

STEM Smart: Pathways to Middle-Skill Occupations and Beyond

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Digitally Supported Pathways Transitioning Students Into Technical Education Fields

Background

The Center for Aviation and Automotive Technology Education using Virtual E-Schools (CA²VES) is funded through the National Science Foundation's Advanced Technological Education (NSF ATE) program and represents a partnership among the Clemson University Center for Workforce Development, technical colleges, school districts, and local industry. During 2013, South Carolina's manufacturing industry had more than 7,000 job openings, but many of these well-paying jobs went unfilled due to a lack of skills in the workforce. CA²VES' mission is to advance aviation, automotive, and manufacturing technician education to support workforce preparedness and meet the advanced technology workforce needs of South Carolina's anchor aviation and automotive businesses, industries, and suppliers. To achieve this mission, CA²VES is developing a cutting-edge digital learning curriculum that includes virtual reality tools, immersive virtual reality environments, and online learning modules. CA²VES' relationship with over 30 industry partners allows for the development of a digital learning curriculum that is current, relevant, and applicable to the industry. As a result of partnerships with all 16 South Carolina technical colleges and various ATE Centers, CA²VES is well positioned to prepare students for careers in high-demand fields and provide maximum workforce impact in the Southeast through the distribution of cutting-edge educational resources that align with nationally recognized certifications.

Documented Results

CA²VES' virtual reality simulations are designed to provide aviation, automotive, and manufacturing technology students the advantage of learning fundamental skills and inspection principles within safe, unrestricted, and authentic virtual environments. Hands-on experience with industry-specified equipment is important in any technician education program, but schools with limited resources may not be able to offer students ample practice opportunities with such equipment. In a recent study, students who utilized CA²VES virtual tools received similar scores in a skill-based assessment when compared with those who received traditional instruction. Schools with limited resources can offer these virtual reality simulations to technician education students so they have plenty of time to master fundamental skills prior to entering the physical lab.

Potential Applications

Clemson University Center for Workforce Development (CUCWD) recently launched EducateWorkforce.com, a new and innovative online learning portal to house the digital curriculum developed through CA²VES and meet the needs of both industry and educational institutions. This learning portal replicates the structure of many notable Massive Open Online Course (MOOC) platforms but will be specifically tailored to the unique needs of two-year colleges and will offer course materials free of charge or at low cost.

EducateWorkforce.com will allow students to navigate the virtual reality tools and digital curriculum at their own pace, with the option of repeating modules when additional practice is necessary. Instructors can also use this portal by integrating the module content, video lectures, virtual reality tools, and/or assessments into their own courses. CA²VES' digital curriculum was

developed according to the universal design for learning (UDL) principles with the aim to make learning experiences more equitable and available to all learners. Students with varying learning styles, learning disabilities, and/or physical disabilities can benefit from the CA²VES curriculum because the material is presented in a variety of formats (eBook, video lectures with interactive closed captioning, and virtual reality simulations) and offers learners ample opportunity to practice concepts and express what they have learned through a variety of assessments (true/false and multiple-choice questions, discussion prompts, authentic critical-thinking exercises, hands-on virtual reality activities, etc.). The EducateWorkforce.com platform allows students to navigate these resources with ease and the platform capabilities allow for immediate feedback for each assessment.

For More Information

For more information about CA²VES and the CUCWD, please visit our website at <http://www.clemson.edu/centers-institutes/cucwd/centers/ca2ves/>

Also visit the Educate Workforce website: [EducateWorkforce.com](http://www.EducateWorkforce.com)

Making Is Learning

Background

The Maker Movement is inspiring thousands of young people across the nation to tinker with and tackle problems involving design, engineering, and programming. There is a strong sense that young makers are accomplishing much more than producing objects—they also seem to be acquiring a host of valuable knowledge and skills. Because making is a relatively recent phenomenon, there are not yet frameworks in place for identifying and documenting these benefits to youth. What are makers learning? How is making changing the way young people engage in science, technology, engineering, and math (STEM)?

The New York Hall of Science (NYSCI) has been at the forefront of embracing authentic approaches to STEM learning that engage young people's desire to explore, create, build, and make. NYSCI embraces a triad of universal, freely chosen methodologies called Design-Make-Play (DMP), which young people use to investigate how “real stuff” works in order to solve problems, build devices that improve, and repurpose the creations of others. The focus on “how stuff works” overlaps extensively with the processes that lead to creative thought and innovation in STEM learning.

As the host site for World Maker Faire, NYSCI has been convening national leaders to converse about learning and engagement as they relate to young people's passions about making. NYSCI hosted a series of annual conferences; the first two yielded learning frameworks related to DMP methodologies. The third built on the previous meetings and took a critical look at how to describe and document the learning that takes place when young people make. The symposium brought together nearly 150 makers, funders, educational researchers, educators from K–12 and informal settings, museum and community-based leaders, and policymakers. The aim of this national symposium was to craft a strategy for documenting the variety of learning and engagement that making methodologies foster.

A distinguishing feature of the symposium was the creation and sharing of a collection of young maker profiles, produced during Maker Faire by six experts known for their creative approaches to learning and assessment in STEM fields. Guided by the DMP learning framework generated during the previous symposium, each expert assembled a profile of an individual or a group of makers in which they examined the makers' work and thinking. The profiles included images, videos, written descriptions, interpretations, and reflections on DMP.

Documented Results

During the symposium, the participants were asked to apply their expertise and experience to reflect collaboratively on the young maker profiles. What resulted was the emergence of four focal points that highlight the affordances of the DMP framework.

(1) Motivation and Persistence. The young maker profiles suggest that makers develop the confidence to view failure as a necessary step in the iterative process of design, in which acquiring the ability to evaluate one's own progress is a natural outcome. The ability and desire to persist in the face of challenges also emerged from all the profiles and took various forms, including investments of many hours and a search for solutions that required multiple

attempts. Another distinguishing feature of making is the role that personal choice and initiative take in driving learning—the makers who were the focus of the profiles were there of their own accord, rather than as a result of externally imposed pressures. Because maker projects are fueled by personal interest, they have the potential to engender interest.

- (2) **Context and Support.** The profiles and meeting deliberations revealed the importance of context for enabling young people to engage in making, as well as for attending to equity considerations. All the makers benefited from supports, whether from their family, schools, or afterschool clubs. Supports include the provision of materials, intellectual constructs, emotional encouragement, and/or opportunities to explore through making.
- (3) **Process, Problem Solving, and Learning.** The essence of making is doing what it takes to first articulate and then solve a problem, including seeking support and new information. Within the diversity of maker projects and the variety of challenges encountered, makers acquire and draw upon a wide range of general and content-specific skills and knowledge to solve problems. Moreover, in contrast to so much formal instruction in which topics are learned and then left behind, the ability to apply strategies learned in an earlier project to the project at hand is a cumulative skill that grows with the maker's experience. Whether novices or experts, the makers all took pleasure in hands-on learning in which they physically engaged with the processes and products of making.
- (4) **Storytelling and Sharing.** The makers also had in common a desire to share their experiences with a broader community. They were eager to share their process as well as their challenges, and eager to offer advice and to seek it. Identifying and communicating the challenges of each project required makers to hone flexible and effective communication skills. There was even evidence that some young people, who would otherwise be less inclined to engage socially, had found a context in making that promoted their participation in a broader social community.

Potential Applications

This research has led us to envision a tool that will honor the sense of efficacy and agency that young makers bring to their work, while at the same time supporting opportunities to document the benefits that accrue through DMP engagement.

The NYSCI Maker Space has developed an approach to creating maker activities informed by the DMP framework. The approach—a work in progress—focuses on investigating the materiality of objects and exploring the potential of tools.

For More Information

Design-Make-Play: <http://nysci.org/design-make-play/>

Making Meaning Report:

http://informalscience.org/images/research/2013-05-24_Making%20Meaning%20Report.pdf

Blog: <http://www.edutopia.org/blog/stem-engagement-maker-movement-anmarie-thomas>

Problem-Based Learning (PBL) Implementation Strategies for STEM Courses

Background

Industry is increasingly looking to high schools, community colleges, and four-year universities to graduate problem solvers—individuals who skillfully communicate and apply their knowledge of science, technology, engineering, and mathematics (STEM) and other disciplines to solve real-world problems. Yet instructor-centered pedagogical methods paired with text-based exercises often do not address the interdisciplinary, ill-defined, and ambiguous problems graduates will face when entering the 21st century workforce. Since 2006, the New England Board of Higher Education (NEBHE) has been funded by the National Science Foundation's (NSF) Advanced Technological Education (ATE) program to develop a series of curriculum and professional development projects using PBL in collaboration with industry.

Curriculum Development. Each project has created a series of instructional materials: authentic real-world multimedia case studies called Challenges in the fields of optics and photonics (PHOTON PBL), sustainable technologies (STEM PBL), and advanced manufacturing (AM PBL). The PHOTON PBL and STEM PBL materials have been field tested in high school and college classrooms and are being pilot tested in middle schools. The AM PBL Challenges are currently under development. Project participants have been recruited in partnerships called an Alliance in order to promote pathways to higher education and careers in STEM. Access to the Challenges is free of charge at http://www.pblprojects.org/?page_id=884.

Professional Development. The projects' instructional materials have been disseminated through multi-day professional development workshops, a distance learning course, short *Introduction to PBL* workshops, and conference presentations across the country. In addition, two teacher education courses have been developed and delivered at Central Connecticut State University: an undergraduate course designed to teach pre-service STEM teachers how to introduce PBL into the classroom and a graduate course designed to prepare in-service teachers for PBL.

Based on requests for assistance in developing PBL curricula from schools that were not part of the ATE projects but are interested in introducing PBL to their students, NEBHE has begun to offer consulting services that prepare instructors to develop their own Challenges based on topics of their own choosing.

Documented Results

Fourteen PBL multimedia materials—eight PHOTON PBL and six STEM PBL Challenges—have been field tested in secondary and postsecondary institutions across the country. Our research shows that PBL engages students in inquiry-based real-world problem solving, teaching students “how to learn” by collaboratively solving authentic real-world problems. The research shows that compared with traditional lecture-based instruction, PBL improves student understanding and retention of ideas, critical thinking and problem-solving skills, motivation and learning engagement, the ability to work in teams, and the ability to transfer skills and knowledge to new situations.

Comments from teachers and students who have used the Challenges include:

- "PBL was a very rewarding experience for me. I felt like an actual scientist instead of a student in high school. When you are just sitting at a desk and teachers are giving you information it's really boring, but when I have to find the information on my own it sticks with me." —Taft Union High School student, California.
- "PBL teaches you what to do when you don't know what to do. First, by process of elimination, you learn what you do know and then it gives you clear steps on how to go about researching the parts that you don't know." —Springfield Technical Community College student, Massachusetts.

All of the Challenges have been developed in collaboration with industry. Follow-up with the PBL industry partners verifies that employers are eager to engage with education institutions in order to increase the number of graduates who have problem-solving, critical-thinking, and teamwork skills. Dale Miller, semiconductor manufacturing and operations director at IBM Microelectronics Division in Vermont, an AM PBL industry partner explained, "IBM's future depends on highly skilled workers, including both technicians and engineers. We fully support programs like AM PBL and are eager to do our part to ensure a well-prepared workforce."

Potential Applications

The projects' team of experienced PBL practitioners trains instructors in "learn by doing" workshops in which instructors experience the PBL process as a student. Participating instructors gain access to a library of teachers' resources, become versed in implementation and assessment strategies for PBL, and are prepared to develop their own PBL Challenges based on industry problems using the project's *Challenge Design Guide*.

NEBHE's PBL projects' instructional materials have been aligned to the science, mathematics, and technological literacy standards, as well as the English language arts and mathematics components of the new *Common Core State Standards* (CCSS) and will be aligned to the science and engineering components of the *Next Generation Science Standards* (NGSS). Instructors are introduced to a template and set of curriculum-mapping tools to align their own PBL curriculum materials to national academic standards and accreditation criteria.

NEBHE is currently in the second year of a consulting project with Kennebec Valley Community College in Maine to help faculty incorporate PBL into a new ATE-funded Energy Services Technology degree program. This initiative was featured in ATE@20 and can be viewed at <http://www.atecentral.net/ate20>.

For More Information

Visit <http://www.pblprojects.org> to access NEBHE's PBL Projects, the PBL Challenges, and supporting teacher and student resources. Contact Fenna Hanes, NEBHE's senior director of professional and resource development, at fhanes@nebhe.org or call 617-357-9620 x129 to learn more about these initiatives.

Research papers presented at regional, national, and international conferences can be found under each of the PBL projects at http://www.pblprojects.org/?page_id=215.

Real World Externships

Background

Real World Externships were developed as a solution to the often heard question of students, "When am I ever going to use this?" Teachers of secondary mathematics, science, and technology may not experience or become knowledgeable about the applications of their disciplines in industry through the course of standard teacher preparation. A bridge is needed to connect educators to the private sector. That is the impetus behind this program. Real World Externships provide educators with the experience to steer students to science, technology, engineering, and mathematics (STEM) related careers. This is accomplished by teachers working side-by-side with local businesses and organizations in or near the community they serve. What all Real World Externships business partners have in common are commitments to STEM education in their communities and the capacity to provide a teacher with inspiring, meaningful projects working in consultation with academic mentors through the Iowa Governor's STEM Advisory Council.

Role of the Business Host:

- Build a five to six-week hands-on, minds-on experience through which the teacher extern contributes to company operations by applying mathematics, science, and technology skills.
- Aid the teacher extern in documenting his/her experience and reflections on a weekly basis and permit the sharing of these reflections in full or in part. (*Externs must be mindful of proprietary information when composing reflections.*)

Real World Externships are a launch point for permanent business-school partnerships, and hosts may contribute to the application of the Externship in the classroom as requested by teacher externs. Hosts are also encouraged to cost-share by contributing to project operational expenses or by helping to pay the teacher's compensation.

Role of the Teacher Extern:

- Contribute talents, knowledge, and skills to business operations.
- Produce a written description of the Externship within the first week or two of the experience.
- Write a weekly blog detailing experiences—including reflections and responses to guiding questions offered by the Externship's mentor.
- Produce a two-page or longer paper stating the direct connections between the value of the Externship experience and his/her personal classroom teaching.
- Produce a detailed project-based learning experience that translates the summer Externship experience to the classroom.

Documented Results

Evaluation findings show that the Real World Externships project furthered the goal to increase teacher and student knowledge of STEM topics and careers in Iowa. In 2012-13, the program provided teachers an opportunity to experience real world application of their discipline and to translate their new work experience and career awareness to classroom lessons. This experience was intended to help teachers increase student interest in, and awareness of, STEM topics.

Business hosts were positive about their experiences with the Real World Externship program. Hosts' expectations to provide teachers with real world applications to take back to their classrooms were met by the end of the summer. Hosts realized mutual benefits from the program by gaining a teacher knowledge base and contributing to advancing and/or completing workplace projects. Business hosts planned to remain engaged with the teachers and contribute further to student learning by providing resources, such as supplies and equipment, guided tours, and assisting with or providing classroom lessons and presentations.

Teachers were also encouraged by the positive experience from the Externship program. By gaining real world experience to apply in the classroom, teachers became more knowledgeable of real world applications and more confident in their abilities to advise students about further education and careers in STEM. Teachers used the ideas and connections gained from the experience to make class activities more relevant and engaging, and reported increased student knowledge and interest in STEM careers and skills.

Teacher-externs' students maintained positive perceptions of STEM topics throughout the 2012-2013 school year. Students viewed STEM subjects as both important and helpful in the real world and found it important to achieve good grades in math and science. Between groups, differences most frequently occurred in student perceptions of engineering, and were most positive among males, middle school students, and students with teachers for the entire year. Middle school students, compared to all other groups, placed the most importance on getting good grades in math, and more frequently agreed that math will help them in the real world. STEM career interest increased across all groups from pre-test to post-test.

Potential Applications

A Real World Externship is similar to a traditional internship but with some distinct differences. The Externship host (i.e., business or organization) can expect a skilled, productive, independent professional with the ability to solve problems from the start of the experience. A thorough teacher application along with an initial meeting between the program coordinators, Externship host, and teacher, help to match the skills of the teacher with the requirements of the Externship host. The Externship itself can take many forms. Our most successful experiences have occurred when the extern has one or more focused projects that utilize skills and contribute to the operations of the business. We have also found that it is important the extern has the opportunity to interact with other professionals along the way, fostering a sense of teamwork and collaboration between the teacher and host employees.

Any Iowa secondary, public or private school, teacher of mathematics, science, or technology is eligible to apply. Selected externs earn up to two graduate credits and a stipend, as well as an experience which utilizes the latest real world applications specific to each extern's discipline. Extern hosts receive a unique opportunity to work with some of Iowa's most talented science, mathematics, and technology instructors who can offer uncommon expertise and save host sites time and money. In turn, Externships provide a launch point for lasting business-school partnerships that enhance classrooms, the workplace and the community at large.

For More Information

<http://www.iowastem.gov/imsep/http%3A/%252Fiowastem.gov/externships>

The STEM Academies at Wheaton High School

Background

Wheaton High School (WHS), a diverse suburban school located in Maryland just outside Washington, D.C., is organized into small learning communities called Academies, each of which has a college and career readiness focus. The Bioscience Academy and the Engineering Academy are State Certified Project Lead The Way (PLTW) programs. The Bioscience Academy has been recognized by the *Washington Post* as one of the top programs in the area and the Engineering Academy was recognized as one of the top 10 engineering programs in the country by PLTW. The Academy of Information Technology is part of the National Academy Foundation and serves students that are interested in computer programming and website development.

The Academies are relevant to students because they connect to their career interests and allow them to build skills and knowledge through project-based instruction. Each Academy connects students to professionals through job shadowing, internships, field trips, and “lunch and learn” presentations, where professionals join students for lunch and explain their jobs and expertise. Each Academy provides students with a cutting edge, rigorous sequence of four or five courses that culminate in a capstone project.

The Academy programs provide academic supports for students that are struggling and academic extensions for students that need additional rigor and stimulation. A program called “Take Action” is in its fifth year of existence. This program provides students with an extended school day, twice a week, to meet with teachers and mentors in an environment that is focused on developing student self-efficacy and supporting students as they meet their academic potential. On Saturday mornings, students in the Bioscience Academy meet with medical school students who mentor them and assist in the facilitation of study groups around Advanced Placement (AP) biology and chemistry content.

The WHS vision is to prepare all students for success in college. For students who are ready for college before graduating from high school, we provide eight college course offerings, taught by college professors on the WHS campus. As a result of these courses and additional avenues, some students graduate having already earned college credits.

The Academies are centered around a rigorous sequence of elective courses where students apply biomedical, engineering, and computer programming to solve problems and produce projects. The implementation of this cutting-edge curriculum comes at a cost. WHS, working collaboratively with the Maryland State Department of Education and Montgomery County Public Schools, has been able to secure more than \$200,000 of grant money since 2007 to establish and maintain the equipment, materials, and classroom space necessary to provide a 21st century learning environment.

Documented Results

WHS celebrated 222 individuals who completed a STEM Academy program in 2012 and 2013, the highest number to complete programs of study at any high school in Montgomery County Public Schools. The combined scholarship money earned by Academy program completers

equals more than 10 million dollars. Since 2010, WHS has graduated three Gates Millennium Scholars, two Posse Scholars, and a Meyerhoff Scholar. Every program completer wears a special stole at graduation and is recognized at a Program Completer Celebration attended by parents, graduates, and business partners.

Many indicators of student achievement from 2008–2013 show that WHS is moving in a positive direction despite an increase in the FARMS rate (i.e., students receiving free and reduced-price meals) and an increase in the number of students enrolling at the lowest levels of ESOL (i.e., English for speakers of other languages) and in the Multidisciplinary Education, Training, and Support (METS) program for students with interrupted education. One reason for the continual improvement in student achievement is that all students at WHS are encouraged to take Honors and AP courses. Teachers hold students to high expectations and provide strategies that allow students to access the learning. Since 2008, WHS has increased the number of AP tests taken by 106 and the percentage of students earning a 3 or higher on the College Board Examination has continued to increase.

Potential Applications

Many of the models we have created for program recruitment, retention, and academic extension are replicable. The foundation of our instructional programs for biomedical science and engineering results from the rich curriculum and tremendous training received by our teachers.

For More Information

Contact Heather Carias (heather_b_carias@mcpsmd.org) or Andrea Robertson-Nottingham (andrea_m_robertson@mcpsmd.org).

DeafTEC: Technological Education Center for Deaf and Hard-of-Hearing Students

Background

On a broad, national level, DeafTEC: Technological Education Center for Deaf and Hard-of-Hearing Students, a National Science Foundation Advanced Technological Education (NSF ATE) National Center of Excellence, serves as a resource for high schools and community colleges that educate deaf and hard-of-hearing (deaf/hh) students in STEM-related programs and for employers hiring deaf and hard-of-hearing individuals. DeafTEC is also establishing a model within targeted regions of the country to create partnerships among high schools, community colleges, and industry to improve access to technological education and employment for deaf and hard-of-hearing individuals.

DeafTEC is housed at the National Technical Institute for the Deaf (NTID), one of the nine colleges of the Rochester Institute of Technology in Rochester, New York. NTID was established in 1968 to reverse the long history of underemployment and unemployment among our nation's deaf/hh citizens. Today, more than 1,300 deaf/hh students study, share residence halls, and enjoy social life together with 16,000 hearing students on the RIT campus.

The goal of DeafTEC is to successfully integrate more deaf/hh individuals into the workplace in highly skilled technician jobs, in which these individuals are currently underrepresented and underutilized. To achieve this goal, DeafTEC is establishing:

- (1) a comprehensive website (www.deaftec.org) that will serve as a clearinghouse for information related to technical education and technician careers for deaf/hh students, including career awareness materials, strategies for improving student access to learning, instructional strategies and materials for teachers to use to develop the English and math skills of deaf/hh students, as well as information for employers to help them provide a more accessible workplace; and
- (2) a model within three targeted regions of the country—California, Florida, and Texas—that will create partnerships among high schools, community colleges, and industry to improve access to technological education and employment for deaf/hh students.

Documented Results

DeafTEC is impacting the knowledge and attitudes of high school teachers, community college faculty, employers, and the deaf/hh students themselves in terms of the educational and employment opportunities and options available to these students. It also provides professional development experiences to improve the instructional expertise of high school and community college teachers in STEM subjects and in pedagogy that will provide greater access to learning for deaf/hh students, as well as all students in the classroom, particularly other students with language difficulties. Finally, DeafTEC is establishing and expanding pathways for deaf/hh students to transition from high school to college in several STEM areas through a national dual-credit program.

Potential Applications

DeafTEC's professional development and assistive technologies can benefit students with different learning styles. In particular, its use of universal design for learning would be beneficial to students with language or other learning difficulties.

For More Information

Visit www.deaftec.org

EAST-2 Alliance

Background

Opportunities for students with disabilities have increased along with the rapid advancement and development of technology, and their enrollment in post-secondary institutions is slowly increasing. However, they continue to be underrepresented in comparison to their non-disabled peers (<http://www.washington.edu/doit/Faculty/Rights/Background/statistics.html>). The National Postsecondary Student Aid Study reports that approximately 45% of undergraduates with disabilities are enrolled at public two-year institutions (NCES, 2008). There also is a growing interest in research on accessibility of higher education for students with disabilities (Newman et al., 2010; Snyder & Dillow 2010).

The mission of the EAST-2 Alliance is to increase the number and quality of students with disabilities who enroll and receive degrees in science, technology, engineering, and mathematics (STEM), and ultimately enter STEM disciplines. EAST-2 achieves this mission by involving students, transforming the academic and professional environments in which they function, and catalyzing STEM activities in southern Maine. EAST-2 has designed a model that includes the creation of a pipeline of supports and services for high school and college students with disabilities as they successfully negotiate critical junctures. The EAST-2 pipeline focuses on undergraduate STEM research fellowships (URFs), mentoring and tutoring, weekly learning community events, accessible technologies, internships, individualized case management, high school summer STEM camps, transition services, and the development of capacity within high schools and the University of Southern Maine (USM) to fully support students with disabilities (SWD). Activities along our pipeline increase students' confidence in their STEM learning and give them the opportunity to participate in life-changing experiences. The EAST-2 pipeline model serves to broaden the participation of students with disabilities in STEM fields.

Documented Results

EAST-2 employs evidence-based practices. Both qualitative and quantitative data we have collected suggest that the support EAST-2 provides contributes to students' persistence in and eventual graduation from undergraduate STEM programs at USM (Langley-Turnbaugh et al., 2014). Analysis of data revealed that students who participated in URFs through EAST engaged fully in research processes, by and large were on track for completing their degrees, were more likely to enter graduate school and jobs in STEM fields than non-URF students, and enjoyed benefits that could be described as both personal and relational (Langley-Turnbaugh et al., 2014).

In an effort to examine the impact that EAST-2 activities have on students' enrollment and graduation, we compared the lengths of time, number of activities, and number of types of activities for three different groups of EAST-2 students: those who had graduated, those who are still enrolled, and those who are not enrolled. Students who had graduated and students who are still enrolled participated for a longer period of time in EAST-2 and in a larger number and variety of types of EAST-2 activities than students who are no longer enrolled. This data suggest that participation in EAST-2 contributes to students' persistence in and graduation from undergraduate STEM programs (Langley-Turnbaugh et al., 2014).

EAST-2 activities for students (including undergraduate research fellowships, learning community seminars, internships, transition sessions, STEM camps) are highly valued by participants and are successful in helping them achieve the desired learning outcomes.

Student outcomes include:

- improved research skills
- increased interest in, familiarity with, and confidence in pursuing specific STEM topics
- increased awareness of their level of academic preparation
- enhanced self-advocacy skills
- increased awareness of tools and support services available at the college level
- increased awareness of transition issues and engagement in transition activities
- increased interest in pursuing advanced coursework and careers in STEM

Potential Applications

The EAST-2 model is adaptable and adoptable; for guidelines on how to replicate models for students with disabilities, access DO-IT at

<http://www.washington.edu/doit/Brochures/Programs/adaptation.html>.

For More Information

- DO-IT <http://www.washington.edu/doit/>
- CAST <http://www.cast.org/>
- <http://fod.msu.edu/oir/universal-design-learning-udl>
- <http://www.ist.hawaii.edu/training/>
- <http://disabilities.temple.edu/programs/ds/hEd3udl.shtml>

Publications

- Langley-Turnbaugh, S., Whitney, J., & Blair, M. (2014). Increasing accessibility of college STEM courses through faculty development. In *Universal Design in Higher Education: From Principles to Practice*. Harvard Education Press.
- Langley-Turnbaugh, S., Whitney, J., Lovewell, L., & Moeller, B. (2014/In Press). Building and implementing a successful undergraduate research fellowship program for students with disabilities. *CUR Quarterly*.
- Langley-Turnbaugh, S. J., Wilson, G. & Lovewell, L. (2009). Increasing the accessibility of science for all students. *Journal of Science Education for Students with Disabilities* 13, 1-8.
- Stumbo, N. J., Martin, J. K., Nordstrom, D., Rolfe, T., Burgstahler, S., Whitney, J., ..., Misque, E. (2010). Evidence-based practices in mentoring students with disabilities: Four case studies. *Journal of Science Education for Students with Disability*, 14(1), 33-54.
- Whitney, J., Langley-Turnbaugh, S., Lovewell, L., & Moeller, B. (2012). Building relationships, Sharing resources, and opening opportunities: A STEM learning community builds social capital for students with disabilities. *Journal of Postsecondary Education and Disability*, 25, 131-144.

FabNet: Extending the FabLab Classroom

Background

According to the Society of Manufacturing Engineers (SME), personal digital fabrication will offer revolutionary changes for manufacturers and the everyday consumer. In fact, personal fabrication was featured in SME's 2009 Innovations That Could Change the Way You Manufacture list. Advanced manufacturing technologies, such as 3D printers, are transforming engineering education; within the past few years, desktop manufacturing systems have become affordable at the K–12 level.

The FabLab Classroom was funded by the National Science Foundation to explore the use of digital fabrication to allow students to create digital designs that are realized as physical objects, such as model satellites (in collaboration with NASA), wind turbines, and speaker systems. This work provided a context for addressing the Commonwealth Engineering Design (CED) Academies' two goals:

- (1) To help create the skilled workforce needed for the future by preparing K–12 students for the jobs expected in the future and related skills required for those jobs
- (2) To respond to draft *Next Generation Science Standards* that call for integration of engineering design into science education (National Research Council [NRC], 2011).

Building on the FabLab work and the existing collaboration with the Smithsonian Institution, the University of Virginia will advance the above goals through the Fabrication Network (FabNet). FabNet is designed to ensure that preparation in K–12 schools is aligned with engineering education strategies in Virginia's community colleges and universities.

Documented Results

In a pilot effort, middle school students in a Lab School engineering class reconstructed a reciprocating electric motor invented by Joseph Henry in 1831. They used supporting materials adapted from Princeton engineering labs to develop an initial design, and employed a CAD program (AutoCAD 123D) and 3D printer (Afinia Model H) in the process. The resulting device has strong applicability to the Electricity and Magnetism standards in middle school physical science and, hence, serves as a useful bridge to link the engineering and science classes. The pole-switching circuit that Henry devised to power the device led to one of the first documented instances of an electromotive device that could perform work (i.e., act on another linked device). This invention played a role in subsequent inventions, such as rotary motors with commutators and brushes.



With appropriate scaffolding, middle school students are capable of designing a working reciprocating motor based on the same principles as the original “electromotive device” developed by Joseph Henry. This affords opportunities for novices to design an initial solution to the challenge, with ample scope for refinement.

Potential Applications

The materials piloted in this manner (scanned artifacts, lesson plans, assessments) will comprise case studies that will be hosted by the Smithsonian and used to create a Fabrication Network (FabNet) of schools using 3D technologies in science and engineering courses. The findings will inform the next generation of schools that are planning to integrate engineering education into their curricula.

For More Information

The activities and designs for the pilot activities described will be housed on the Smithsonian 3D printing educational website, <http://3d.si.edu/>. Other resources that support digital fabrication in the classrooms are available at <http://maketolearn.org/>.

The GLOBE California Academy Program

Background

In October 2011, WestEd and University of California Berkeley's Career Academy Support Network (CASN) received a three-year collaborative ITEST Strategies grant to improve learning and workforce development in science, technology, engineering, and math (STEM), and in information and communication technology (ICT)—especially for underserved students. The proposed strategy integrates the hands-on science pedagogy of the Global Learning and Observations to Benefit the Environment (GLOBE) program¹ into the multi-year curriculum of the California green high school academies². The GLOBE California Academy Program (CAP) engages students in research related to climate change, provides career development activities, and supports teachers in career academies through professional development and other forms of support that focus on the growing renewable energy and clean technology workforce sector.

Hands-on laboratory experiences and inquiry- and project-based learning have long been standard features of science education. Project-based learning can also be part of a multi-disciplinary strategy to engage students and prepare them more effectively for college and careers. In career academies, students implement projects that both strengthen their science practices and connect the content and practices to students' career aspirations. Furthermore, integral to career academies are opportunities for students to engage in “work-based learning”—an extension of project-based learning beyond the classroom that is linked to professional standards and transferable 21st century skills, uses employer or community interaction to engage students, and intentionally promotes learning and access to future educational and career opportunities (Darche, Bracco & Nayar, 2009). The GLOBE initiative offers students the opportunity to contribute to real science by using high-quality scientist-developed protocols, and entering their data into an international database for scientific analysis, which is consistent with this definition of work-based learning. Students not only learn, but produce outcomes of value to others beyond school. These kinds of experiences also activate adolescents' developing sense of agency (Bandura, 2006), which may produce further positive outcomes. Finally, the structure of the academies, based on cohort scheduling over three years, offers coherence and continuity for students over time, and supports academic skill-building as well as both career and socio-emotional development from one grade to the next. This structure also allows for the embedding of multi-year initiatives. GLOBE CAP will build students' knowledge and skill over a span of three years as follows:

- **9th and 10th grades:** Students focus on collecting data using GLOBE protocols and learning activities, understand science from scientists, and gain exposure to the career path of a scientist through direct interaction.

¹ The GLOBE program is a worldwide hands-on, primary and secondary school-based science and education program. GLOBE's vision promotes and supports students, teachers and scientists to collaborate on inquiry-based investigations of the environment and the Earth system working in close partnership with NASA, NOAA, and NSF's [Earth System Science Projects \(ESSPs\)](http://www.globe.gov) in study and research about the dynamics of Earth's environment. See www.globe.gov.

² Career academies are schools-within-schools that organize learning around career themes. Students typically enroll in academies for three years, in grades 10–12. Teachers also commit to their academies and work collaboratively to integrate the curriculum across disciplines. In California, the state-funded California Partnership Academy program requires that at least 50% of the students meet “at risk” criteria.

- **11th grade:** Students continue to collect data but, in addition, develop their analytical skills through data visualization and interpretation; begin collaboration with sister schools in other countries to build global awareness; and continue career exploration in STEM fields.
- **12th grade:** Students continue to collect, interpret, and create visualizations of data but also explore the links to public policy, and they apply their knowledge and skill in a service learning project or social enterprise in their local community.

Documented Results

In its first year, GLOBE CAP enrolled teachers and students; conducted needs assessments in order to customize teacher support; provided GLOBE training to teachers; built partnerships with key organizations, including the Chabot Space and Science Center, the UC Berkeley Departments of Chemistry and Earth and Planetary Science, and the GLOBE Program Office; placed college mentors in classrooms; created a three-year framework for student projects that embeds GLOBE data collection and activities; developed assessment tools; facilitated scientist visits to GLOBE classrooms; built internal and external websites; and laid a foundation for future replicability. Six northern California high schools are participating in GLOBE CAP, including 19 teachers and over 300 students. GLOBE instrument shelters have been sited and student data collection is underway. In its second year, teachers were trained to download GLOBE data for data analysis and visualization, and students are now engaged in projects to develop these skills. Graduate student scientists are supporting teachers as both career speakers and in curriculum development, bringing real-world relevance and role models to GLOBE CAP classrooms.

GLOBE CAP is undergoing a rigorous evaluation process to track students' course-taking patterns and grades in science, GLOBE-related science content knowledge, students' science-related attitudes, and the development of an array of science practices and 21st century skills. It is also examining teacher facility with GLOBE protocols and science practices, as well as programmatic outcomes. Year one results showed gains in science-related attitudes, especially "enjoyment of science lessons" and gains on the science content knowledge assessment developed for use in the study. Lead teachers in GLOBE CAP showed measureable growth on 9 of 14 items assessing their knowledge, skills, and experience with GLOBE protocols and practices.

Potential Applications

A growing number of schools are implementing career academies as a high school reform model; there are currently over 7,000 academies nationwide. In addition, the demand for professional and technical workers in the renewable energy sector is likely to grow. Occupations in this sector, from installing and maintaining new energy technologies to conducting basic research, require knowledge and skills across several STEM disciplines. Implementation of GLOBE within California's green academies will provide a proof of concept for more widespread implementation in California and across the country. Partnership with the GLOBE network, detailed documentation, and communication with national groups involved with STEM and career academies will help pave the way to broader replication.

For More Information

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Health IT Entry Certification: A Rapid-Growth Industry Beckons New Talent

Background

American Recovery and Reinvestment Act incentives drove healthcare providers to adopt electronic patient record software systems. The resulting demand for IT professionals in healthcare was rapid and has continued to increase, illuminating the lack of a coherent entry sequence for job seekers in the field. Due to the unique, stringent patient security requirements and the singular nature of information technology at the point of patient wellness and care activities, health IT has emerged as a discrete domain in education. Graduate programs in healthcare informatics have proliferated in the past decade. Employers are calling on community colleges to infuse allied health and nursing curricula with information technology content, as well as to produce educational offerings that provide new and necessary skills for incumbent workers. Community college IT instructors who teach in areas such as database management, network security, and data analytics are in need of healthcare-specific content. In addition, career awareness is nonexistent for this high-demand, high-wage sector, which lacks the navigational aids for job seekers commonly found in a more mature field.

Recognizing the need for certification in the burgeoning area of information technology in healthcare, the National Science Foundation recently supported the development of a credential geared towards entry-level learners. In partnership with the largest professional association in the sector—the Health Information Management and Systems Society (HIMSS)—the Certified Associate in Health Information & Management Systems (CAHIMS) certificate was created, along with a preparatory curriculum. Dozens of health IT practitioners contributed to the surveys, job analysis, item writing, and item review.

Documented Results

Within nine months of launch, as of March 2014, nearly 300 candidates have taken the CAHIMS examination, with a pass rate of 73%. Eleven colleges have adopted the preparatory curriculum, or are in the process of doing so. Some of these institutions are embedding CAHIMS curriculum into existing health or IT certificate and degree programs; others are offering the course as a standalone to prepare for test taking.

The CAHIMS curriculum has been incorporated into the Federally Registered Health IT Specialist Apprenticeship as an interim credential, which will be inaugurated within 2014. CAHIMS was also selected for suitability for military personnel with an IT or medic background who wish to enter the health IT field when transitioning to civilian life. An example of this implementation is the Camo to Commerce program funded by the Department of Labor (2014).

A collaboration with the YOUR Center, a faith-based organization in Flint, Michigan, resulted in a roll-out plan for health IT career awareness and action for underserved youth and their families, a landmark of which is the attainment of the CAHIMS certification.

The Carnegie Mellon Open Learning Institute selected the CAHIMS curriculum for redevelopment into a metrics-driven, interactive online format, to be hosted on their learning platform. This freely available, self-paced preparatory course will be completed in September

2014. A free, downloadable version of the CAHIMS curriculum is currently accessible at www.nerlearning.org.

Potential Applications

Industry: The Certified Associate in Health Information & Management Systems credential is intended as a first step into professional life, and onto the path of the only other HIMSS certification—the Certified Professional in Health Information & Management Systems—which requires five years of practice and a bachelor’s degree. CAHIMS was piloted in the University of Mississippi Medical Center system, in part, to assist administrators in gauging incumbent workers’ skills and skills gaps. This application can assist those already on the job to demonstrate mastery in pursuit of job and wage progression. Early acceptance by employers indicates receptivity for the entry-level industry certification, which can signal a job applicant’s investment and intentions in the field of health IT.

Higher Education: Members of a nine-college consortium, funded by the Department of Labor, developed a Common IT Core Curriculum, keyed to pair with the CAHIMS curriculum. The consortium’s goal was to define a base for learners to test the waters of a health IT career pathway. Elements of the Microsoft Certified Associate curriculum were used for the Common IT Core Curriculum. Developers noted that the utility for this dual-faceted program included beneficial exposure to healthcare content for IT instructors in a nonthreatening format.

Individual CAHIMS curriculum elements may be infused into a wide range of nursing and allied health programs. Many community college learners in these fields find themselves unprepared for clinical experience and employment due to unfamiliarity with information systems now ubiquitous in healthcare settings. At the same time, nursing and allied health instructors typically do not have historic ties to data science departments on their campus, and may lack interest or aptitude for professional development in this area. Incorporating elements of the CAHIMS curriculum into their courses is a low investment with the potential to add industry relevance and exposure for learners.

Secondary Education: High school students aspiring to a career in information technology can benefit from exposure to elements of the CAHIMS curriculum, and be on the path to certification before graduation. Although employment and wage projections are significant in this field at least through the next 10 years, health IT is not a well-known field. Underserved learners may well benefit from introduction to a sector that appears far afield of their surroundings.

More Information

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Evidence-Based Practices for Increasing the Number of Female Students in STEM

Background

The Institute for Women in Trades, Technology & Science (IWITTS) offers products and services that help technology and science educators increase the number of women and girls enrolled in their classes and encourage those students to stay enrolled. In 2006, IWITTS was awarded a five-year National Science Foundation (NSF) grant from the Research on Gender in Science and Engineering program to fund the CalWomenTech (CWT) project. Between 2006 and 2011, seven California community colleges received training and technical assistance to help recruit and retain women into STEM programs through the CWT project.

IWITTS' Proven Practices Collection—an online clearinghouse of over 100 downloadable papers, journal articles, podcasts, webinars, videos, and case studies—was developed during the CWT project and expanded during the CalWomenTech Scale Up (CWT SU) project to provide educators with current evidence-based resources for increasing the number of women and girls in the STEM classroom.

Documented Results

The CWT project was highlighted by the NSF in December 2009 for demonstrating significant achievement and program effectiveness to the Committee for Government Performance and Results Act Performance Assessment and was chosen as one of three model projects in an American Association of University Women's (AAUW) research report, *Women in Community Colleges: Access to Success*, released in May 2013. CWT provided intensive assistance (over a three-year period) to seven community colleges with the goal of increasing the number of women enrolled and retained in STEM programs in which they were underrepresented. Highlights include the following: six of seven community colleges had increases in female enrollment in introductory STEM courses targeted by CWT; five of the colleges achieved substantive increases in female enrollment ranging from 22% to 47% in introductory courses; four colleges increased both female and male completion rates substantially in targeted STEM courses; and six of seven colleges increased the retention rate of male students. Female completion rates increased between 9% and 25%, and increases in male retention ranged from 4% to 21%. CWT also utilized a collaborative Leadership Team model of key stakeholders that has been employed successfully in three of IWITTS' multi-site national community college projects. IWITTS provided Leadership Team members with evidence-based training on recruiting and retaining female students in STEM and facilitated their Strategic Plan development and implementation.

The improved retention of both women and men across seven community college sites is a major accomplishment of the CWT project. IWITTS attributes this achievement to evidence-based classroom strategies employed by instructors that positively impacted female and male students alike. In 2009 and 2010, CWT conducted anonymous surveys of female students (n=60) in targeted technology classes across seven colleges on what recruitment and retention strategies had proven most effective. The results from a survey of female technology course students

allowed the colleges to see which classroom strategies the women were currently experiencing, found most helpful, and would most like to experience going forward. The results were as follows: 9 of the 21 strategies had >50% of respondents reporting exposure; 20 of 21 strategies were rated helpful by 100% of those exposed; and >50% of those who had not experienced a strategy were interested in experiencing them.

The main focus of the CWT SU project is to begin bringing the evidence-based strategies from CWT to more educators. A key objective of the CWT SU project is delivering professional development in multiple formats—including in-person training, online training, and webinars—to STEM educators. The WomenTech Educators Online Training was developed during CWT SU.

The initial WomenTech Educators Online Training was held in 2012 and the second online training in 2013. Both received an average evaluation of 4.1 on a scale where 5=Excellent and 4=Very Good. On average, 89% of the participants from both trainings reported that they planned to share what they learned with their colleagues (n=38). Participants' knowledge of effective practices for recruiting women to STEM increased by 105% and their knowledge of effective practices for retaining women in STEM increased by 107% during the two online trainings (n=38). Participants' confidence in their ability to recruit more women increased by 51% and their confidence in their ability to retain more women increased by 50% during the second online training.

A participant from the CWT SU project's initial training—a computer programming instructor from a Texas community college—has already increased female enrollment in her required introductory programming courses by 62% and retention of all students by 45%, in less than six months. Her retention of female students went from a baseline of 0% to 86% the semester following the training.

Potential Applications

The proven strategies from the CWT project that have been widely disseminated in the CWT SU project will work for STEM educators across career pathways and school levels. These evidence-based practices are available to everyone through the WomenTech Educators Training and Proven Practices Collection.

For More Information

Institute for Women in Trades, Technology & Science (IWITTS) Website: <http://www.iwitts.org>

Proven Practices Collection: <http://www.iwitts.org/proven-practices>

American Association of University Women's (AAUW's) research report, *Women in Community Colleges: Access to Success*: <http://www.aauw.org/research/women-in-community-colleges>, and related webcast: <http://www.aauw.org/event/2013/05/women-in-cc-webcast>

"How to Recruit Women & Girls to the STEM Classroom" published by International Technology and Engineering Educators Association (ITEEA) in *Technology and Engineering Teacher* magazine: <http://www.iwitts.org/images/media/How-To-Recruit.pdf>

Regional Center for Next Generation Manufacturing

Background

The Regional Center for Next Generation Manufacturing (RCNGM) is a National Science Foundation-funded Advanced Technological Education (NSF ATE) Center of Excellence developed by the Connecticut College of Technology (COT) in 2004 to develop a response to workforce needs for all 12 community colleges in Connecticut. The goals of the RCNGM are the creation of articulation pathways, student recruitment and retention, curriculum development, and professional development. Through open meetings of the Site Coordinator Council, input is received from community college and university faculty, government representatives, business and industry partners, and educational program partners.

Articulation agreements with four-year colleges and universities are essential to support community college students' transition to four-year institutions. Partnerships with both public and private four-year institutions have led to the creation and implementation of two College of Technology AS degree choices: Engineering Science or Technology Studies. After completion of either of these degrees, all credits will seamlessly transfer to one of the four-year partner universities for the student to complete a bachelor's degree.

The RCNGM is continuously designing and implementing student recruitment and retention programs. These programs strengthen and help expand articulation agreement and instructional collaboration among four-year colleges, community colleges, and secondary schools. Student recruitment activities include regional career expos that allow students to talk to local manufacturers about their workforce needs, tour a community college campus, and attend presentations on advanced manufacturing technologies. Marketing activities include the RCNGM website, social media, and DVDs with accompanying teacher guides. The *Manufacture Your Future 2.0* and *You Belong: Women in Manufacturing* DVDs include "day-in-the-life" scenarios of employees who represent different roles in a variety of manufacturing jobs. The teacher guides include activities that can be done in the classroom to teach students about manufacturing career possibilities. Over 8,000 copies of the *Manufacture Your Future 2.0* DVD have been distributed nationally.

Curriculum development and implementation is an integral aspect of the RCNGM. With the assistance of industry input and education/industry collaborations, the RCNGM is able to ensure that students who enroll in the community colleges' College of Technology pathway programs can transition from high school to higher education without loss of credit, and obtain employment in cutting-edge technologies in the region.

Professional development activities for faculty are just as important as the student activities. The RCNGM continuously provides opportunities for community college and high school faculty to upgrade their knowledge base of emerging technologies needed for next generation manufacturing. Faculty externships with local industries, workshops, seminars, and conferences all provide faculty with the tools and ideas needed to create curricula that will meet current

workforce needs. High school counselor workshops are also a key activity that exposes counselors and faculty to career possibilities that they can bring back to students and parents.

Documented Results

The RCNGM has developed numerous programs and activities to prepare the future workforce for employment in advanced manufacturing fields. Since the center's creation in 2004, more than 65,000 students and 3,000 teachers have attended its career expos. As a result, STEM program enrollments have seen impressive growth, with a 15 percent increase from 3,913 students in 2009 to 4,482 students in 2012. There was also an associated 38 percent gain in enrollment of underrepresented populations, which went from 1,096 to 1,514 students. Student persistence rates received a tremendous boost from 270 industry-sponsored scholarships, 600 student internships, and 24 student design competitions.

Potential Applications

RCNGM programs are developed with the intention of dissemination and replication on a national level. Participants are able to use activities and modules to develop and implement their own curricula based on current industry needs. The third round of NSF funding for the RCNGM includes training regional partners in New England to implement these successful programs.

For More Information

RCNGM website: <http://www.nextgenmfg.org>

Facebook: COT RCNGM

Twitter: @RCNGM

Strategies for Recruiting Underrepresented Populations into STEM Fields

Background

The National Resource Center for Materials Technology Education (MatEd) is funded by the National Science Foundation; an Advanced Technological Education (NSF ATE) initiative. MatEd is developing an online collection (www.materialseducation.org) of instructional materials that can easily be integrated into a variety of courses, classroom settings, and industry. The MatEd collection is expanding rapidly, providing material for science labs, hands-on demonstrations, modules, and papers. MatEd's goals are to advance materials technology education nationally; disseminate industry-approved core competencies for technicians who handle materials; facilitate industry, education, and community collaborations to meet materials technology workforce needs; and provide easy and direct access to Web-based resources and professional development opportunities. MatEd is housed at Edmonds Community College in Lynnwood, Washington, and is creating a national network by partnering with industry, high schools, and higher education institutions, including other NSF ATE-funded centers and projects.

One of these projects was a special research project called Proven Practices in Recruiting Women into STEM Fields. This research project gathered information that assisted in the identification of successful practices/strategies used by NSF-funded centers and projects to recruit females into STEM fields. The research activities focused on how each center and project identified which strategies worked best for them, and how these strategies and/or activities were implemented.

After an extensive literature review and initial information was compiled, the project conducted a national survey that helped to identify NSF-funded ATE centers and projects that would be appropriate candidates to participate in this research project and that met the project's criteria. Following the survey, the Proven Practices in Recruiting Women project team visited selected sites; conducted focus groups at those sites; facilitated one-on-one interviews with faculty, students, and administration; and toured STEM programs. All of these activities allowed the project team to gather additional information. Attention was also given to NSF centers and projects located in areas that served underrepresented populations.

Documented Results

Based on this research, the Proven Practices project developed a summary tool that has been shared at workshops, conferences, roundtable events, and presentations. Several centers and projects preparing to submit for funding have used this tool to streamline and align their recruitment strategies and efforts with the NSF and other funding organization requirements. MatEd has been incorporating the findings of the Proven Practices research project into many of the professional development activities it has offered. Since 2010, over 600 people have attended MatEd workshops and events.

For More Information

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www.materialseducation.org

The New Tech Network: Transforming Schools into Innovative Teaching and Learning Environments

Background

The New Tech Network (NTN), a national nonprofit organization, engages with public school districts and charter school organizations to develop innovative schools. NTN schools are centered around a culture that empowers, teaching that engages, and technology that enables so that students graduate ready for college and career. Student achievement is the measure of our success.

Founded on the core belief that public schools can create, operate, and sustain innovation, NTN strives to ensure that all students have the skills, knowledge, and attributes they will need to thrive in post-secondary education, career, and civic life. Professional development and coaching are the secrets to successful NTN schools. Teachers and administrators participate in comprehensive professional development and receive on-site and virtual coaching during the first four years of implementation. Adult learning takes place during national events, including a one-week in-depth training for new NTN schools, an annual conference for all schools in the network, and events designed specifically for school leaders and targeted content areas.

Students and teachers utilize Echo, a learning management system designed to facilitate project-based learning (PBL), which is the heart of our instructional approach. PBL is a form of inquiry-based learning aligned with state content and/or *Common Core State Standards* that is contextual, creative, and shared.

The NTN design is simply a blueprint, accompanied by a set of core beliefs, tools, and strategies to help schools become successful. Because each school's context is different, it is local leadership, judgment, and adaptability that lead to long-term success.

Documented Results

There is compelling evidence that the public school innovation envisioned by NTN can, and does, lead to success for students from diverse backgrounds, in rural, urban, and suburban schools across the United States. For example, NTN students:

- graduate at a rate 6% greater than the national average.
- enroll in college at a rate 9% greater than the national average.
- persist in four-year colleges at a rate 17% greater than the national average, and in two-year colleges at a rate 46% greater than the national average.
- grow 75% more in higher order thinking skills between freshman and senior years than comparison groups.

NTN participates in the Deeper Learning Student Assessment Initiative (DLSAI), jointly sponsored by the William and Flora Hewlett Foundation, Carnegie Corporation of New York, W.K. Kellogg Foundation, and James Irvine Foundation. The purpose of the DLSAI is to validate methods for assessing deeper learning. As part of this work and NTN's ongoing effort to promote and assess deeper learning, NTN is implementing College Ready Assessments (CRA). CRAs are co-developed, refined, and validated by the Stanford Center for Assessment, Learning,

and Equity (SCALE) and Envision Learning Partners. The assessments represent a common, high-quality standard for student work grounded in a discipline. CRAs align to the *Common Core State Standards* and are embedded in project-based learning with the explicit purpose of assessing students' ability to produce college-ready work.

Potential Applications

While the NTN design has the versatility to accommodate just about any curriculum program, a great many of our schools, such as Tech Valley High School (TVHS), have used the NTN design as an excellent foundation for creating a STEM-designated school. TVHS has had success with this endeavor because so many facets of the model align with best practices for STEM schools and STEM education. Hence, NTN schools are “STEM-ready” because:

- they represent whole school reform, not a change in just methodology, or just schedule and classes. From pedagogy, to culture, to technology used, NTN schools reimagine schooling. Whole school change has been identified as a crucial step to improving STEM education by the Carnegie Corporation on New York's Institute for Advanced Study;
- project-based learning supports and reflects the kind of work that scientists and engineers do. The efficacy of this teaching approach is proven with test scores and at least one study of students after graduation;
- teaching, assessment, and grading of 21st century skills (like oral communication, written communication, collaboration, and agency) at NTN schools maximize the likelihood that students exit with skills needed in the collaborative workplace;
- integration of courses as part of the NTN model allows for technical disciplines to be melded into classes such as literature or history that traditionally do not include STEM concerns/topics;
- internships are a graduation requirement, which affords students clearer understanding of STEM careers and rigor, if they choose an internship in a STEM field;
- digital portfolios are a graduation requirement, which ensures heightened communication skills in digital media;
- the expectation of outside assessors for projects creates porosity between school and STEM-related businesses and community members, and paves the way for partnerships with schools; and
- consistency in pedagogy and 21st century skill instruction create “Clear Goals and Assessments,” as called for by the National Science Board as one of the ingredients for successful STEM schools.

For More Information

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Carnegie Foundation's Community College Pathways Program

Background

More than 60 percent of all students entering higher education in the United States are required to complete remedial or developmental courses as a first step towards earning associate's or bachelor's degrees. A staggering 70 percent of these students never complete the required mathematics courses, blocking their advancement in higher education and entry into a wide array of technical and occupational careers. Recognizing the grave consequences around these alarming statistics, the Carnegie Foundation for the Advancement of Teaching engaged with a network of faculty members, researchers, and designers to create and put into the field two new mathematics Pathways: Statway and Quantway.

Statway is an academic year-long course that allows students to simultaneously complete their developmental mathematics requirements and receive college mathematics credit in statistics. Quantway is designed as a two-term course: Quantway 1 is the first semester of this program and fulfills the requirements for students' entire developmental mathematics sequence; Quantway 2 is the subsequent single semester college-level course.

Both Pathways are built upon ambitious learning goals that set rigorous standards for deep conceptual learning and procedural fluency. These goals were established by a group of college and university faculty, including representatives of all the major mathematics, statistics, and quantitative reasoning professional societies. The learning goals are enlivened through a research-based pedagogy that facilitates specific learning opportunities. These enable students to struggle productively within complex authentic contexts, to make explicit connections between mathematical concepts within lessons and across the course, and to engage in deliberate problem-solving scenarios that both reinforce and extend their learning.

Both Pathways focus on mathematics that matter for work, for personal living in an increasingly quantitative age, and for critically examining issues of public life, and that are embedded in complex authentic contexts. This creates reading and writing challenges that are unique for a mathematics course. For that reason, the program has *interwoven language and literacy* supports into the instructional materials and classroom activities so that language isn't a barrier to learning mathematics. Another distinguishing feature is the work in student motivation, tenacity, and college success skills—that is, *productive persistence*—and the resulting evidence-based package of practical student activities and faculty actions that is integrated into the instructional system.

In addition, both Pathways use real-time data analytics to provide faculty with information about their classroom ecology and about the performance of individual students. Because the Pathways represent a multi-faceted reform that is significantly different from traditional mathematics education practices, it includes a comprehensive professional development program for faculty. This program provides a cohort learning experience for new faculty that occurs both online and in person and that includes supports for examining instructional practices through interactive videos. It also includes a suite of online resources and a mentorship program that assigns an experienced faculty mentor to each new faculty member.

Documented Results

The Pathways are now in their third year of implementation. Statway launched in fall 2011; Quantway 1 launched in spring 2012; and a pilot of Quantway 2 launched in spring 2013. Thus, we now have student performance and characteristic data for students enrolled in 2011–12 and 2012–13. The Pathways are highly successful:

- Among the Statway colleges, only 9 percent of students complete developmental math and one semester of college-level math in a single year, and only 16 percent complete it within two years. By comparison, for two years in a row, over 50 percent of the students who were enrolled in Statway earned college credit in a single year.
- Among Quantway colleges, only 20 percent of students complete their developmental math sequence in a single year. By comparison, for three semesters in a row, over 50 percent of Quantway 1 students have completed their developmental math requirements in a single semester. Quantway 2, the single semester, college-level course, achieved a 70-percent success rate in its first semester.

The extraordinary success rates have created a strong interest across the nation, from both community colleges and educational researchers. The network has grown to 48 institutions which have, to date, enrolled roughly 7,000 students.

Potential Applications

The Pathways approach has demonstrated remarkable results for students at participating institutions. But perhaps equally important, it has advanced the national conversation on mathematics reform and led to the spread of proven instructional practices beyond the Pathways classrooms. Mathematics professional societies now uniformly support a Pathways approach to mathematics education that challenges traditional notions of intermediate algebra as a prerequisite for college-level math. Faculty and staff in the Pathways are now applying what is known about effective pedagogy and productive persistence to their other classes. The benefits of the Pathways are spreading to many more students.

For More Information

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Carnegie Foundation for the Advancement of Teaching
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Broadening Advanced Technological Education Connections (BATEC)

Background

Broadening Advanced Technological Education Connections (BATEC) is the National Science Foundation's Advanced Technological Education (NSF ATE) National Center for Computing and Information Technologies. BATEC's efforts in curriculum, outreach, and research reflect the demands of the 21st century workplace.

BATEC is working in the urban areas of Boston, Chicago, San Francisco, and Las Vegas to:

- define and strengthen academic pathways and career opportunities for computing and information technology professionals;
- facilitate and leverage strategic partnerships to build awareness, generate interest, and support learning opportunities in these ethnically diverse urban areas; and
- conduct actionable research that informs policymakers, educators, workforce development agencies, and industry leaders on the subject of authentic curriculum and applied information technology.

Community Colleges Offer State of the Art Curriculum Designed for an Innovation Economy

BATEC's academic partners collaborate to define new academic programs and revise existing curricula with the support of industry professionals committed to successful student outcomes. This approach to authentic education is often out of the comfort zone for faculty but invaluable to the students they serve.

Curriculum development is holistic in nature. In an effort to connect cybersecurity and computing, Middlesex Community College—with industry advisors from the Massachusetts Institute of Technology's (MIT) Lincoln Laboratory and the MITRE Corporation, and assistance from Bunker Hill Community College and the Center for Security and Information Assurance (CSSIA)—has redefined their Computer Science degree program to offer a Secure Software Development track. This curriculum conforms to the newly released *National Cybersecurity Workforce Framework* developed jointly by the National Security Agency (NSA) and the Department of Homeland Security (DHS).

Program development encourages student advancement. Bunker Hill Community College, with the support of the U.S. Department of Labor, has developed a seamless progression for all of their computing, information, and networking technology programs. These stackable credentials afford students the opportunity to achieve shorter term success and earlier work-study employment while they continue to make sequential progress towards a traditional degree.

The pathways are informing work in Chicago with their Early College STEM and College to Career initiatives. Stackable credentials have also been a strategic asset credited with workforce development for returning veterans and displaced workers.

Professional development connects educators with business and industry. College of Southern Nevada (CSN) and Western Nevada College (WNC) are leading an initiative entitled *Content in Context*. This professional development workshop series, which brings together industry leaders with educators in meaningful dialogue, has served to integrate professional skills training with technical skills development in response to Nevada's state-issued guidelines for employability skills. More than 3,000 students in technical education programs at CSN are benefiting annually from industry-driven approaches to experiential exercises developed during the CSN-offered workshops. This endeavor is being scaled to other locations in Nevada, Southern California, and Cleveland.

Students Gain Access to a Vibrant Career Pathway Supporting Their Advancement as IT Professionals

BATEC's industry partners provide technology work-based opportunities that are increasing student access to career pathways in information technology. In addition to the highly successful Tech Apprentice summer program for high school students, which places over 100 interns each year, our community college partners have collaborated to develop a systematic, scalable model for student qualification, preparation, and placement in semester-long internships at small and medium businesses in their local communities. Mass Bay Community College and Quinsigamond Community College are placing 50 Web Development and Media Technology students annually, with a placement success rate of over 90 percent, with no dedicated faculty or school resources required. Lessons learned from these successes are now benefiting the campuses of the College of Southern Nevada in their internship implementation.

The Mid-Pacific ICT Center is replicating the processes used in Boston to identify and strengthen the linkages between their ICT programs, courses, certificates, and credentials in the five ICT-related departments at City College of San Francisco to the pathway and academy programs in the San Francisco Unified School District and local community-based organizations, four-year colleges and universities, ICT industries, and employers. These partnerships are creating new opportunities for student success.

Educators Enter into Data-Driven Discussions with Industry Leaders about Career Options for Their Students

BATEC's academic partners are the beneficiaries of a data-driven research initiative aimed at better understanding and profiling middle-skill career pathways. Jointly authored by BATEC and Monster Government Systems, *Sizing the Middle Skill Employment Gap* is a comprehensive analysis of work activities, prerequisite skill requirements, current employment data, and trend analysis. This report and its analysis of regional workforce development efforts has proven to be a powerful and effective platform of information from which to engage industry professionals in real-time, data-driven discussions of workforce needs and student outcomes.

For More Information

<http://www.batec.org>