of intensity and duration that allows for knowledge acquisition and skill development across a wide range of STEM topics.



Authentic Learning

Teachers work together with students to pursue research questions and deepen their scientific and technological expertise—and learn strategies for integrating IT concepts, skills, and applications into their classrooms. Teachers are learning the strengths of combining formal and informal learning environments together to create authentic learning experiences for their students.

"I Am a Scientist"

Students experience what it is like to "be" STEM professional and technical workers, building their self-efficacy as future scientists, engineers, technologists and mathematicians making transformative discoveries in STEM. Young people ages 5–18 use sophisticated technology to explore their environment, conduct research, build programmable machines, and create media in community settings after school and during the summer. Across all ITEST projects, youth are using the same technologies, tools, and methods that scientists use on the job.

The Importance of Out-of-School Time STEM Learning

Out-of-school time is fertile ground for STEM learning and support for STEM career development. In its 2009 report, *Learning Science in Informal Environments: People, Places, and Pursuits*, the National Research Council notes that science is "receiving more emphasis in out-of-school time programs" (p. 298). The authors found "a range of evaluation studies show out-of-school programs can have positive effects on participants' attitudes toward science, grades, test scores, graduation rates, and specific science knowledge and skills" (p. 178).

In the excerpts below from the Working in Afterschool chapter (pp 34-41), of *Preparing Tomorrow's STEM Workforce Through Exploration, Equity & Engagement* (Education Development Center, Inc., 2010), Tony Streit and Wendy Rivenburgh share studies illustrating the role of out-of-school-time STEM programs in STEM career development.

According to the Coalition for Science AfterSchool (*Science in after-school: A Blueprint for action,* 2007), an affiliation of more than 100 leading science, technology, engineering, and mathematics (STEM) education intermediaries and afterschool advocates, out-of-school time offers "the kind of STEM learning that is likely to interest and motivate: less restricted uses of time and settings, strong roles for youth that encourage their participation and voice, mastering skills on individual timelines and in response to interests, mixed aged groups with the chance to mentor and tutor peers, and access to partnerships with community science resources" (p. 4). Out-of-school time is fertile ground for STEM learning experiences. The Carnegie Corporation of New York in its 2009 report on transforming math and science education (*The opportunity equation: Transforming mathematics and science education for citizenship and the global economy.* 2009) pronounces, "Science and math content that is presented in ways that engage students in active, often cooperative work with interesting material is essential" (p. 50). These kinds of active, collaborative learning experiences, interweaving the best of the formal and informal learning environments, dominate the teacher professional development and youth programs that are part of ITEST.

For example, an evaluation of the enrichment program GEAR UP found that program services, including a robust math-science component, improved students' academic performance, increased graduation and college admissions rates, and cultivated interest in STEM fields (Heisel, M. (2005) *Preparing New Jersey students for college and careers: Evaluation of New Jersey GEAR UP*. Berkeley, CA: University of California, Office of the President.) In their literature review entitled *Connecting informal stem experiences to career choices: identifying the pathway* (Newton, MA: Education Development Center, Inc., 2006), Dorsen, Carlson, and Goodyear of the ITEST Learning Resource Center point to the research of Stake and Mares (Stake, J. E., & Mares, K. R. (2005). "Evaluating the impact of science-enrichment programs on adolescents' science motivation and confidence: The splashdown effect." *Journal of Research in Science Teaching*, *42*(4), 359–375.), who found that youth completing "a summer science enrichment program reported increased science confidence and motivation months after returning to their regular high schools. The students also reported feeling more confident in their abilities to pursue science careers" (Dorsen et al., 2006, pp. 8–9).

Other programs that have been shown to change perceptions and build interest in STEM include Girls Creating Games (precursor to the ITEST Project Girl Game Company). Designed to empower girls as technology users and producers, Girls Creating Games gives participants hands-on experience in computer programming as they design their own games. The experience breaks down gender stereotypes about programmers and, with a pair programming approach, counters assumptions that computer programming is solitary work (Denner, J. L., Werner, L., Bean, S., & Campe, S. (2005) "The Girls Creating Games Program: Strategies for engaging middle-school girls in information technology." *Frontiers: A Journal of Women Studies 26*(1): 90–98.)

Why are ITEST Projects Good Illustrations of Afterschool STEM Learning?

Whether online, or on an expedition to an urban center, a rural outpost, or the sea, ITEST projects transport learners to new domains of thought and experience.

Treading lightly on the banks of the Red River in Minnesota and North Dakota, students and teachers with the Understanding the Science Connected to Technology project (ITEST Cohort 2) collect samples of the often turbid water. They use GPS devices to record coordinates of their location and enter data into a custom designed Web-based data portal. Mud may cling to their shoes—if they forgot their waders—and their sleeves may drip a little from reaching into the water. These are the trappings of doing important water quality work within this international watershed.

Meanwhile, across the country, groups of young people and teachers participating in the Community for Rural Education, Stewardship, and Technology (CREST) project (ITEST Cohort 3) dig in the mudflats, test water quality, interview elders about access to working waterfronts, and carry out a variety of different place-based activities around islands off the coast of Maine. Students truly take on the role of researcher to investigate community questions important to them, such as "Why has the clamming industry in our town disappeared?", "Where are the ecologically sensitive areas in our community?", and "Where are the best spots to release larval lobsters for survivability?"

> *"Our projects empower students to really understand what is happening in their community and teach them how to apply this exciting technology to make change."*
> —Ruth Kermish-Allen, Principal Investigator, CREST, ITEST Cohorts 3 and 5

These are just two examples of how ITEST projects feature robust, hands-on learning experiences that are rooted in the local community. To prepare for and follow up on their fieldwork, youth participants employ technology tools to make calculations and document what they're learning. They also search online to gather more information and participate in group discussions that build on their experiences. In these and other ways, the ITEST projects blend formal and informal learning techniques to engage STEM learners. Student-centered, experiential learning approaches empower educators and learners. Moreover, introducing young people to science projects and technology tools through hands-on experience, instead of lecture or demonstration, yields better outcomes. When they work directly with the materials and tools of inquiry, young people retain far more about what they've learned as compared with traditional pedagogical approaches.

A synthesis of the research on inquiry-based and project learning published in the George Lucas Educational Foundation's Edutopia finds that "Students learn more deeply when they can apply classroom-gathered knowledge to real-world problems, and when they take part in projects that require sustained engagement and collaboration" (Barron & Darling-Hammond, n.d.). In addition, "Active-learning practices have a more significant impact on student performance than any other variable, including student background and prior achievement" (Barron & Darling-Hammond, n.d.).

Another term for the approach ITEST educators take is problem-based learning, which "has been shown to increase students' active engagement with content, as well as their capacity for self-directed learning, collaboration, and social interaction" (Knowlton, 2003, as cited in Partnership for 21st Century Skills, 2007). ITEST educators encourage participants to take responsibility and drive their learning experiences, drawing on different resources to help them study problems and develop solutions. In keeping with this, technology is used as a tool in STEM investigations rather than as a content area of its own.

Dr. Michael Barnett, principal investigator of the IT and College Pathways through Application of Technology to Explore Urban Ecological Challenges ITEST project which works with Boston Public School students, teachers and guidance counselors, explains, "We have purposefully included technological learning tools in our inquiry framework because we want students to recognize that, through the use of technological tools, they can ask the same questions that scientists are asking, and be able to develop sophisticated answers to their own questions." The project is built around the use of cutting-edge geospatial and computer modeling to investigate pressing urban ecological problems in their neighborhood. The work in a previous ITEST grant that demonstrated an increase in student self-efficacy and interest in science is expanded to integrate career discernment, college preparation, and engagement with innovative technologies. With a project team that includes a counseling psychologist, an educational researcher, a science educator, an urban ecologist, an environmental lawyer and a cross-cultural educator, the project designs an innovative program and conducts research on both the design of the program and on student career discernment.

Working as scientists with scientists, teachers and students involved in ITEST projects endeavor to address real world problems and issues in ways that are deep and meaningful. The learning is contextual, rooted in the lives and communities of the young people. With an emphasis on engaging traditionally underrepresented groups in the STEM fields, the ITEST Program has generated a number of innovative strategies for building participant interest. Among these are techniques to draw connections between culture and learning. Incorporating local issues, resources, and traditions honors young people's life experiences and makes the content more relevant. Moreover, diversity—in the classroom as in the workplace—is advantageous and sparks creativity and innovation.

In the northeastern peninsula of Alaska, the Arctic Climate Modeling ITEST project engages teachers and students from the Bering Strait School District, which serves isolated indigenous communities. The population primarily survives by subsistence living; the families must hunt and fish during the summer months so as to acquire sufficient commodities for the winter. ITEST participants are studying climatic impacts on their community, guided by curriculum that includes cultural components and native language terms. Community elders provide historical background and offer additional insights, which the young people document on video. The weather data generated by the project equipment is helpful to climate scientists, as well as to community members in their daily work.

Conducting fieldwork with professional scientists is a key element of the ITEST Program. It is powerful for young people and teachers alike to carry out authentic research in their communities. To facilitate participants' learning experiences and exploration of career pathways, ITEST projects partner with local businesses and create unique opportunities for carrying out science activities that have real-world applications. ITEST's focus on workforce development, an aspect largely missing in afterschool programs, is one the field appears highly suited to embrace, particularly as it relates to connecting young people with STEM professionals as mentors."

Data on How ITEST is Meeting STEM Workforce Development Needs

In 2009, the ITEST LRC piloted a Management Information System (MIS) to collect and store data that describes ITEST projects. As described above, ITEST contributes to the development of the future STEM workforce by helping youth develop necessary foundational skills, knowledge and attributes needed to access advanced STEM education and careers and by providing career development experiences to nurture an ongoing interest in STEM education and careers. Through MIS activities the ITEST Learning Resource Center collects information on the following elements that contribute to the development of STEM career trajectory for youth.

These elements include:

- Use of real world STEM tools/procedures
- Developing foundational concepts/skills in mathematics, science, technology and engineering needed for STEM careers
- Interactions with scientists, engineers, technologists including as mentors, and STEM professionals co-teaching classes/guiding field work
- Solving real world STEM problems
- On site experiences in STEM workplaces/laboratories
- Interest in/motivation for STEM education and careers.
- Taking of advanced STEM courses and/or entry onto a stem career path

Using real world STEM tools/procedures can help ITEST participants understand how information and engineering technologies are used to conduct routine tasks and solve problems in scientific laboratories and workplaces. Through the use of these tools participants have opportunities to explore what it is like to do technical work.

Technologies used in projects (n=88)

	% of projects
Visualization/computer modeling tools	38
Programming tools	37
Data analysis/computation tools	36
Multi-media tools	34
Communication tools (email, messaging, blogs, video conferencing)	33
Game development	24
Engineering/design tools	22
Social networking tools	21
Electronics/robotics tools	21
Geospatial technologies (GIS/GPS/RS)	20
Hand-held devices	16
Imaging technologies	12
Virtual reality	11
Other	14

Developing foundational concepts/skills in mathematics, science, technology and engineering needed for STEM careers can increase participants' access to higher level STEM education options and career opportunities; develops technical competence and challenges participants to create and innovate.

Technology skills promoted in project (n=88)

	% of projects
Visualization/modeling skills	41
Computing/data analysis skills	39
Programming skills	34
Communication/social networking skills	31
Digital media skills (photos, imovie, music...)	31
Computational thinking skills	29
Computer driven equipment skills (e.g. CAM, Robotics..)	24
Data management skills	21
Web development skills	17
Other	14

Interactions with scientists, engineers, technologists, solving real world STEM problems, and on-site experiences in STEM workplaces

Participants can develop confidence in their abilities and help to build self-efficacy as future scientists, engineers, technologists and mathematicians when they have success experiences working on real world problems, in scientific work teams, in real world work settings (see two tables below).

Focus areas with youth

	% of all projects (n=85)	% of out of school youth-focused projects (n=60)
Technology-based learning (computer-based, game-based)	72	70
Career skills development (lab work, engineering or science lab, using tools, equipment, instruments used in STEM careers)	56	58
Classroom work (academic content learning, in-class projects, guest speakers)	48	44
Participation of scientists/engineers/technologists	40	37
Field work (internships/externships, experiential learning, out of school projects, skills training)	35	36
Career development (creating a career plan, providing information about career pathways)	29	26
Youth mentoring	21	23
Engagement of STEM researchers	19	14
Engagement of parents/caregivers	11	14

Partner institution activities (n=88)

	% of projects
Participate in delivery of program	74
Assist with recruitment	64
Provide field trip sites, shadowships	55
Provide tools/equipment/use of laboratory facilities	55
Provide real world problems for students to solve	43
Provide mentors	42
Contribute to dissemination	41
Volunteer in classroom/team teaching of lessons	34
Provide incentives for participation (prizes, meals, events)	31
Provide internships/externships	20
Provide funding	17
Provide employment to ITEST participants (part/full time)	8
Other	5

Interest in/motivation for STEM education and careers is tracked by gains listed below.

Target youth outcomes of project

	% of all projects (n=85)	% of out of school youth-focused projects (n=60)
Gains in youth interest in STEM	81	85
Gains in youth interest in STEM careers	75	78
Gains in youth STEM content knowledge	74	75
Gains in youths' skills using technology tools	64	63
Gains in youth knowledge of STEM careers, preparation and/or workplace demands	58	62
Gains in youth engagement in STEM	59	60
Gains in youths' skills applying science, technology, engineering and/or math concepts.	48	41
Gains in youth participation in STEM-related activities	41	38
Changes in youth preparation for STEM careers (technical/scientific training related to a specific career)	22	24
Youth entry into STEM career paths	16	21
Other	12	14

Data collection methods for youth

	% of all projects (n=85)	% of out of school youth-focused projects (n=60)
Pre-assessment of youth attitudes	79	83
Post-assessment of youth attitudes	78	82
Pre-assessment of youth content/skills	71	73
Post-assessment of youth content/skills	70	72
ITEST project observations (summer institutes, youth activities)	62	65
Student/youth interviews	45	47
Youth focus groups	39	47
Performance-based assessments	31	25
Embedded assessments	29	28
Youth web-based data (blogging, emails, posts)	28	32
Youth self-reports (journals)	25	32

Taking of advanced STEM courses and/or entry onto a stem career path

External youth outcome metrics

	% of all projects (n=76)	% of out of school youth-focused projects (n=60)
Participation in high school courses	30	33
Examples of student academic work	33	29
Videos of students and/or teachers	30	24
Participation in advanced STEM classes	26	24
Selection of post-high school pathway	20	20
Participation in science fair/STEM competitions	20	18
Standardized test scores	20	18
High school grades	16	18
Participation in extracurricular activities	14	16
Participation in STEM-related work experience	12	14
College major	9	10
Participation in college courses	4	4
Other	21	18

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