

A Research Brief from STELAR

Translating Career Development Research to Practice in ITEST

Part 2: The Career Development Continuum & ITEST At-a-Glance

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Introduction

Science, technology, engineering, and mathematics (STEM) education plays a critical role in a technology-driven society. Developing interest and foundational skills in STEM can help youth take advantage of the many STEM career opportunities available in the world around them. Between 2023 and 2033, STEM occupations are expected to grow by 10.4%, nearly three times the rate of non-STEM jobs (3.6%) (U.S. Bureau of Labor Statistics, 2025). As the demand for STEM jobs continues to grow, especially in emerging industries such as AI, quantum information science, and semiconductor manufacturing, expanding and improving STEM workforce pathways for youth remains a priority in K–12 education.

This paper is the second in Translating Career Development Research to Practice in ITEST, a two-part series of white papers examining important theories in career education research and how these theories have been translated into PreK–12 education to prepare future generations for STEM careers. The two

papers are authored by the STELAR Center, the national resource center for the National Science Foundation’s (NSF) Innovative Technology Experiences For Students and Teachers (ITEEST) program. In this paper, we take a closer look at the developmental stages of career development and how the NSF’s ITEST program provides formative experiences in formal and informal settings that engage and inspire youth at critical points in their career journey.

Translating Career Development Research into Practice in and out of School

Career Education

The current state of the art recognizes that career development occurs across developmental, iterative cycle of awareness, exploration, and preparation, described further below) which can be applied to the education continuum (K–20+). The model in Figure 1, adapted from the ITEST STEM Workforce Education



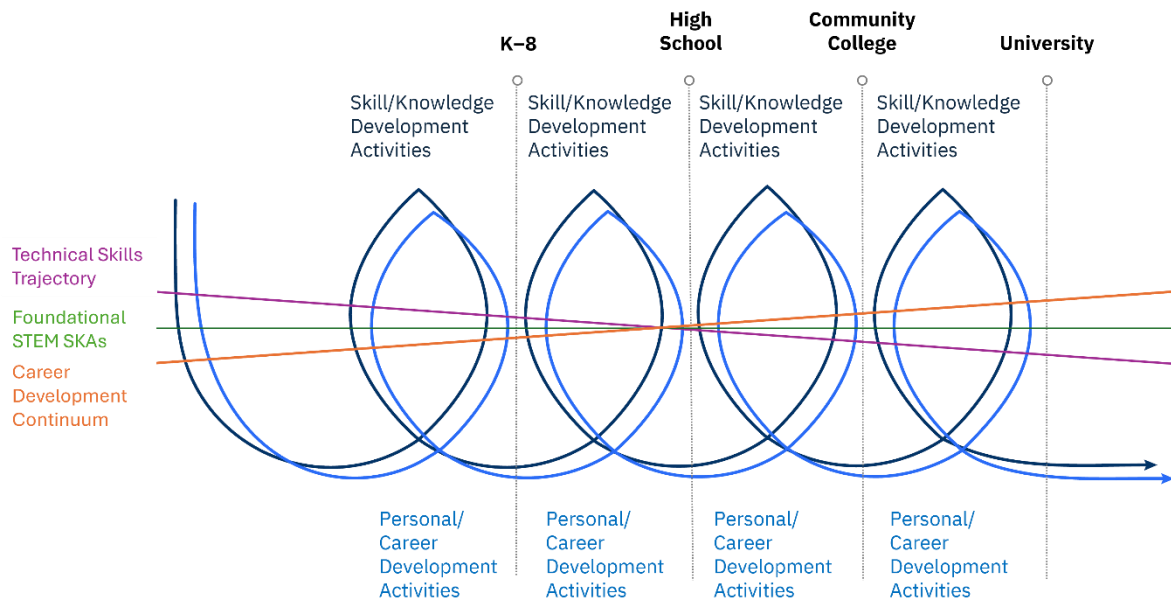


Figure 1: Career Development Continuum

Helix conceptual model (Reider et al., 2016), illustrates the interplay between skill and knowledge development and personal and career development activities as individuals progress from formal education to the workforce.

Beginning in the home and in elementary schools, students develop foundational STEM skills, knowledge and dispositions (black line) and specific technical skills related to emerging technologies (blue line) through personal and career development activities. As they move through their formative years and into the world of work, these experiences build upon each other, shaping the ongoing development and refinement of skills, knowledge and dispositions that are later applied in life roles and careers.

Career education research (Bailey & Stadt, 1973; Hoyt, 2005) indicates that the development of these capacities continues throughout the life stages, and

when effectively guided, leads to productive and rewarding careers.

During an intense period of research and development of nationally supported career education efforts in the 1980s, groundbreaking educators from Project BICEP (Barnstable Instructional Career Education Program) in Hyannis, MA, developed a model, along with a comprehensive curriculum, to support educators in integrating career awareness and career competencies into subjects across K-12 grades. They identified six career education goals that translate career development research into practice in K-12 career education. These goals, described below, continue to be relevant today.

1. To foster in each child a positive **self-concept and awareness** that demonstrates an appreciation of one's interests, abilities, feelings, values, and skills necessary for the



encouragement of a realization and acceptance of one's personal and social responsibilities.

2. To develop in each child the **interpersonal skills** needed to function in and contribute to a variety of social settings.
3. To develop in each child wholesome **attitudes toward the dignity of work** and the satisfactions, both personal and economic, which can be derived from meaningful work experience.
4. To help a child understand the value and process of rational **decision making, planning, and problem solving**; through practice, to help one discover facts that influence decisions and actions.
5. To develop in each child a knowledge and understanding of **occupational information** as it applied to life roles.
6. To develop an **economic awareness** in each child as it relates to the world of work.

(Project BICEP: Barnstable Public School System, 1983)

In addition to these goals, empirical research highlights the importance of fostering critical consciousness in the career development process, particularly for youth from marginalized groups and low-income backgrounds (Diemer & Bluestein, 2006; Diemer et al., 2010). Critical consciousness refers to the capacity to identify and critically analyze sociopolitical barriers in one's

environment, to reflect on how barriers have shaped the career development pathway, and to exercise agency by taking individual or collective action to address them (Diemer & Bluestein, 2006). Alongside critical consciousness, modern K–12 career development practices also benefit from culturally relevant approaches to broaden participation in STEM careers for all students. Practices include the involvement of STEM mentors and role models who can provide supportive career networks and affirm youth's career interests and identities and expanded opportunities to participate in STEM learning activities in out-of-school contexts such as the home and in the community (Mark, 2016; Kang et al, 2018; NASEM, 2024).

Career Education in ITEST At-a-Glance

The following section illustrates what Career Education theory and concepts look like when applied to practice in preparing future generations of STEM talent. It provides an overview of career awareness, exploration, and preparation as it occurs in K–12; and each phase shares examples of ways in which the ITEST program is translating research into formal and informal learning environments. The examples illustrate ITEST's innovative technology experiences for students and teachers and provide a glimpse of the collective impact of the ITEST program (i.e., numbers of students, range of communities and industry sectors served).



Elementary school is a time to build Career Awareness

According to developmental theorists, career awareness begins early in life when children become aware that their significant caretakers leave their presence to go to a place called “work.” This can happen as early as age 2. In primary schools, children become aware of careers as they learn about people in their families and communities who are teachers, dentists, doctors, crossing guards, police, librarians... and as they participate in activities that bring parents and other adults into the classroom to talk about their jobs. An important part of career awareness is also a child’s awareness of what they like and do not like to do as they develop their foundational academic and technical skills and as they discover their own talents and successful experiences. Do I like to play with numbers... words? Do I like to talk with people? Do I like to build things? Do I like to work with computers? Do I like to create art and visualizations? Even as early as this, children begin on a path to their own career identities as they experience learning and doing, and as they observe work role models at home and in society that reflect their gender, race, and ethnicity.

ITEST At-a-Glance: Career Awareness

The following examples describe how grantees of the ITEST program guide the career awareness process to help students become aware of their own skills and interests and uses of technology, aware of various careers and what they might like to experience:

Early Childhood Maker Literacies: Fostering Computational Thinking Among Navajo Youth and Educators (2024–2027) Nine early childhood educators and 100 indigenous youth in the rural Red Mesa Unified School District located on the Navajo Nation, Arizona are developing computational thinking skills and STEM interest by working with portable maker carts that combine hands-on making activities commonly found in early childhood classrooms with tangible computing tasks (e.g. incorporating e-textiles and squishy circuits for weaving patterns, interactive play, and storytelling). Young children learn about cause and effect, patterns, and sequencing in a manner that is developmentally appropriate and connected to culturally significant practices such as Navajo rug weaving.

Integrating Artificial Intelligence with Smart Engineering and English Language Arts in Upper Elementary Education (2021–2025) Over 50 teachers in St. Louis County, MO are part of a research-informed ecosystem that is engaging over 1,000 students in afterschool and summer programs in constructing functional AI-enabled solutions to problems presented in fictional stories. The ecosystem includes Smart Motors, a novel, low-cost, AI-enabled hardware toolset for students to build smart systems, as well as support for teacher professional development.



Supporting Early Learning of Computational Thinking Using Mixed Reality Technology (2021–2025) Young children (K–2) are learning problem-solving skills in a mixed-reality learning environment that combines visual displays and a robot with programmable movement. Through embodied learning activities, immersive experiences, and gameplay, children get an early start in learning to solve path-finding problems as they understand and use symbols and sequences, which are fundamental concepts in computational thinking.

Cultivating Elementary Students' Interest in Cryptography and Cybersecurity Education and Careers (2019–2024) Elementary students are learning about cryptology and cybersecurity in an 18-hour transmedia curriculum called CryptoComics, which introduces these topics through a blend of digital comics, games, and unplugged activities. Hosted online or on tablets, the curriculum follows four diverse characters as they make and break secret codes while learning about global symbols, historical contexts, and modern cybersecurity careers. Evaluation findings showed increases in students' cybersecurity knowledge and career awareness, and improved afterschool educators' perception of and confidence with cybersecurity education.

The FabLab Classroom: Preparing Students for the Next Industrial Revolution (2010–2015) In school systems in Texas and Virginia, 15 in-service teachers and their upper elementary and middle school students engaged in digital fabrication activities as part of an effort to integrate advanced manufacturing technologies into the K-12 curriculum. These technologies included rapid prototyping technologies such as 3D printers and laser cutters. Affordable technologies such as digital die cutters were also employed to scaffold introductions to more expensive and complex systems. The results demonstrated that with appropriate scaffolding, upper-elementary and middle school students can successfully undertake digital fabrication activities in the classroom.

Middle school is a time for Career Exploration

Youth are exploring their own interests, values, and experimenting in order to explore the world around them. They begin to think about their futures and what type of lifestyles they might want as adults. Middle school is also an important career decision point as youth make their preliminary decisions such as what high schools they want to attend (academic, technical, magnet, pathways...) which can set them on an educational path that will determine their future career opportunities. **Middle school, therefore, is considered a tipping point** – a point at which guided career exploration can help students become aware of the many opportunities there are in the world of work and how their own interests, values, knowledge and skills can be aligned with possible futures.



Providing middle school students with opportunities to explore emerging technologies, their own interests and the world of work can make a difference in the educational and career path they choose to follow. Educators play a vital role in ensuring that all students have the opportunity to explore a broad range of career options through exposure to STEM experiences. They help students develop the foundational skills necessary to choose and succeed in career pathways that offer both personal fulfillment and economic stability, ultimately contributing to stronger families and communities. This is why many future focused educators ensure that students have opportunities in elementary and middle school to develop the foundational skills in STEM along with fundamental skills in communication, expression and writing, and the dispositions needed to be successful in a highly technical world. It is with this exploration of self and the technology-enriched world around them that youth will make informed career decisions that will set them on a path to a productive and rewarding career.

ITEST At-a-Glance: Career Exploration

The following are examples of how ITEST-funded projects guide the career exploration process as students move along in their career journey.

[Rural Energy Futures: Facilitating Community Understanding of Energy Transition Opportunities through Middle-School Math Skills](#) (2024-2027). Impacting up to 720 students, 48 middle-school teachers in 12 rural schools across Maine are working with local energy workforce mentors, policymakers, and community experts to co-develop a place-based, technology-mediated mathematical modeling set of learning experiences. Integrated into the middle school mathematics curriculum, students will use mathematical modeling, statistical reasoning to illustrate the breadth and complexity of local energy transition issues. Student models include data from policy and workforce sources as well as local knowledge from community and family members.

[Integrating Quantum Concepts and Technologies into Middle School Science Lessons](#) (2024–2026). In partnership with 10 science teachers across 6 diverse schools in Indiana, 1040 middle school students per year are developing knowledge about quantum technologies and their applications through simulations and hands-on activities in science classes. The project aims to make abstract quantum concepts accessible and engaging through interactive educational materials for the middle school science curriculum and web-based media resources for a broader audience.

[Middle School Teacher and Student's Experiences with Artificial Intelligence via Computational Cameras](#) (2020-2026) In summer workshops, middle school students from underserved communities in Phoenix, Arizona and rural areas in Georgia are learning about machine learning, computer vision concepts, and future careers in AI and STEM through ImageSTEAM, a professional development program and open-source curriculum currently



in development. The program uses computational cameras to integrate computer science, mathematics, and design thinking in teaching visual AI concepts while also drawing inspiration from media arts to enhance science learning experiences.

Smart Clothing, Smart Girls: Engineering via Apparel Design (2012–2016) Middle school girls across the nation were introduced to STEM careers in schools, art and science museums, and community groups through Style Engineers, an informal learning curriculum that used apparel design as a vehicle developing STEM skills and interest. Each curriculum module focused on essential components of wearable technologies, which includes understanding material properties, electrical circuits and electronics, 2D to 3D visualization, and the engineering design process.

Community Platform for Ocean and Climate Education, Careers, and Workforce Development (2011-2014) Middle and high school students in Prince George's County, Maryland increased their knowledge of ocean and climate science, remote sensing data, and National Oceanic and Atmospheric Administration (NOAA)-related careers through STEM activities, field trips to NOAA research labs, and community programs at the Climate Ocean Weather Institute. As part of the project's STEM Cybermentoring initiative, high school students conducted studies with NOAA scientists and interviewed them about career development.

High School is a time of Career Preparation

At the high school level, students begin their career preparation by deepening their academic skills/knowledge and applying these skills to projects and problem solving. Students develop basic technical skills in computer science, data science, robotics, IT and other courses; develop marketable skills in career and technical education programs; and expand their skills and interests in after school programs, part-time and summer jobs and internships. Students hone their academic and communications skills and other dispositions in and out of school as they expand their personal reach beyond their families and school communities.

Elective and out-of-school activities play an important role in career development as does informal and self-directed learning that takes place after school, in community centers and at home. Important decisions leading students along their career paths are made during a student's high school experience. Shall I go to college? If so, what college?... What program would I like to major in? Shall I go directly to work? Shall I take a gap year and continue my exploration? While some students move directly into the workforce, others enter more intensive career preparation programs, with future technicians moving into community and technical college programs and future STEM workers entering colleges and universities to prepare themselves for life as working adults.



ITEST At-a-Glance: Career Preparation

The following are examples of how ITEST-funded projects support students in preparing for their adult work roles.

[*Biology Meets Engineering: Expanding Transdisciplinary STEM Education*](#) (2024-2029) High school students in 10 schools and 4 school districts in Cincinnati, OH participate in a three-week summer program where they build and program their own autonomous robots (animal-robot sensorimotor systems) and study how biological species sense and respond to their environment. Students use robotics technologies to connect biology and engineering concepts and apply biomimicry to problem-solving. They also gain work experience and career preparation through paid summer internships in biology and engineering research labs at four area universities.

[*Connecting Indigenous Culture and Integrated STEM in Hawaii Through Smart AgTech*](#) (2024-2028) Working with community mentors, high school students in Oahu, Hawaii will use smart farming technologies and sensors to collect data and employ data science to determine the best ways to grow limu, a historically significant Hawaiian crop (seaweed). The project is developing an AgTech-focused integrated STEM curriculum that will connect traditional and modern practices in aquaculture to promote culturally responsive STEM education.

[*A Semiconductor Curriculum and Learning Framework for High-Schoolers using Artificial Intelligence, Game Modules, and Hands-on Experiences*](#) (2024-2028) In summer workshops in Maine and Texas, 150 high school students over three years are developing skills and interests in semiconductor fields through an innovative game-based learning platform to be developed and tested by this project. Hands-on activities and field trips to semiconductor companies will help students connect game-based learning with real-world industry experiences.

[*Empathy-Driven Engineering Internships for Teens: Connecting Technical Work to Social Needs*](#) (2021-2026) Through engineering internship experiences at five sites around the country, high school students design and fabricate accessible media such as games, books, toys, and tactile maps for authentic community clients who are blind, have low vision, or have other special needs. Students use engineering design processes and fabrication tools to create these resources while gaining exposure to career opportunities in engineering and developing their 21st century workplace skills.

[*MapTEACH: Place-based Geospatial Learning and Applications in Rural Alaska*](#) (2004-2008) By the end of this project, 3,319 students—including 2,025 Native Alaskans—and 243 teachers gained access to a culturally relevant geospatial information technology (IT) curriculum supported by web-served imagery, GIS data, and field kits. The project also



engaged 160 secondary students, most of whom were Native Alaskans, and 16 teachers in intensive, internship-like experiences totaling 19,200 and 1,920 contact hours, respectively. Participants integrated geospatial IT with traditional ecological knowledge through cartography, geomorphology, topographic and geologic map interpretation, and remote sensing, culminating in a capstone field experience. Researchers documented new models for strengthening STEM learning in rural Alaskan communities.

Post High School is a time for Continued Preparation and Continuous Lifelong Learning

After high school students continue their career preparation in universities, technical and community colleges, through on the job, and informal learning as they engage in ongoing professional development to advance in their careers and explore their ever-evolving interests. As new technologies and related career opportunities emerge, individuals engage in the career development cycle again with an awareness of the emerging technology and its potential for new career opportunities. They explore their own interests, skills and knowledge related to those emerging technologies and the education/training needed if they want to move into emerging fields. And, some will choose to prepare for work in new fields by participating in professional development, certificate/certification/degree and/or training programs to make a job/career change. Over a career lifetime, individuals may move through the awareness, exploration, and preparation cycles multiple times.

Implications

What does career education research coupled with the ITEST experience mean for K-12 educational leaders and practitioners in formal and informal settings?

Education intends to prepare youth for success in their adult life roles as active/engaged citizens living and continuously learning in our rapidly changing world. As an adult, however, success in life means more than success in learning. It also means success in working – and a desire for a productive and rewarding career.

Career education in schools aims to help students understand the connection between their skills, interests, and potential future career paths and helps them make a smooth and successful transition from school to work. The U.S. model places career decision making in the hands of its citizens who have varying degrees of information and experience with the full range of career opportunities available. The education sector, therefore, is often called upon to “fill in” missing information and experience by providing opportunities for students



to develop skills/knowledge needed to succeed in personally rewarding and productive careers. Research into career development education and the ITEST program encourages educational leaders and practitioners focused on developing a robust future STEM workforce to address career development education in the following ways

What school leaders can do to support STEM Career Education:

- Serve as a STEM Career Education Champion in your school district and community; nurture others as Career Education Champions.
- In partnership with community/business leaders develop and support system-wide STEM Career Education Initiative grounded in innovative uses of technology. Provide professional development and other resources. Start early in elementary school by integrating career awareness and technology-driven habits of mind activities with other classroom activities. Follow-through with support for career exploration/technology activities in middle school and career preparation/technology activities in high school.
- Develop a district-stakeholder council to guide/manage district-wide career education activities.
- Develop public/private partnerships with local business/industry to co-design/develop in and out of school time career education interventions (classroom visits, mentors, student internships, faculty externships)
- Seek outside funding to innovate
- Engage in continuous improvement: track and monitor activities, evaluate short and long-term impacts, refine career development plans, and disseminate results to raise visibility and share successes.

What educators can do to support STEM Career Education:

The table on the next page, organized by career development themes, describes specific recommended actions elementary, middle school and high school level educators can take to support the STEM career education of students in K-2.



Implications for Educators Supporting Students' Career Development (K–12)

Career Development Theme	Elementary School (Career Awareness)	Middle School (Career Exploration)	High School (Career Preparation)
Integrating Career Education Goals	Integrate age-appropriate career activities to build interpersonal skills, self-concept, respect for work, decision-making, and problem-solving. Illustrate/ enrich science, technology, math learning through career examples making connections between what is taught in school and applied in STEM careers.		
STEM Foundational Learning	<p>Introduce STEM “habits of mind” (inquiry-based, technology-driven).</p> <p>Ensure sufficient time and attention to developing foundational knowledge in STEM.</p>	<p>Reinforce foundational STEM, computer science, and technology/computer science skills (e.g., CS Discoveries).</p> <p>Ensure all students leave middle school with a grounding in computer science. Include information on emerging technologies (AI, quantum sciences).</p> <p>Add STEM components to career exploration and competitions.</p>	<p>Offer sequences of STEM courses and electives (engineering, computer science, computer modeling in sciences).</p> <p>Connect classroom learning to real-world STEM careers through projects, competitions, and work-based learning experiences.</p>
STEM Activities & Hands-On Learning	<p>Introduce basic engineering and computer science (CS) programs (e.g., LEGO, CS Fundamentals).</p> <p>Provide hands-on experimentation, engineering and making activities using technology tools to build confidence and curiosity.</p> <p>Integrate STEM into after school programs and exhibitions.</p>	<p>Engage students in projects tied to community issues/interests in which they apply STEM competencies.</p> <p>Host student exhibitions, encourage after-school STEM clubs, and connect in-school and out-of-school STEM learning.</p>	<p>Expand STEM engagement through after-school, summer bootcamps, internships, and exhibitions.</p> <p>Encourage work-based learning, field trips to STEM workplaces, and community-connected projects.</p> <p>Create projects that help students connect their interests, knowledge and skills to relevant STEM issues being discussed in the world around them.</p>



Career Development Theme	Elementary School (Career Awareness)	Middle School (Career Exploration)	High School (Career Preparation)
Career Information & Exposure	<p>Develop career awareness among students by providing opportunities to learn about people who work in the community representing a wide range of STEM careers (through books, posters, photos, guest speakers, videos, role play).</p> <p>Use accurate technical STEM vocabulary and link classroom topics to career examples.</p>	<p>Help students explore careers related to their STEM interests/abilities. Bring in diverse mentors, guest speakers, and videos (e.g., Science Makers). Connect STEM learning to real-world applications.</p>	<p>Invite STEM professionals as role models to mentor, co-teach, and/or judge student work. Illustrate how skills learned in school are used in careers. Emphasize career relevance in all technical instruction.</p> <p>Provide examples of how STEM technical and professional workers apply in their daily work—the foundational concepts/skills developed in high school courses.</p>
Building Career Self-Efficacy	<p>Ensure students' STEM success experiences.</p> <p>Reinforce that students are "scientists" when engaged in field work and experimentation.</p> <p>Provide role models reflecting students' identities.</p>	<p>Help students explore personal interests and expand awareness of career options.</p> <p>Record STEM activities in a STEM career portfolio.</p> <p>Ensure STEM success experiences.</p> <p>Reinforce "I am a scientist."</p> <p>Engage in science competitions.</p>	<p>Ensure STEM success experiences.</p> <p>Maintain student career portfolios.</p> <p>Support reflection on career goals, interests, and pathways.</p> <p>Provide authentic problem-solving experiences linked to real-world contexts.</p> <p>Participate in STEM competitions.</p>



Career Development Theme	Elementary School (Career Awareness)	Middle School (Career Exploration)	High School (Career Preparation)
Soft Skills & Professional Dispositions	Integrate collaboration and teamwork in class projects to build interpersonal and problem-solving skills.	Organize interdisciplinary team projects that foster communication, teamwork, and resilience.	Incorporate team-based, real-world case studies and role plays to develop professionalism, adaptability, and leadership. Provide opportunities for students to engage in problem solving that demonstrate the use of technologies in purposeful ways.
Decision-Making & Career Pathways	Encourage curiosity and awareness about different kinds of work and their purpose in society. Integrate decision-making into student activities.	Help students practice decision-making. Introduce career pathways. Help students recognize that middle school choices (e.g., selecting a high school) affect future career pathways.	Support informed decision-making about elective courses, postsecondary options, aligning coursework and extracurriculars with STEM career goals.
Learning About Work	Invite community members/guest speakers to discuss their careers and connect learning to real-world applications.	Provide examples of how STEM skills translate into workplace tasks. Invite guest speakers to share their work experiences and the importance of what they learned in school to their success. Introduce students to working STEM professionals. Help students understand that employers pay for skills/ knowledge.	Develop student internships, work-study, and summer employment opportunities. Participate in teacher externships to bring real-world industry experience into teaching. Build ongoing partnerships with industry. Help students understand the relationship between jobs and the economy; and between jobs and income.



Conclusion

ITEST has played an important role in the design, development, testing, and implementation of innovative projects that support the STEM career development of America's youth as they prepare for adult life roles in a world driven by technology. ITEST experiences introduce students to innovative uses of technology as they become aware of their own developing STEM interests and skills; learn about STEM workers in their families and communities; explore their own values, interests and abilities; and consider the opportunities available in future STEM careers. These experiences also help students make preliminary career decisions and prepare for next steps in their journeys toward productive and rewarding careers. ITEST projects contribute significantly to the STEM education knowledge base by identifying models, strategies, and learning experiences that hold promise for fostering youth interest and efficacy in STEM, and by advancing understanding of the conditions that support the development of a future STEM workforce able to create and innovate at the Human-Technology Frontier.

For more information on the breadth and depth of ITEST's work see NSF ITEST abstracts at NSF.gov and ITEST's collection of career education and future of work publications:

- [Building the Foundational Skills Needed for Success in Work at the Human-Technology Frontier](#) (Malyn-Smith et al., 2017) for a more detailed description of what types of skills may be required of future workers;
- [K-8 STEM Career Competencies: Developing Foundational Skills for the Future of Work](#) (Malyn-Smith et al., 2021) and [Artificial Intelligence and Learning: AI At-A-Glance in ITEST](#) (Malyn-Smith & MacGillivray, 2022) for examples of how various technologies and topics can be integrated into K-8; and
- [Developing the Next Generation of Talent: Perspectives from the Field on Equity and the Future of Work](#) (Malyn-Smith, 2022) for a toolkit for managing difficult conversations around equity and work.



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