JerseyCAN

PREPARING THE CHILDREN OF TODAY FOR THE JOBS OF TOMORROW

A WINDOW INTO STEM EDUCATION IN NEW JERSEY

Preparing the Children of Today for the Jobs of Tomorrow

A WINDOW INTO STEM EDUCATION IN NEW JERSEY

This report was published in September 2017 by JerseyCAN

To order copies of this report please contact JerseyCAN: info@jerseycan.org

JerseyCAN: The New Jersey Campaign for Achievement Now
www.jerseycan.org

Design & Layout
house9design.ca

This research was generously supported by JerseyCAN and a grant from the PSEG Foundation.

PSEG

Table of contents

Executive Summary

Detailed Report

Appendix

Executive Summary

Overview

What is the purpose of this report?

JerseyCAN was created in 2013 to address two big issues and opportunities: excellence and equity in New Jersey's K–12 education system. For the last four years we have been advocating for policies that we believe will advance excellence and equity, such as enhancing quality school options, expanding pre-K access and setting high academic standards paired with accountability. While we've seen important successes, the nature of this work, and the challenges of driving change, have caused us to think about finding new ways to discuss excellence and equity—and to question if we are thinking big enough. To do this, we went back to our roots.

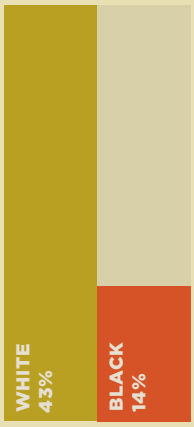
New Jersey was the original center for innovation and scientific progress before Silicon Valley. We have a rich history in STEM (science, technology, engineering, math) leadership—home to Thomas Edison who invented the light bulb and Bell Labs that invented the transistor—and yet, today, we see a growing skills gap between students interested and prepared for the growing STEM job sector.

When you look at how our students are performing academically, it is clear we are not adequately preparing them for STEM fields. And the data also shows that many children are left behind. Let's keep this simple by just looking at 2015 NAEP science exams for 8th grade children in New Jersey, where we rank 24th in the nation.

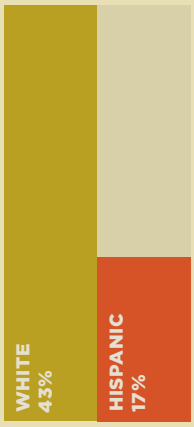
As shown on the graph that follows, only 43 percent of white students score at or above proficient in the science exam. The graph also illustrates that only 14 percent of black students and 17 percent of Hispanic students score at or above proficient in the science exam, respectively. This data on overall performance and equity is alarming. (See Appendix for additional New Jersey data.)

With New Jersey's rich STEM history, and our very diverse state, we decided to explore the conversation around excellence and equity using STEM education

NAEP 8TH-GRADE SCIENCE—2015
PROFICIENCY GAPS BETWEEN STUDENT SUBGROUPS



29 percentage point gap



26 percentage point gap

DEFINITION

WHAT IS STEM? STEM stands for science, technology, engineering and math, not only as individual disciplines, but also as an interdisciplinary area of study. The STEM field today is shifting away from rote memorization and procedures and moving more into design thinking, investigation and inquiry. To add further emphasis to the multi-disciplinary approach, some practitioners refer to the field as STEAM (adding in an A for the arts). When done best, STEM and STEAM can transform learning into a vehicle for students to learn the four C's—collaboration, critical thinking, communication and creativity—which constitute 21st-century skills[1] that many employers believe are missing from today's younger workforce.

as our framework. We are very encouraged by the many pockets of innovation and the pioneer leaders who are working to improve excellence and equity in New Jersey STEM education. However, the complexity of driving change and the need to scale this work is evident.

Why STEM is important?

In the 21st century, technological and scientific innovation is a vital engine of the U.S. economy. Unfortunately, we are not preparing our students to grow our innovation economy in this fast-changing global landscape. In the United States alone there are three million more STEM jobs than the number of available trained professionals to fill them.[2] In New Jersey, there are 1.4 open jobs in STEM for every unemployed person.[3] STEM-related jobs are expected to grow at almost twice that of other jobs in the market, and the vast underrepresentation of female, black and Latino professionals in these fields illustrates equity issues and challenges that we must address. This challenge and opportunity is only going to grow over time. The U.S. Department of Labor estimates that 65 percent of today's grade-school students will end up in jobs that do not yet exist.[4] Our current education system was built for an industrialized age of standardization. In our globally connected and fast-changing world, we need to free the education system to innovate.

Report Overview

In this report, we will examine New Jersey's STEM education landscape, with a focus on evidenced-based innovations. Districts and schools around the state have championed STEM education, as well as personalized and blended learning, with some leaders reimagining education in even bigger, more holistic ways. We shine a light on the pioneers and early adopters that are showing results with outcomes supported by improvements in excellence and equity. Although research on this topic is limited due to the recent nature of these innovations, we were able to find evidence in specific programs and strategies.

We focused on best practices at the local level, scalable models and obstacles to advancing K–12 STEM education. To do so, we conducted a listening tour with over 70 individuals and organizations including visits to schools and programs

throughout the state. We spoke with superintendents, principals, technology and science leaders, teachers and students. We met with think tanks, foundations, corporate leaders, scientific institutions, the military, state leaders and academics. We reviewed countless news articles, studies and reports. We also explored the world of "off-the-shelf" national programs and curriculums that have taken root here in our state.

In the following report, we highlight compelling examples of innovation in K-12 STEM education in New Jersey. Examples include personalized and project-based learning, out-of-school time STEM programs, STEM-rich institutions, STEM teacher preparation and important systems level change work. We also address the importance of equity, with examples of proactive work showing results. Finally, we close with a series of recommendations.

"The U.S. Department of Labor estimates that 65 percent of today's grade-school students will end up in jobs that do not yet exist."

Examples of STEM Innovations in New Jersey

1. In-School: Personalized and Project-Based Learning

Teach to One Math

This is a personalized/blended-learning math program found in 10 northern New Jersey middle schools. Technology is used to strengthen traditional best practices in teaching and learning.

Project Lead The Way, The Full Options Science System and i2 Learning

These three innovative examples illustrate the application of project-based learning. Project Lead The Way provides curriculums in computer science, engineering and biomedical science along with professional development for teachers. Currently, 137 Project Lead The Way programs are active in 90 New Jersey school districts. Full Option Science System provides an active learning science curriculum and extensive professional development to support schools. i2 Learning brings STEM learning to middle schools and just completed a STEM week in Newark with 26 schools.

Freehold Township School District

This elementary and middle school district integrates both personalized/blended and project-based learning. The district has proactively transformed itself to create a strong culture where students are leaders of their own learning.

2. Out-of-School Time STEM Programs

FIRST Robotics

This is a mentor-based, national program designed to inspire and help students learn and apply engineering, technology and important life skills by designing and building their own robots.

Girls Who Code

This organization teaches girls to code with a curriculum for school clubs and summer immersion programs. Through nationwide sites, including 48 in New Jersey, Girls Who Code aims to close the gender gap in technology.

Crazy 8s

This organization supports math clubs for elementary-age students, with a curriculum designed to make math fun, providing a non-competitive option for extracurricular math clubs.

3. STEM Rich Institutions

Liberty Science Center

This is a world-class science learning center that makes science and technology fun for its more than 650,000 annual visitors. As a leader in STEM education, Liberty Science provides significant professional development for teachers and dynamic activities for students. The Science Center is a premier field trip destination, and STEM educators bring programs directly to schools.

Students 2 Science

This program allows kids to engage in hands-on experiments in state-of-the-art labs side by side with scientists in the field. Students can go to the East Hanover Technology Center or participate in virtual labs. Newark Public Schools and Students 2 Science are in the process of building a dedicated Newark facility to increase access and scale.

4. STEM Teacher Pipeline

Woodrow Wilson Teaching Fellowship

This program offers a new, innovative way to prepare STEM teachers. Five New Jersey universities partner with the Fellowship to provide redesigned curricula and clinical experiences. Graduates commit to teaching in underserved communities for three years.

New Jersey Center for Teaching and Learning

This program is a top producer of physics teachers in the country. Their novel approach includes curriculum that flips the traditional order of teaching the science sequence.

5. Systems Level Change

New Jersey Department of Education

Next Generation Science Standards. In 2014, these new academic benchmarks in science were adopted and are driving change in how students engage in scientific learning.

Future Ready Schools. New Jersey has joined in with the Future Ready Schools movement, designed to improve teaching and student outcomes through the effective use of technology. The framework to drive systematic change is embedded in the new Future Ready Schools New Jersey certification program.

Career & Technical Education. Some county vocational technical schools have a STEM focus. These schools, as well as other CTE programs embedded in comprehensive high schools, include relevant work-based learning opportunities. Many of these public schools are in high demand, have competitive admission and rank among some of New Jersey and the nation's top STEM schools.

Higher Education—STEM Pathways Network

This network supports the creation of STEM ecosystems, where communities can cultivate cross-partnerships and create STEM-rich, 24/7 learning environments.

Each of these innovative examples will be explored further in the remaining report. Where possible, we identify the New Jersey schools, districts or communities involved in these initiatives. Despite this extensive review, we know that in a state with over 600 school districts, we missed many gems. We also recognize the vital role of institutions of higher education and the business community in advancing STEM across the state, which is not fully covered in this report.

We also examine equity issues within STEM and highlight some clear examples of proactive strategies to ensure more women, black and Latino students are represented in the STEM talent pipeline moving forward.

Recommendations

Based on our extensive discussions with education experts, practitioners and policymakers, we have developed several recommendations that can help our state advance STEM education.

Create a Gubernatorial-Sponsored Task Force on K-12 STEM EducatioN

JerseyCAN recommends that the Governor create a diverse task force to develop a comprehensive plan for strengthening K–12 STEM education in New Jersey. It is time to step back and understand where we are, the vision of the future and what actions must be taken to get there. Clearly some building blocks are in place, but we need a vision owned by key stakeholders and a leader that can bring resources to execute the plan.

Invest in STEM Teachers

New Jersey has a shortage of teachers trained in STEM fields. Two of the programs we profiled in this report address this issue, but more can—and should—be done. More STEM-focused preparation and resources, for example, could be provided to elementary school teachers. We believe the New Jersey Department of Education and the Office of the Secretary of Higher Education should continue to work together to develop strategies to address this talent gap.

Expand Access to Computer Science

Digital technologies are now reshaping many parts of our global economy. Computing jobs are growing at three times the national average, and yet only 40 percent of our schools teach computer science nationwide. We must increase investment in teachers and other creative strategies to expand computer science offerings in our schools so that all students have access.

Expand Access to Career and Vocational Technical Education and Work-Based Learning Opportunities in STEM Fields

A recent McKinsey report identifies a growing labor-market mismatch between the demand for middle-skills workers and the supply of workers with the appropriate skills. New Jersey's Career and Technical Education schools and programs were created to provide rigorous programs of study aligned to workforce needs and career pathways. JerseyCAN recommends that the STEM education task force evaluate the best strategy to expand existing CTE schools and programs.

Leverage Personalized and Blended Learning

Technology has the potential to transform education. We are seeing some of the transformational possibilities with personalized and blended learning, as shown in Freehold Township where students are becoming leaders of their own learning. We support the New Jersey Department of Education's collaborative effort to

create a path for systemic change around digital learning with the Future Ready Schools certification program. The long-term potential for school transformation here is significant, and New Jersey is creating evidenced-based proof points. Policy changes can also help enable growth over time.

Establish an Innovation Fund

Many of the recommendations we suggest here require new resources. These start-up costs alone can create barriers for schools even considering change. JerseyCAN sees significant potential in forming an Innovation Fund that leverages public and private resources to support pioneers leading evidenced-based innovations. JerseyCAN will continue to evaluate optimal ways to organize such a fund.

Implement Targeted STEM Strategies for Women and Underrepresented Minorities

There is a growing list of educational strategies and discrete programs that support girls and underrepresented minorities in STEM education. An advisory council should be created to help grow this work and track results.

We have an opportunity in New Jersey to reclaim our leadership in today's innovation economy. To do that, we need to change the education paradigm to effectively prepare all children for 21st-century jobs.

Detailed Report

New Jersey's Challenge and Opportunity

Our Garden State boasts 14 of the 20 largest pharmaceutical companies, the most scientists per capita and ranks fourth place in bioscience patents. Innovation has long been a theme—New Jersey currently has 475,500 people working in STEM jobs. These positions require education and skills in STEM disciplines, and they represent more than 12 percent of the state's total 3,906,800 jobs.[I] STEM jobs are not only well-paying—individuals with STEM college majors have the potential to earn $500,000 more than non-STEM majors over their lifetimes[5]—but they also strengthen our economy overall. The National Science Foundation has reported that scientific innovation has produced roughly half of all U.S. economic growth over the last 50 years and a 2014 study found that the STEM workforce accounts for more than 50 percent of the nation's sustained economic growth.[6] This growth is not predicted to continue in a linear fashion. Leaders such as Klaus Schwab from the World Economic Forum believe we are in the midst of a fourth Industrial Revolution, which is moving at an exponential pace without historical precedent.

Unfortunately, our nation and state's leadership roles in STEM are in severe jeopardy as has been well documented by everyone from U.S. presidents and the military to industry and academia. Here's a sampling:

- In the United States there are currently 3 million more STEM jobs than the number of available trained professionals to fill them.[7] In New Jersey, there are 1.4 open jobs in STEM for every unemployed person.[8]
- The New Jersey Institute of Technology has quantified what many New Jersey transit riders experience each day: a crumbling infrastructure. New Jersey needs "15,289 lane miles of highway to be rehabilitated; a $16 billion commitment to water infrastructure; and the restoration and expansion of New Jersey Transit Services to be designed and managed by STEM professionals." Yet "we are 36th among the states in bachelor's degrees in STEM fields and 25th in graduate degrees."[9]
- Code.org, a leading voice in computer science, posits that most of the challenge is in computer science citing the fact that 71 percent of all new jobs in STEM are in computing, but only eight percent of STEM graduates earn degrees in computer science.[10] According to their research, New Jersey had 22,778 open computer jobs and 1,111 computer science graduates in 2015, with 85 percent of those graduates being male. The average salary for a New Jersey computing position is $102,535, which is almost double the average state salary. Taken together, these add up to over $2 billion in salaries left on the table. We could simultaneously rebuild industry and break the cycle of poverty for many New Jersey families if we can effectively address this.

I At JerseyCAN's request, the New Jersey Department of Labor Assistant Commissioner Jeffrey Stohler's team calculated the STEM related jobs that require STEM skills such as doctors, that are not included in the traditional federal methodology.

OPEN STEM JOBS IN NJ

1.4 open jobs

in STEM for every unemployed person

DEGREES IN STEM FIELDS, NEW JERSEY RANKING

36th
in bachelor's degrees in STEM fields

25th
in graduate degrees in STEM fields

OPEN COMPUTER SCIENCE JOBS IN NEW JERSEY, 2015

1,111 computer science graduates

22,778 open computer jobs

Perhaps most importantly, our STEM educational pipeline is underserving and subsequently missing the person power and brilliance of thousands of talented female, black, and Latino students as well as those scholars from a low-income background. In addition to reduced career and income opportunities for these students, we're missing their diverse perspectives and solutions. For example, underrepresented minorities[II] represent 40 percent of New Jersey's college-age population, but earn only 12 percent of all engineering and certificate degrees, while women only earn 27 percent of degree and certificates in engineering.[11]

II The phrase underrepresented minorities refers to racial and ethnic groups that are underrepresented in STEM relative to their numbers in the general population, namely, black, Latino and Native American populations.

"The nation can only achieve and sustain growth and prosperity by integrating all into the economy, including those who have too often been left behind."[12]

—Angela Glover Blackwell, CEO of PolicyLink

Top STEM Industries in NJ

Science	Technology
Pharmaceutical	Scientific Instrumentation
Biotechnology	Communications
Chemical	Web Development
Diagnostics	Software Developer
Polymers	Computer Information Systems
Environmental	Computer Programming
Flavor & Fragrance	
Healthcare	
Petrochemical	
Consumer Products	

Engineering	Mathematics
Chemical	All of the above
Mechanical	Accounting
Electrical	Data Management
Civil	SCM & Logistics
Aeronautical	Finance
Biochemical	Market Research
Industrial	Insurance
Petroleum	
Medical	
Nuclear	

Information provided by Students 2 Science

Examples of STEM Innovations in New Jersey

Framework

Since innovation occurs everywhere, in this section we review the New Jersey landscape from the perspective of districts, schools, curriculums, out-of-school time, teacher pipelines and professional development, and state- and community-wide frameworks. We searched for efforts focused on excellence and equity that were supported by evidence. While we certainly need more, there is so much happening in New Jersey in this field that it was impossible to include all of it in one report. The following highlights will hopefully raise awareness on programs that could be expanded to all children and inspire more engagement from key players—from school leaders to policymakers to philanthropists.

We have organized this review by themes of In-School: Personalized and Project-Based Learning; Out-of-School Time; STEM Rich Institutions; STEM

Teacher Pipeline, and Systems Level Change. We recognize that by their very definition, STEM initiatives can cut across multiple fields, meaning they do not fit neatly into one theme. Nonetheless, for the ease of readership, we have done our best to fold things together.

DEFINITIONS

"**Personalized learning** is instruction that offers pedagogy, curriculum and learning environments to meet the individual student's needs. The experience is tailored to learning preferences and the specific interests of different learners. In a personalized learning environment, the learning objectives and content, as well as the method and pace, may all vary. Personalization also encompasses differentiated instruction that supports student progress based on subject matter mastery."

—DreamBox[13]

"**Blended Learning** includes teaching through multiple modalities including "at least in part through online learning, with some element of student control over time, place, path and/or pace; at least in part in a supervised brick-and-mortar location away from home; and the modalities along each student's learning path within a course or subject are connected to provide an integrated learning experience."

—Christensen Institute[14]

"**Project-based learning** is a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging and complex question, problem, or challenge."

—Buck Institute for Education[15]

"**Problem-based learning** is an approach that challenges students to learn through engagement in a real problem. It is a format that simultaneously develops both problem solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem-solvers confronted with an ill-structured situation that simulates the kind of problems they are likely to face as future managers in complex organizations. Problem-based learning is student-centered."

—Professor Ron Purser, San Francisco State University[16]

1. In-School: Personalized and Project-Based Learning

Personalized/blended learning and project/problem-based learning constitute two worlds of creative thinking in reimagining education with students leading their own learning. At JerseyCAN, we found them both in STEM—sometimes separately and occasionally mixed together. While project- or problem-based learning is not a new concept, it seems to be undergoing resurgence, particularly in the STEM field. Similarly, personalized learning is not a new concept, but technology has transformed it. In this section, we review exciting programs that are engaging students in new ways around STEM. We also highlight one district—Freehold Township—that has completely shifted the way students are learning with these concepts.

TWO WORLDS OF CREATIVE THINKING IN REIMAGINING EDUCATION

Personalized/ Blended Learning

Project/ Problem-Based Learning

1.1 Teach to One Math

Teach to One Math (TTO), a program of the nonprofit New Classrooms, can be found in ten northern New Jersey middle schools this year. TTO has a personalized curriculum that uses technology to strengthen traditional best practices in teaching and learning such as personalized learning and differentiation in instruction.

This spring JerseyCAN visited Passaic Gifted and Talented Academy School 20 where students in grades five through seven learn math exclusively through TTO.[III] About 60 to 80 students gathered in unique sections of a large room without walls, which had been renovated and repurposed for TTO, and worked intently on math in various clusters of three different modalities: teacher-delivered, collaborative and independent. In the busy room, this translated to some students

III TTO also is partnering with schools in Elizabeth and Jersey City.

sitting at hutch-style desks working on laptops as they advanced through their own playlists; other small groups with a teacher leading them through a "live investigation" as they jointly solved problems on a white board, with still more middle schoolers working together in small peer groups.

As for the teachers, TTO sends their assignments regarding which modality and content they will teach the day before. The assignment also has sample lesson plans and additional resources if teachers wish to add to it or devise their own during the shared prep time built into their schedules.

At the end of a classroom session, students complete an exit slip, which sends assessment data back to the TTO "scheduling engine". The TTO team receives and reviews the student data, which in turn dictates each teacher's schedule the following day. In addition, every few weeks, the students take a larger assessment which feeds into their overall learning arc and the scheduling engine "gets smarter" about what works best for each student over time, further personalizing their learning experience.

TTO enables students to track their own progress through their portal. They follow a personal playlist and know when their summative assessment is coming up. This data also helps struggling students understand why they have more time on TTO and not in the classroom.

A recent evaluation found that TTO students made annual academic gains that were equivalent to one and a half times the national average, or about half a year of additional learning. The evaluation also found that English language learners and special education students accelerated their learning by 1.7 and 1.4 times the national average, respectively. Passaic G&T Principal John Mellody found that in four months his students, on average, showed about 80 percent more growth on the Measure of Academic Progress (MAP) exam than the average student across the country. In terms of growth over time, this would be closer to an additional three months of learning, on average, over the period of four months.[17]

All of this requires additional funding, and a clear challenge to implementing TTO Math is the significant upfront investment in renovating classrooms, professional development time and ongoing fees to TTO for all the support they provide daily. Schools typically seek philanthropic or public grants to implement the program.

1.2 Project Lead The Way, Full Option Science System & i2

The following three innovative examples illustrate the application of project-based learning.

Project Lead The Way. PLTW offers schools an opportunity to broaden and deepen their STEM offerings with evidence-based, out-of-the-box curricula and professional development for teachers in computer science, engineering and biomedical science. While flexible, PLTW is not intended to replace other required courses. Currently, there are 137 PLTW programs in 90 school districts across New Jersey.[18] PLTW's intent with the K–12 pathways is to "engage students at an early age, equipping them with the knowledge and transportable skills they need to thrive throughout their education and careers."[19]

Different schools and districts in New Jersey have implemented different pieces of PLTW, in part because of the expense of materials and teacher training.

For example, at Buzz Aldrin Middle School in Montclair, a STEM magnet school, all the roughly 600 students enroll in one of three pre-engineering concept courses that incorporate PLTW units of study: Computer Aided Design and 3-D Printing, The Science of Technology, and Automation and Robotics. With a diverse student population, this requirement ensures all students are exposed. Thanks to philanthropic investment from Josh Weston, former CEO of ADP and a JerseyCAN Board member, the schools also have 3D printers and a fab-lab[IV] to help lift their designs off the page.

PLTW is also backed by research, specifically around student engagement, academic achievement and persistence. Change the Equation summarizes, "Studies show that students who participate in PLTW programs outperform their peers in school, are better prepared for post-secondary studies, and are more likely to consider careers in STEM-related fields than are their non-PLTW peers."[20]

Although an effective tool, PLTW requires training, which often involves expenses related to travel and teacher stipends. Given the highly specialized training, some schools have at least two teachers trained per course in the event of a teacher transition. Corporate partnerships have helped to ease the full cost of PLTW in some districts. Several companies including Lockheed Martin, Verizon and ArcelorMittal have supported the program locally. All funds donated by these corporations go directly to support the PLTW programs, including purchase of materials for the curriculum and for teacher professional development.[21]

The Full Option Science System. FOSS is an evidence-based science curriculum developed at the Lawrence Hall of Science, University of California, Berkeley and published by Delta Education for Elementary and Middle School students. The FOSS team explains that it is less a curriculum than a philosophy to engage students in science through active learning style led by a teacher who uses "Investigations" as a methodology. "Investigations" include students questioning and planning; doing and observing; recording and organizing data; discussing and writing explanations; and extending student learning through multimedia experiences and reading informational text. Like PLTW and others, part of the success of FOSS lies in its extensive professional development and support offerings to schools.[22]

According to Jennifer Slavick, Assistant Director of Science at Mastery Charter Schools in Camden, when they piloted FOSS, teachers immediately noted the higher level of student engagement and that students were more confident in answering open-ended questions. In addition, Slavick noted that Mastery likes the teacher support.[23] The curriculum is divided up by investigation and focus questions so educators can understand the science behind what they are teaching. FOSS also highlights common misconceptions so teachers can listen and help students who may otherwise be lost. In a comparison of students in Fresno, CA, researchers found that students with more exposure to FOSS performed better in science and reading.[24]

i2 Learning. i2 Learning is a project-based approach to STEM learning for middle school students. This past spring, i2 developed a partnership with Newark Public Schools and brought their STEM week program to 26 schools in a pilot. Working with NPS' science lead, Ivory Williams, i2 provided the curriculum, teacher professional development and materials and supplies.

IV A fab lab is a fabrication lab where students can learn digital fabrication.

"[Innovators are] comfortable with both the arts and sciences... the creativity comes from standing at the intersection of the humanities and technology."

—Walter Isaacson, CEO of the Aspen Institute

At First Avenue School in Newark, one of the pilots, the i2 STEM Week culminated in a library showroom with sixth graders presenting their work to classmates. Against one wall, a group of students explained the concepts of friction and kinetic energy to younger students as their marbles careened through their paper-towel-roll-roller-coasters before landing (ideally) in a cup. They explained how rubber bands created friction to slow the marble when needed. At another table, small fans blew "wind" towards small windmills designed to harness their power and transfer the voltage so that a toy would operate.

Nearby, a math teacher described himself as "exhausted but good exhausted because you know you have accomplished something great. I wish we could teach this way (project-based learning) all year long." Notably, only two of the First Avenue teachers that participated in the two-day professional development prep were STEM teachers (in Newark, 80 teachers across 25 schools participated). During the training, teachers practiced the same activities that they would be teaching students so they understood not only the exercise, but also the frustration of failure, the power of resilience and the need to collaborate in groups.

Inspiration and engagement are key goals for i2 and the organization has invested in evaluation to make sure they achieve both. Their data demonstrates students are engaged in the activities and more interested in science, engineering and its applications in general. Based on the pilot's success, NPS will expand the program citywide in the 2018–2019 school year as i2 has also done in Boston Middle Schools.

DEFINITION

WHAT IS STEAM? Recognizing the importance of creativity and the interdisciplinary nature of STEM, many in the field use the phrase STEAM instead, adding in an 'A' for the Arts. In the book "From STEM to STEAM," authors David A. Sousa and Tom Pilecki conclude the following: A) The arts develop cognitive competencies and skills that broadly benefit learners such as creativity, problem solving, critical thinking, communications, self-direction, initiative and collaboration; B) Students exposed to arts-related instruction will have an advantage in acquiring some important STEM-related skills and concepts, and visa versa; C) The arts can make teaching more interesting for STEM teachers; and Creating arts-integrated lesson plans innately promotes a collaborative culture within the schools.

1.3 The Freehold Township School District

The Freehold Township School District (FTS) is a pre-K to 8th grade school system in Monmouth County with eight schools serving 3,900 students. FTS's Superintendent Dr. Ross Kasun was named New Jersey's 2017 Superintendent of the Year for his pioneering work grounded in a central belief that students should be leaders of their own learning. This concept is supported in Freehold Township schools with student-centered, technology-infused personalized learning environments and project based or expeditionary-based learning in STEAM with STEAM makerspaces.

In April, we traveled from school to school in Freehold Township, speaking with students engaged consistently in student-led learning experiences through makerspaces, personalized learning on Chromebooks and project-based, multidisciplinary exercises. Dr. Kasun noted that personalized learning can often be misunderstood as simply putting kids on digital content, which he believes will not alone yield results. He blends personalized learning strategies with other strategies such as project-based learning. For example, in one classroom, fourth graders were sprawled around the room, measuring, cutting and building schools for students in Nepal. Students first learned about Nepal's geography and culture before working in teams to design a scale model. On our site visit, they were building their 3D version from recycled materials and enthusiastically explaining to visitors the reasons for their various design decisions. The social studies and science teachers collaborated to design the project during their shared prep time and before school started.

In addition to project-based learning, FTS's approach to personalized and blended learning was described by one teacher as a "technology-infused growth-minded environment," where students can understand and recognize their own growth, which is vital if students are going to be to be leaders of their own learning.

FTS learned and modeled itself in part after a school in Middletown, NY from a connection made through the Lexington Institute's Education Leadership

DEFINITION

WHAT ARE MAKERSPACES? Makerspaces provide access to space, tools, mentors and projects needed to design, create and make. Many schools are creating makerspaces so students can engage in problem solving and collaboration through meaningful hands-on activities, experiments and projects. The maker movement aligns with the need to increase STEAM education, as both involve generating new ideas, engaging in hands-on work, collaborating and the integration of different fields. Many believe that making and STEAM fit very nicely with project-based learning. This type of learning emphasizes the process over product, and when combined with integrated learning and real-world connections, can be very powerful.[25]

Award Fellowship focused on digital learning. Middletown is a few years ahead and has strong results: students in the blended-learning program are outperforming their peers who are not in the program in both reading and math and almost all teachers reported an increase in student engagement.[26]

So how did Dr. Kasun and the administrators at FTS create the desire to change, the buy-in and leadership from its teachers and garner the resources needed to reimagine their schools? Freehold's district-level transformation occurred because of a successful change management plan, led by Superintendent Kasun and Pamela Haimer, Assistant Superintendent. Dr. Kasun and Dr. Haimer recognized that for profound change to happen sustainably, they needed a deliberate strategy—one that mirrored the creative, collaborative approaches they sought from their teaching staff. They also knew they had to allow time for change.

Dr. Kasun and his team worked together with teachers to pilot different ideas—from data-driven strategies to blended learning to maker strategies—and they learned from each other. Dr. Kasun also leveraged the Lexington Education Leadership Award Fellowship (which was paired with a year's worth of free professional development), and a partnership with Education Elements[V] to help create a vision and a plan, owned by his leadership team, to help transform learning throughout the district. Teachers who were early adopters of change also played a vital role, showing others what was possible. Dr. Haimer and Dr. Charlene Marchese, Supervisor of Mathematics and Science, pointed out the importance of professional learning communities and the need to create "an educational environment where teacher collaboration and communication is fostered, developed and sustained as a critical part of education reform."[27]

To garner additional resources, Dr. Kasun partnered with his school board and his district's education foundation. For example, the town's education foundation raised $212,000 through business donations, events, parents and other resources to build the STEAM Center and Makerspaces in each school. Dr. Kasun also developed strategic partnerships with Higher Education, in New Jersey and North Carolina, and the business community to bring in expertise and resources.

Dr. Kasun also benefited from his own peers. "Having a cohort of innovative creative leaders that are trying to do similar things although along different paths and trajectories was key...they help you with pitfalls, traps and successes."[28] FTS is also a leader in this space nationally, as they are part of the League of Innovative Schools, which is a national network of K–12 school district superintendents working together through innovation and technology to solve the biggest challenges facing our schools.[VI]

V Education Elements is a personalized and blended learning design and implementation consulting firm.

VI Several NewJersey school districts are members of the League of Innovative Schools: Elizabeth Public Schools, Freehold Regional High School District, Freehold Township School District, Morris School District and Pascack Valley Regional High School District.

i2 Learning, credit: Newark Public Schools

2. Out-of-School Time STEM Programs

After-school and summer (referred to as out-of-school time) opportunities in STEM are critical as time spent in these programs in general contribute to the 6,000-hour learning gap—or five extra years of school—between children born into poverty and their middle-income peers.[29] In general, many communities in New Jersey need additional resources in order to provide high quality out-of-school time programs for everyone. In this section, we focus on some innovative STEM programs that can be easily layered into an out-of-school time platform.

2.1 FIRST Robotics

This mentor-based national program is designed to inspire and help students learn and apply engineering, technology and important life skills by designing and building their own robots in out-of-school time programs.

A proud team of almost entirely first-generation American girls at Eastside High School in Newark introduced JerseyCAN to "Pythagoras", the robot they built in six weeks as part of FIRST Robotics "Coopertition"[VII] this past spring. Bouncing with enthusiasm, team members described the exciting and exhausting six weeks in January and February when they built it from scratch, starting with a basic set of materials from FIRST Robotics and, in their case, scrounging for recycled parts and gratefully receiving materials and mentorship from their sponsor, Picatinny Arsenal.

FIRST Robotics has been evaluated for over ten years and Change the Equation summarized their results: "... as a result of participating in FIRST, team members are more interested in doing better in school (87 percent), more interested in attending college (89 percent) and plan to take more challenging math or science courses (87 percent); over 90 percent have improved 21st-century work-life skills such as problem solving, time management and conflict resolution. FIRST graduates are twice as likely as a national comparison group to major in a STEM career with 33 percent of female participants and 41 percent of males majoring in engineering."[30] Picatinny Arsenal, located in Morris County, is a U.S. Army Educational Outreach program focused on STEM. Picatinny has taken note of FIRST Robotics' success and has supported over 45 clubs throughout the state providing mentors and $5,000 per club. If corporations partnered with them, they note that they could support even more together.[31]

VII Coopertition: "Displaying unqualified kindness and respect in the face of fierce competition. Coopertition is founded on the concept and a philosophy that teams can and should help and cooperate with each other even as they compete. Coopertition involves learning from teammates. It is teaching teammates."

2.2 Girls Who Code

With 48 clubs in New Jersey, Girls Who Code (GWC) plays a key role through after-school clubs and summer immersion programs. With a free "out of the box" curriculum that can be led by any facilitator—even those without a technical background—GWC provides important options for computer science. Club requirements include space, a laptop and wi-fi for all members and a facilitator. "Club girls learn the concepts of loops, variables, conditionals, and functions that form the basis for all programming languages—whether they want to build a website, an app, or a robot."[32] Two other central philosophical tenets of the program are

that girls are in a supportive sisterhood of computer scientists and they work in teams to help solve real-world problems through computer science. The Summer Immersion program advances the experience for 10th and 11th grade girls by engaging them in summer internships and project-based learning.

GWC has been tracking their results and found that 65 of the participants in their clubs and 93 percent of participants in their Summer Immersion program say they are considering a major or minor in Computer Science because of Girls Who Code. Companies are taking note, too. Sixty companies, including including New Jersey-based Prudential, have pledged to share paid internships and other job opportunities with GWC alumni.[33]

Credit: Girls Who Code

2.3 Crazy 8s

Crazy 8s is a national after-school club model developed by the nonprofit Bedtime Math. In New Jersey this past school year, coaches ran more than 400 Crazy 8s clubs impacting over 6,400 students.[34] The project-based program has activities such as Toilet Paper Olympics deliberately designed to be hands-on, fun and not competitive like most math clubs, which often only appeal to some kids. For example, at a Millburn elementary school, students created a zip line for stuffed animals and measured the changes in speed that occurred when they varied the zip line length. Jyoti Sharma, a parent and engineer explained: "The kids are learning math in a fun way. We want to make sure that math is fun, just like soccer or other sports."[35]

Crazy 8s is a free kit designed for elementary-aged students, and is run at a mix of schools, libraries and other nonprofit organizations during the school year. An offshoot of the evidence-based app Bedtime Math, Crazy 8s has not yet undergone the same type of rigorous evaluation. However, Chief Operating Officer Sara Thom says "preliminary data suggests that participating in Crazy 8s reduces kids' math anxiety, particularly among younger kids (K–2)."[36]

3. STEM Rich Institutions

New Jersey has many terrific STEM institutions connecting with schools to help enrich student experiences and teacher professional development. Both Liberty Science Center and Students 2 Science (S2S), while different in size, play this role along with others that we did not have room to spotlight here. Both of these organizations connect students and teachers with additional physical resources, such as sensitive or hard-to-procure materials, expensive state-of-the art lab equipment or a specialty gear for a robot. As such, they help schools use their funds more efficiently.

3.1 Liberty Science Center

With a mission to "get learners of all ages excited about the power, promise and pure fun of science and technology," the Liberty Science Center (LSC) in Jersey City is a world-class institution, perfectly poised at the intersection of informal and formal STEM education. While many of their 650,000 annual visitors are families poring through exhibits such as Dino Digs, students comprise a third of the attendees and LSC provides professional development to almost 1,500 teachers annually.

Beyond serving as a state-of-the-art science destination, LSC was also a strategic partner in the development of the Next Generation Science Standards (NGSS),[37] which form the basis for New Jersey's Student Learning Standards for Science. The NGSS are a set of research-based, up-to-date K–12 content standards in science. Liberty Science Center's VP of STEM Education, Patrick McQuillan, gives a concrete example to explain the importance of the shift to these standards: "It used to be that students needed to learn content, that the change in seasons was due to tilt of the earth. We have now moved to abstract thinking in fifth grade and the standards are no longer fact-based. Instead it's about understanding the concept of cyclic pattern of motion so you can apply it to a lot of things, such as why a lunar eclipse happens."[38]

Given their leadership role in developing the NGSS, LSC is deeply invested in professional development to ensure teachers can successfully transition to the standards, which changed from content-driven to inquiry-driven. Through LSC's professional development, New Jersey teachers can deepen their skills in teaching "evidence-based learning, exploration of science phenomena and science discourse."[39] As part of several workshops, teachers can then modify existing science lessons to better align with the new standards.

While influencing in-classroom opportunities, the LSC also engages students directly in science through hands-on computer science labs, maker labs and a Live from Surgery program that enabled almost 9,500 students to observe real-time surgeries such as kidney transplants or neurosurgeries this past year via feed. As VP of External Affairs Christine Arnold-Schroeder explained, the surgery program offers an opportunity for students to learn about all the staff roles in the surgical room because "it's hard to aspire to a career if you don't know it exists".[40] Student labs include offerings such as Bee-Bots (programmable robots that follow algorithms), dissecting a cow's eye, exploring water samples to identify plankton or assembling a device to collect hydrogen power. LSC does not limit itself to its facility. A team of science educators travel the state to bring science-based programs to schools as well as after-school settings.

The LSC and Jersey City schools have taken advantage of their proximity to build several unique partnerships. They have co-designed a weekly lab program that is built into the curriculum for 3rd and 4th graders at 4–5 schools with plans to expand. Through this hybrid program, teachers and LSC scientists developed a curriculum wherein students have a typical four days of school and then spend Fridays side by side with LSC scientists in a lab on experiments or other project-based learning. The program aims to expose and engage elementary students to STEM careers and coursework before they advance to middle school. Research has shown that "students who reported a career interest in a science-related field in 8th grade were two to three times more likely to earn STEM degrees a decade later."[41]

Credit: Liberty Science Center

3.2 Students 2 Science

Located in East Hanover, Students 2 Science (S2S) is a non-profit whose mission is to inspire, motivate and educate K–12 students to pursue high-demand, 21st-century STEM jobs, especially for students from vulnerable communities.

S2S partners with major players in the state representing life sciences, biotechnology, and pharmaceuticals and has a $4 million commercial quality laboratory that hums with innovation where students work side by side with scientists conducting complex experiments on state-of-the-art scientific instrumentation. On the day JerseyCAN visited, students from Newark participated in a biotechnology day, where they engaged in one of four experiments around the topic of solving population growth needs including examining diabetes and vaccines, monitoring fish farms and generating ethanol as a biofuel from yeast. After the experiments, the students presented in front of all the groups and visitors, with their teachers and scientists supporting them.

On any given day, students may interact with scientists volunteering from companies including, but not limited to, Merck, Becton Dickinson, Daiichi-Sankyo, Novartis, PerkinElmer, Bristol-Myers Squibb, Benjamin Moore or Thermo-Fisher Scientific. This provides students with more concrete understandings of careers, and teachers with the opportunity to learn cutting-edge practices. Importantly, many of the scientists who volunteer come from corporate affinity groups of women and underrepresented minorities. This helps inform student perceptions that they belong in STEM, a concept that is supported by a recent random-assignment study from University of Massachusetts researcher Nilanjana Dasgupta. She found that female engineering students with mentors felt more accepted by their peers and less invisible; more confident in their engineering skills and more likely to think they had engineering talent; and believed in their ability to persist. Dasgupta likened mentors to a social vaccine that inoculates "the mind against the stultifying effects of negative stereotypes."[42] Thus, the partnerships between companies, S2S and schools leverage multiple benefits.

Traveling to the S2S East Hanover site provides a unique opportunity for scholars to work alongside scientists in a state-of the-art lab. To eliminate travel constraints, S2S has designed additional complementary experiences through their Virtual or V-Labs. V-Labs essentially beam a scientist into a classroom to lead students through additional experiments.

V-Labs start with a lesson plan and training video that teachers can review ahead of time to prepare. In advance of a V-Lab, teachers receive a package of materials and special resources required to conduct the experiment for three classrooms, the first conducted simultaneously by an S2S scientist and the second and third by the teacher alone with additional classrooms.

One such V-Lab lesson is "Glow it Up" which teaches students how "glow-stick" technology is used in industry for safety and also tracks the science back to bioluminescence found in fireflies and the bioluminescent bay in Puerto Rico.

For Peter Larabee, the VP of Science at Newark's Science Park High School, S2S solves many of his procurement and teacher professional development challenges. He explains that many materials needed for experiments don't last long and are hard to procure at the small scale needed for schools. When S2S sends the V-Lab experiment kits, replete with materials, it reduces waste and saves time and money. Combining the procurement help, the technical support through volunteer scientists plus a curriculum that helps students understand complex ideas makes S2S a powerful partner.[43]

S2S served 15,000 New Jersey students last year, two-thirds through V-Lab and the remainder at the East Hanover site. Newark Schools have engaged deeply with S2S's East Hanover site over the years, including 25 Newark schools that participated in 2016–2017 school year. While this combination broadens and deepens the reach, Superintendent Christopher Cerf and science lead Ivory Williams want to ensure more of the 35,000 Newark Public School students have this opportunity with less transportation time and related expense—which is why they are building a 10,000-square foot facility of their own in the basement of 765 Broad Street that will open fall 2017. The project has already received $4 million in donated equipment and $1 million from corporate and philanthropic supporters, with professional fundraisers focused on raising the remaining $7 million.[44] In addition, Mayor Ras Baraka is an advocate and champion for the project citing the exposure for the city with increased employers.[45]

4. The STEM Teacher Pipeline

Classroom teachers are the most important part of moving STEM education forward in New Jersey. A recent analysis by the nonprofit 100Kin10 identified several common teaching challenges around STEM including: a lack of pre-service and professional development in STEM; insufficient time to collaborate with peers; lucrative and seemingly more prestigious opportunities in other fields; the intensity of focus on math and English language arts at the expense of other subjects; and the lack of funds or access to quality STEM curriculum.[46]

New Jersey does not have enough qualified STEM teachers which has created significant barriers to student access and equity. Urban students and black and Latino students have diminished access to teachers with a STEM major. When examining computer science, a Google-Gallup study in 2016 found that, "when asked which potential reasons for not offering Computer Science apply to their school, 63 percent of K–12 principals and 74 percent of superintendents currently not offering computer science in their school or district say they lack teachers with the necessary skills to teach computer science curriculum. Additionally, 55 percent of principals and 57 percent of superintendents say their school does not have enough money to hire or train a computer science teacher."[47]

Credit: Students 2 Science

In testimony to the New Jersey Legislature, Stephanie Hull, Executive Vice President and Chief Operating Officer of the Woodrow Wilson National Fellowship Foundation noted that while New Jersey has 24 teacher preparation programs in our state colleges and universities, in recent years this group has produced only nine physics teachers and 16 chemistry teachers.[48]

The good news is that the numbers, at least in computer science, are rising and innovative approaches are working: "Forty percent of principals of K–12 schools in the U.S. report having at least one computer science (CS) class available in which students can learn computer programming or coding, according to Google and Gallup's study on computer science education. This is up from 25 percent a year earlier."[49]

As mentioned earlier, the STEM field, outside of schools, is highly lucrative in part due to the supply shortage of skilled staff. This shortage compounds the challenge of recruiting and retaining STEM teachers. Institutions throughout the state are providing pre-service and professional development. We chose to highlight just a few of these, specifically those that explicitly prepared STEM teachers. To solve for this problem, approaches vary from 1) helping STEM professionals in other fields successfully transition into teaching; 2) teaching non-STEM teachers how to teach certain STEM classes; and 3) supporting teachers with opportunities to practice and receive feedback and mentorship to hone their craft.

4.1 The Woodrow Wilson Teaching Fellowship

The Woodrow Wilson Teaching Fellowship (WW) currently operates in New Jersey and four other states to recruit and place STEM professionals to teach in high-needs secondary schools and "enhance the quality of university-based teacher education by creating models of exemplary practice at participating universities."[50] While the New Jersey Fellowship program is relatively new, its goal is to have participants spend three years in a high need school from the state in which they received training. For example, in Indiana, 81 percent of the Fellowship's fellows remained in high needs schools in Indiana while 100 percent stayed in the profession overall. The highly competitive program accepts only 13 percent of applicants and invests deeply in them.[51] Fellows receive admission to a master's degree program at a partner university, preparation for a teacher certification in STEM and high needs settings, and support and mentoring throughout the three-year commitment. Since 2014, they have awarded 180 fellowships to fill high need positions who are teaching 18,000 students each year. Further, 80 percent of the fellows live in New Jersey and 40 percent are teachers of color.[52]

WW builds partnerships with local teaching institutions and helps them build model clinical STEM programs collaboratively. This may include a redesign of curricula, clinical classroom experiences and performance assessment of the teachers. In New Jersey, clinical teacher education programs have been built in partnership with The College of New Jersey, Montclair State, Rowan University, Rutgers-Camden and William Paterson University.

The master's degree program functions as an instrument to recruit and train teachers and the approach could function equally well filling other hard-to-fill positions such as English language learner and special education positions. WW helps teacher preparation schools bring the clinical focus to other areas of the work as well. Recognizing that their success is critical and small in scale, the WW team also utilizes their impact data to help shape policy and transform teacher education overall. New Jersey recently changed their regulations on teacher preparation programs and they now reflect the mentoring and clinical nature of the fellowship.[53]

4.2 The New Jersey Center for Teaching and Learning

Dr. Robert Goodman, a former audio electronics CEO turned physics teacher and 2006 State Teacher of the Year, leads the New Jersey Center for Teaching and Learning (CTL). CTL is a nonprofit created by New Jersey Education Association and is the top producer of physics teachers in the country; a major producer of chemistry teachers; and a top producer of free editable K–12 course materials for mathematics and science. In the last eight years, CTL produced over 200 physics teachers for the state.[54]

Camden City School District's Superintendent Paymon Rouhanifard called CTL the most impactful happening in K–12 that no one is talking about. As he explained, "We have a dire need for high quality STEM teachers. And traditional routes to becoming a physics teacher simply aren't producing enough for our students in Camden (and throughout the country). CTL has shaken up the status quo by taking existing teachers in other fields, like, say, English or history, and develop them into top-notch STEM educators."[55]

The Center has designed the Progressive Science Initiative and the Progress Mathematics Initiative to offer an effective new approach that includes curriculum, materials, teacher methodology, environment, scheduling, policies and practices.[56] In fact, eight of the top 20 schools in New Jersey for AP Physics participation used PSI in 2014. Dr. Goodman developed PSI while teaching physics and engineering at Bergen County Technical High School. To begin, the Center reverses the typical science sequence by teaching physics first so that physics courses reinforce the skills students are learning in algebra. CTL also utilizes technology to conduct formative assessments. Additionally, existing certified teachers can take the online courses to obtain endorsements in physics and chemistry. The training includes 300 hours of instruction and the results, researched by Hanover Research, are are shown below:

- ***Participation in AP Physics exams:*** A comparison of students in PSI schools in New Jersey to the US found that PSI students were 4.4 times more likely to participate in the AP physics B exam than other New Jersey students and 5.4 times more likely to participate than students in the U.S. PSI students of color and girls are more than five times as likely to participate in the AP exam.

- ***Higher passing rates on AP Physics exams:*** Students in PSI schools were 3.4 times more likely to pass the AP Physics B exam than US students. PSI students of color and girls were more than twice as likely to pass the exam."[57]

Effective STEM teachers are desperately needed to advance equitable STEM education and opportunities for New Jersey children. Innovative, effective approaches are needed at a greater scale.

5. Systems Level Change

Thus far, we have focused on K–12 programs and initiatives designed to tackle discrete issues in parts of the STEM education world. We now transition to initiatives that are designed to drive systems level change. We will look at the New Jersey Department of Education's (DOE) initiatives in three areas and Higher Education's work with the creation of the STEM Pathways Network.

5.1 New Jersey Department of Education

In Trenton, DOE's Acting Chief Academic Officer Laura Morana and Chief Innovation Officer Joshua Koen shared the state's perspective on what's happening with STEM statewide and how they support schools and districts as they make discrete and transformational changes.

5.1.1 Setting Standards—Next Generation Science Standards

Perhaps one of the most notable systemic shifts occurred in 2014 when the New Jersey State Board of Education adopted the Next Generation Science Standards (NGSS). These standards were developed in concert with 26 state partners, including New Jersey. With their adoption, a fundamental shift was made in the way students engage in scientific learning. The NGSS are not a curriculum. Rather, they are a set of benchmarks, goals and best practices to guide the way students are taught science. The NGSS facilitate a more student-oriented approach, meaning that students are expected to observe phenomena, note it, explain to peers why it happens and then debate and discuss. This reflects a goal to mirror the real world where scientists explain things to other scientists. This goal further affirms New Jersey DOE's continued commitment to establishing and sustaining high standards for teaching and learning as an approach to ensuring that our high school graduates enter an economy prepared to meet more challenging skills required in STEM fields.

5.1.2 Encouraging Innovation—Future Ready Schools

The New Jersey DOE supports district innovation through several ways. For one, DOE aggregates student performance data and then visits these schools to see what's working so that they can scale effective innovations. In addition to research, the DOE in partnership with the New Jersey School Boards Association and the New Jersey Institute of Technology (NJIT) has developed a Future Ready Schools—NJ school certification program to help schools develop personalized, research based digital learning programs. Rather than have all school districts forge their own path, the New Jersey DOE initiated the New Jersey version of Future Ready Schools (FRS), which is based on a national model developed by the Alliance for Excellent Education and the US Department of Education. New Jersey chose to focus on the three core areas: Leadership, Education and Classroom Practice, and Technology Support and Services.

To begin the certification process, districts embark on a collaborative Future Ready pledge. This commitment fosters coordination and sustainability by requiring a school board resolution supporting participation and a vertically-integrated team ranging from members of a board of education to technology leads

and teachers. During the subsequent certification process, schools will submit evidence of actions taken that are designed to lead to success in digital learning. Actions, such as implementing a flexible schedule, are measured by indicators along a scoring rubric.[58]

While a certification program may sound bureaucratic, it serves as a means to an end. As Koen explains: "The FRS-NJ program is the vehicle to help schools leaders take the necessary steps and learn from a roadmap to meaningfully leverage technology to greater personalize the learning experience for every student. The true mission is to identify those districts successfully preparing future ready students and have those districts provide narrative, documents and evidence that will be hosted on FRS-NJ website so that each of the over 600 New Jersey school districts will benefit from their lessons learned."[59]

NJIT leads the ground effort on FRS for the New Jersey DOE and recently announced that 34 districts, comprising 80 schools, have committed to supporting their schools' Future Ready efforts as of June 30th of this year.[60]

5.1.3 Providing Work-Based Learning Opportunities—Career & Technical Education

New Jersey's Vocational-Technical (Vo-Tech) schools and programs, commonly referred to as Career and Technical Education (CTE), educate 80,000 students—61 percent at CTE programs that are part of traditional high schools and 39 percent at 21 county vo-tech high schools.[61] Vo-techs, as well as CTE programs embedded in other schools, include a set of courses aligned both to academics and relevant technical knowledge and skills. While CTE programs for traditional vo-tech areas such as agriculture still exist, in recent years there is an increased focus on STEM, reflecting workforce needs. Out of the 27 CTE programs approved in 2016, 13 were STEM programs.

Most county vo-tech schools have become extremely competitive (there are 2.5 applicants for every available seat)[62] and have admissions requirements. In a list of the top 251 STEM high schools in the country, New Jersey has 21 of the top schools. Of those 21, county vo-tech schools comprised a third, according to US News and World Report.[63] In fact, the top honor went to High Technology High School in Monmouth County's Vocational School District.

County vo-tech schools are not to be confused with district-based "magnet" schools, which can have a STEM focus, and may or may not have admissions requirements. In addition, some districts also have STEM themed programs within their schools. The chart on page 33 highlights some of the major differences between the county vo-techs and magnets.

A primary change to CTE began with New Jersey DOE's strengthening the rigor and accountability in part due to the changing federal landscape through the 2006 Carl D. Perkins CTE Act of 2006. Marie Barry, Acting Deputy Chief Academic Officer, Postsecondary Readiness and Partnerships at NJDOE, explains, "(A) rigorous DOE CTE program approval and reapproval process is in place that ensures high-quality programs are offered. More than 500 programs were removed over the past five years, while approved programs of study grew from 78 in 2011 to 317 in 2015."[64]

Alongside the change in rigor for the approval process, DOE collaborates regularly with New Jersey's Department of Labor and Workforce Development (DOL) to ensure that CTE programs align with industry needs which are increas-

ingly STEM-related—reflecting an overall transition from the trade preparation of the past.[65] Jeffrey Stoller, Assistant Commissioner at DOL believes that to help develop a thriving workforce the DOL must engage before high school—too many students have not learned relevant or in-demand skills after four years. The DOL created seven Talent Networks, which help them gain industry intelligence, develop employer-driven partnerships and inform CTE course offerings and pathways. These Talent Networks include industry experts, academia, employers, associations and work-force organizations as well as DOE's CTE staff that meet quarterly and have deepened DOL's integration into education.[66]

DIFFERENCES BETWEEN COUNTY VO-TECH AND MAGNET SCHOOLS IN NEW JERSEY

	County Vocational-Technical School Districts	Magnet
Governance		
	State DOE must approve a CTE school or program in order to qualify for federal Perkins funding. These are public school districts that operate on the county level with their own school boards.	Local school board and district govern the schools.
Funding Sources		
	County taxes, local taxes, state and federal aid fund the schools. They are eligible for Federal Perkins dollars. Local school districts send money to county vo-techs to cover the cost of educating students.	Local taxes, state and federal aid fund the schools. Funding for students is a part of the local school district's budget.
Transportation		
	If admitted, the student's home district must pay for transportation to the school.	Transportation is at the discretion of the district.
Technical Qualifications		
	NJDOE requires: 1) a coherent sequence of at least three courses that integrate academic and technical skills at traditional high school or two years of CTE courses at a stand-alone CTE high school; 2) provide a student with a work-based learning opportunity; and 3) meet the state CTE standards for content and industry-recognized standards.	Must meet general guidelines for public schools, but there are no state-level qualifications to have a specific magnet theme.
Admission Process		
	The process varies by school but is often highly competitive. The New Jersey Council of County Vocational-Technical Schools reports there are an average of 2.5 applications per seat.	Processes vary by district. Some are open to all, some are application-based, while others are lottery based.

With CTE's transition, demand and competition for seats at the county schools is high—last year, over 15,000 students were turned away due to lack of slots.[67] To address this demand, some policymakers are suggesting new funding through a bond measure to expand the number of schools.[68] In addition, New Jersey DOE is expanding CTE's reach by building capacity for growth of high-quality, rigorous programs within comprehensive high schools starting with eight pilot schools. As Barry shared, "These eight schools are a learning laboratory—we were seeing fewer and fewer students participating in CTE since many comprehensive high schools stopped offering programs. These eight pilot schools present a good opportunity for the DOE to understand the challenges associated with offering CTE programs and provide support to grow quality CTE programs so all students can access equally rigorous programs such as biomedical, health science or engineering." Barry sees this infusion of CTE into comprehensive high schools as part of an overall evolution wherein the lines between CTE and academics are increasingly blurred. Today, traditional schools are adding more project based learning, which have long been at the heart of high quality CTE and academic rigor is an integral part of all CTE programs.

NEW JERSEY DOL'S TALENT NETWORKS

— Advanced Manufacturing
— Financial Services
— Health Care
— Life Sciences
— Retail, Hospitality & Tourism
— Technology
— Transportation, Logistics & Distribution

5.2 Higher Education—the STEM Pathways Network

New Jersey Secretary of Higher Education, Rochelle Hendricks, launched the New Jersey STEM Pathways Network (NJ SPN) in 2014 as "a public-private strategic alliance established to inform the alignment of STEM resources, support an education-to-workforce STEM pipeline, identify exemplary formal and informal learning opportunities, and promote STEM career pathway awareness."[69] NJ SPN set out to support the creation of local STEM Learning Ecosystems[VIII], a national concept upon which the New Jersey initiative is based.

A STEM Learning Ecosystem provides architecture to cultivate, coordinate and thereby enable cross-sector learning at the community level. By integrating the work of individual partners, they strive to create STEM-rich learning environments, equip educators and support youth pathways through college and career. This is in recognition of the fact that teaching and learning are not the sole

VIII The initiative was modeled after The STEM Funders Network STEM Learning Ecosystems Initiative.

province of K–12 and that greater coordination and alignment among P-20, out-of-school time, STEM institutions, non-profits and industry will result in better STEM outcomes for students and their future employers.

To help New Jersey communities take advantage of this national model, NJ SPN ran a competitive grant process in 2016 and selected four communities: Delran STEM Ecosystem Alliance, Liberty STEM Alliance, Newark STEAM Coalition and the South Jersey STEM and Innovation Center. Grant recipients each received $60,000 worth of technical assistance from the Teaching Institute for Excellence in STEM,[70] with funding provided by Overdeck Family Foundation. In addition, this spring, the Delran STEM Ecosystem Alliance and Newark STEAM Coalition earned entry into a nationwide Community of Practice funded by the STEM Funders Network. This robust network is comprised of 56 communities located throughout North America. Here in New Jersey, NJSPN is managed by the Research and Development Council of New Jersey, led by Hendricks and chaired by Laura Overdeck.

Families
Help spark student interest and understanding and support STEM success

Pre-K–12 Schools
Interactive and engaging instruction in STEM fields for students and professional learning support for teachers

Business Community
Lend experitse, philanthropic support and access to STEM in local industry

STEM-Rich Institutions
Spark interest and excitement about STEM and bring academic lessons to life

Out-of-School Programs
High quality STEM learning opportunities that emphasize real-world applications

Higher Education
Offer STEM programs, resources, and training to community

Content and concept adapted from the U.S. Department of Education

The Delran team remarked to JerseyCAN that while much of STEM learning is happening in their community, it can often be disjointed. As Mary Jo Hutchinson, K–12 Supervisor of Math, Business and Robotics in Delran described it, "everyone had little pockets of innovation, but they weren't connected." Their coalition brings together local industry (Lockheed Martin, Barnes & Noble, Simon & Schuster and CBC, for example), families and the community, the U.S. Army, out-of-school time organizations, educators and institutions of higher education such as Rowan University and Princeton University. When working collaboratively, they spark new partnerships and build towards greater alignment for industry, out-of-school-time, higher education and K–12 education.

As a network, Delran is focusing intentionally on equity issues within STEM as well. For example, school leaders hope that computer science and coding can move out of the realm of elective so that a more diverse cross section of students enroll. In addition, when they introduced a robotics course, school leaders ensured that it was offered to everyone and not solely for students in gifted and talented or honors courses.[71] Similarly, the NJ SPN recently launched an Equity Committee, chaired by Dr. Nannette Wright of Lockheed Martin and Chairperson of New Jersey's Educational Opportunity Fund, to review how to improve access and opportunity in STEM education across the state.[72]

Throughout the ecosystems, many corporations are engaged in part due to their future workforce needs. As a result, some New Jersey companies are creating stronger education-to-employment pathways by reviewing the current data on majors or graduate degrees earned in the skillsets they need and are focusing their corporate investments to support those subject areas. Newark-based Prudential Financial is one such company. They have a particular focus on the math part of the STEM equation, as they have identified a gap in the actuarial talent pool. Actuarial sciences require a strong foundation in mathematics, statistics and technology in high school and college, and many students in Newark are not graduating with the requisite skills to fill these jobs. Part of Prudential's strategic approach is to work with K–12 and higher education partners in Newark to create a stronger pipeline of math and computer science students, thereby increasing the number of math and computer science graduates that could potentially fill actuarial job openings.[73]

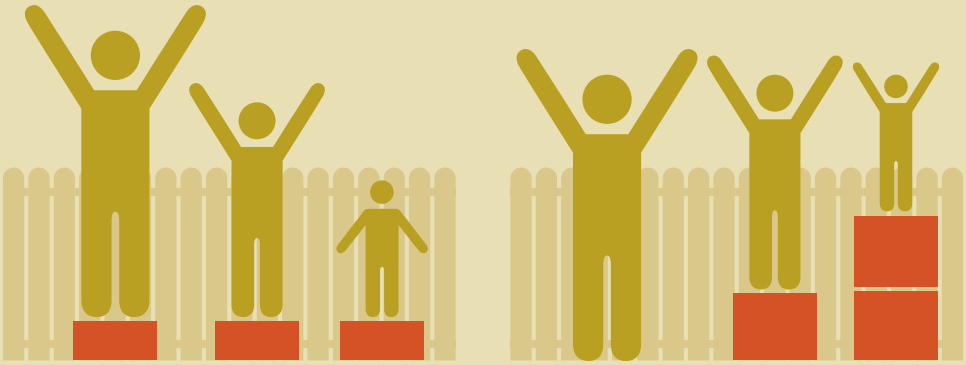
The Importance of Equity

New Jersey's STEM field is significantly weakened because it lacks the perspective of female, black and Latino professionals. It is both a moral responsibility as well as a smart economic decision for New Jersey to invest in creating equitable STEM educational opportunities.

Achieving equity requires multiple ingredients: access to high quality, culturally relevant content supported by appropriate resources and delivered with the adequate dosage to ensure students can close the achievement gap. Programs and schools also need to instill the belief that everyone belongs and can achieve in the field, especially for girls and underrepresented minorities. Starting with a

look at the entry-level issue—access—our pipeline leaks from the start. As former US Education Secretary John King recently noted, inequitable access is part of the problem particularly in schools with high concentrations of students of color: "For example, only a third of high schools with large Black and Hispanic enrollments offer calculus, compared to 56 percent of those that serve small numbers of these students. And less than half of high schools with high Black and Hispanic enrollments offer physics, while two out of three high schools with low numbers of these students do so."[74]

EQUALITY VS. EQUITY



Equity involves trying to understand and give people what they need to enjoy full, healthy lives.

Equality, in contrast, aims to ensure that everyone gets the same things in order to enjoy full, healthy lives. Like equity, equality aims to promote fairness and justice, but it can only work if everyone starts from the same place and needs the same things.

Content and concept from
Annie E. Casey Foundation

While equal access forms the foundational layer for achieving equity, educational opportunities for all students must also be high quality, an issue which can be difficult to quantify as quality takes many forms and is rarely tracked. However, researchers in Florida recently shed some light on the issue. They found that while Florida has closed some digital divide issues, others remain. Namely, Tina Holfield and colleagues report that "low-SES[75] students generally use software more for computer-directed activities such as drill and practice or remedial work, while their high-SES counterparts are using software more for student-controlled activities such as creating with or communicating through technology."[76]

When access and quality are married, the results can be spectacular. Uncommon Schools' North Star Academy College Preparatory High School provides one such example. A few years ago, as the North Star team reviewed their internal data on their high school graduates in college, the low number (six percent) of students selecting STEM majors jumped out at them. Looking back at their curriculum, they recognized that lack of STEM courses was part of the problem, so they added courses in engineering and computer science. Allison Cuttler, a

teacher who went on to win the prestigious Milken Educator Award, taught their AP Computer Science course. In the second year of her teaching, 100 percent of her students performed at three or above on the AP exam, accounting for about a quarter of all black students in the entire state who achieved the same or better results.[77] Similarly, about half of all ninth graders chose engineering as an elective after a popular math teacher developed and taught it. Now, over 30 percent of their more recent cohorts of graduates who are college students are choosing STEM majors.

Access plus quality still does not ensure equity, however. As Reshma Saujani, Founder and CEO of Girls Who Code, exhorts: "Despite unprecedented attention and momentum behind the push for universal computer science education, the gender gap in computing is getting worse. The message is clear: a one-size-fits-all model won't work. This ... is a rallying cry to invest in programs and curriculum designed specifically for girls."[78] To help those working in STEM advance gender equity, Accenture and GWC jointly published "Cracking the Gender Code: Get 3X More Women in Computing" which should be required reading for all folks interested in STEM. It dives into three keys to success and actionable items. These are:

1. Sparking the interest of girls in junior high school.
2. Sustaining girls' commitment in high school where early gains are often lost.
3. Inspiring college undergraduates by reframing computer curriculums.

The article concludes: "Implementing our recommended strategy focused on these three stages of education could help to more than triple the number of women working in computing in the U.S. to 3.9 million by 2025. In turn, this could boost women's cumulative earnings by $299 billion over the next 10 years."[79]

The College Board has also taken action and recently launched a new computer science class, AP Computer Science Principles, "with the goal of creating leaders in computer science fields and attracting and engaging those who are traditionally underrepresented with essential computing tools and multidisciplinary opportunities".[80] The theory, which aligns with the GWC research, is that girls are more driven to improve the world and the creative aspect of CS and are good at collaborating and getting things done. The College Board also made research-based recruitment recommendations to actively recruit students by speaking about the creative and collaborative aspects of CS as well as the doors it opens to many fields. They also advise recruiting in clusters, especially those that are your target demographic such as the girls basketball team or student affinity groups. The roll out has been impactful. In this first year of AP CSP, over 45,000 students at 2,700 schools took it this spring across the country.[81]

The final ingredient is inspiration or belief. Research from Lara Perez-Felkner and colleagues at Florida State University illuminates the challenge that even when mathematical abilities are the same, boys rate themselves 27 percent or higher than girls.[82] In many settings, schools and organizations are engaging women and underrepresented minorities as mentors, volunteers and speakers to expose students to adults in STEM who look like them or come from a similar background. In New Jersey, Latinas In STEM, Million Women Mentors and the Institute for Electronic Electrical Engineers' Women in Engineering program are just some of the many organizations and corporate affinity groups with women or people of color in the STEM field who stand ready to mentor or volunteer.

Recommendations

We have examined STEM quite broadly in this report, shining a light on just a sample of innovative strategies and programs being used by pioneers to advance STEM education in New Jersey. We have also highlighted some of the New Jersey Department of Education's leadership in STEM, and the collaborative work that is growing between community colleges, universities and businesses, which will help the New Jersey STEM skills gap.

But the bottom line is that we have to focus on this problem from two dimensions. First, we do not have enough teachers and quality programs to produce the skilled workforce needed to fill STEM jobs today or in the future. Second, we have "leaky pipes" in the K–12 education system. We are losing potential STEM talent, especially among women and underrepresented minorities. To advance STEM opportunities, which is fundamental to New Jersey's economic competitiveness, we need to address both sides of this issue.

We can and must strengthen New Jersey's innovation economy by increasing accessibility to quality STEM education. We recommend the following seven action items to capture this opportunity.

The Governor Should Create a Task Force on K–12 STEM Education

JerseyCAN recommends that the Governor of New Jersey create a task force to develop a comprehensive plan for strengthening K–12 STEM education in New Jersey. It is time to step back and understand where we are, where we want to go, and what actions must be taken to get there. Clearly some of the building blocks are in place, but we need a well-articulated vision, and a state leader that can bring resources needed to execute a thoughtful plan.

The task force should include a diverse group of stakeholders including teachers, educational leaders, academics, the business community, and legislative representatives. Beyond the traditional STEM education leaders, we also recommend including experts from the arts community. For the task force to be effective, it will need strong leadership and a clear mandate leading to actionable recommendations.

We suggest the task force focus on the following areas:

- ***STEM educators:*** Teacher preparation, teacher pipeline, professional development, leadership
- ***STEM offerings including curriculum and instructional practices:*** STEM curriculum and courses including computer science; project based learning, and personalized/blended learning and practices that promote learner agency and development of 21st century skills
- ***Community and business partnerships:*** Out-of-school STEM programs, pre-school offerings, higher education, STEM institutions, and business partnerships

The task force should make clear recommendations with an action plan that would include strategies to raise public awareness, secure resources, increase access to high-quality STEM programs and experiences, allow flexibility for con-

tinued innovation, support talent development, and leverage the ecosystem. We want inspired and prepared students, empowered teachers that will lead and drive change, and a system that is built around excellence and equity.

This comprehensive approach to change can help accelerate New Jersey's work to strengthen our innovation economy and improve the lives of our residents.

Invest and Expand Training of STEM Teachers

New Jersey faces a shortage of teachers trained in the STEM fields, especially in our urban communities—for example just 21 percent of 8th grade math teachers in urban communities have an undergraduate degree in math compared to 51 percent in suburban settings. It is clear we need to better prepare and resource our teachers, and attracting them from more lucrative STEM jobs outside of teaching is also part of the challenge. The Department of Education and the Office of the Secretary of Higher Education should evaluate and expand effective strategies to address this need.

Two innovative programs were discussed in this report—the Woodrow Wilson National Fellowship and the Center for Teaching in Learning. What can we learn from these programs? Should they be scaled up? Should our teacher preparation and requirements include enhanced STEM certificates and micro-credentials? Should we look to enable STEM professionals to become teachers with thoughtful pedagogical training, and a streamlined process? Should we incentivize or ease a process for teachers to train and transition to STEM? Should our teachers in the early grades receive more training in math and science, since these are key years for building interest and confidence in STEM subjects? Should we pay hard-to-staff positions more? Are we investing enough in strong STEM Professional Development? How can we ensure children living in low-income communities have not just parity, but equity with regard to well-prepared STEM teachers? New Jersey should prioritize this work, which is vital to supporting our teachers in STEM fields.

Expand Access to Computer Science

Digital technologies are now reshaping many parts of our global economy, and computing jobs are growing at three times the national average. Code.org[IX] reports that 93 percent of parents want their child's school to teach computer science, but only 40 percent of schools teach it. Given this disparity, and the growing need for technology proficiency in most jobs, we must evaluate the benefits of requiring some form of computer science to be taught in all schools—both as standalone coursework and/or integrated into other subjects. New Jersey has added a computer science standard to the K–12 literacy standards, but the State is evaluating whether a broader effort is needed.

We must increase the number of schools that offer computer science, but that will require an investment in teachers, and most principals and superintendents cite the lack of computer science teachers as the biggest obstacle to offering the courses. Policymakers should examine multiple means to accomplish this such as those listed in the recommendation above as well as developing clear certification pathways or computer science endorsements (for teachers certified in other fields), and establishing computer science programs for pre-service teachers.

IX Code.org is a non-profit dedicated expanding access to computer science and increasing participation by women and underrepresented minorities. They also provide the leading curriculum for K–12 computer science in the largest districts in the US, and they help certify computer science teachers with various training programs.

It is worth noting that this year, the New Jersey legislature recently allowed AP Computer Science to count as one math credit. Code.org also recommends allowing computer science courses to count as core admission requirements at colleges and universities. The legislature's move on AP is a good step, but additional action is needed to ensure all students, at a minimum, have access to computer science that engages a diverse student population. Code.org also suggests several strategies to target underrepresented minority and female students.

Expand Access to Career and Vocational Technical Training and Work-Based Learning Opportunities in STEM Fields

As discussed in this report, New Jersey has some exceptional county Vo-Tech/CTE high schools focused on STEM, several of which are among the top performers in the country. However, access to these schools can be extremely competitive and, as we discussed earlier, some efforts are underway to expand the programs and services offered in these schools more broadly to a greater number of students. One proposal focuses on issuing a bond to fund the growth of these Vo-Tech/CTE high schools. A second proposal involves adding more CTE programs to traditional high schools. Because we believe in both excellence and equity, we support the expansion of CTE programs in traditional high schools. These CTE programs might be well suited to address the shortage of middle skills workers identified in a recent McKinsey research report looking at New Jersey's economic growth opportunities.

The McKinsey report, entitled "Re-seeding the Garden State's economic growth: A vision for New Jersey" identifies a growing labor-market mismatch between the demand for middle-skill workers and the supply of workers with the appropriate skills. Middle-skill jobs are defined as those that require a high school education with some college education or specialized training, often in technology. The report recommends "improving labor-market matching by working with employers to create training programs and curricula to qualify middle-skill workers for positions in growing fields."

We recommend that the STEM task force analyze the options here further, as the outcomes of this work could create more pathways for children linked to jobs of the future, while also improving New Jersey's economic growth opportunities.

Further Leverage Personalized/Blended Learning into More Classrooms

We are at the cusp of learning how technology can significantly transform or redefine education, not just augment it. Programs like Teach to One Math and districts such as Freehold Township demonstrate how personalized learning can be used to transform schools and have students become leaders of their own learning. Other districts and schools in New Jersey are also leading the way here. We believe this can create an opportunity to contribute to closing the achievement gap.

The DOE's collaborative, schools-led initiative around Future Ready Schools should begin to build a foundation around personalized and blended learning. JerseyCAN supports the Future Ready Schools leadership group and will continue to shine a light on this work as it advances.

In the short term, policymakers at the state and district level should invest in professional development alongside any investments in hardware to make

sure the investment is well leveraged. They should also remove obstacles to the type of flexible scheduling both students and teachers may need to optimize blended learning.

The long term potential for school transformation is significant. Research published by RAND Education outlines policy changes that can enable growth that include flexibility on course progressions, autonomy to design school schedules, accountability policies that value growth, and grading policies that incorporate competency-based approaches.

Innovations in this space will continue, and we need to stay abreast of new strategies that work.

Create an Innovation Fund

Many of the recommendations we are suggesting to improve our K–12 education system require new resources. Indeed, start up costs can create barriers for schools to consider change. JerseyCAN recommends evaluating the benefits of forming an Innovation Fund.

Over the next several months, we will be reviewing the optimal way to structure such a fund. New Jersey has proposed two different Innovation Grant programs over the last several years that have stalled in the legislative process.

In 2013, a bill was introduced to establish a $5 million Innovation Grant Program in the Department of Education. The intent was to establish a competitive grant program where school districts could apply for funding for professional development or to develop innovative educational practices. Private philanthropy would have been used to leverage public dollars. Unfortunately, this bill did not make it out of the legislature. In contrast, Ohio set up a $250 million fund in 2013 as part of their state budget, which has provided seed money to spur local innovation and adoption of personalized learning models.

In 2016, another bill was introduced that established the "New Jersey Innovation Inspiration School Grant Program" to fund non-traditional STEM programs. Again, this was to be administered by the Commissioner of Education as a pilot program. This was a much smaller program that involved approximately $1 million of public money that would be leveraged by corporate or private sector donors, but it did not move forward. Perhaps we need to find a new approach.

As we surveyed the landscape for innovative STEM work, we identified many one-off examples of innovations where superintendents have found corporate partners and private philanthropists to help fund important programs and new innovations. In a state with over 600 school districts, there may be more leveraging power if there is an organized way to shine a light on evidenced based innovations to draw in funders.

JerseyCAN will continue to evaluate the potential of an Innovation Fund.

Implement Targeted STEM Strategies for Women and Underrepresented Minorities

There is a growing list of educational strategies and discrete programs that engage girls and underrepresented minorities in STEM education, and some were highlighted in this report. JerseyCAN recommends that an advisory council be formed to track these activities, look for points of leverage, and help build

further momentum. The advisory council should work to attract programs to the state that add to the New Jersey ecosystem. Progress could be assessed by looking at participation by women and underrepresented minorities in STEM courses, including related AP courses, STEM competitions, STEM college majors and pursuit of STEM careers. This data tracking should be feasible through the new Education to Earnings longitudinal database.[x] The New Jersey STEM Pathways Network might be ideal to own this strategic equity initiative.

x This new data system is New Jersey's centralized longitudinal data system that was developed in 2012. It's a collaboration between the New Jersey DOL, DOE, Office of the Secretary of Higher Education and the John J. Heldrich Center for Workforce Development at Rutgers University. It brings together data from multiple state sources for the purposes of policy and research.

Conclusion

Throughout our Garden State, we have great seeds of STEM excellence, of which we only had space to highlight a few. As a state, we need to nurture these seeds so we can meet our future workforce needs, invest in innovation and ensure all our children have access. The importance of innovative leaders, professional development, key partnerships and thoughtful change management cannot be understated. Our state will fully prosper and continue its legacy of innovation when we have a diverse talent pipeline. From our perspective, this requires an intentionality and solution that neither our state nor every district has embraced to date.

While every student needs to be prepared for college and/or career, the traditional classroom model is failing many students. We must have the flexibility and resources to innovate. If the status quo remains, the STEM sector will not reach its potential in New Jersey and as a result, thousands of young people will be denied the chance at a middle or upper middle-class life and our state's economy will lose out on growth. Now is the time to double down, New Jersey!

What You Can Do to Support STEM Opportunities in New Jersey:

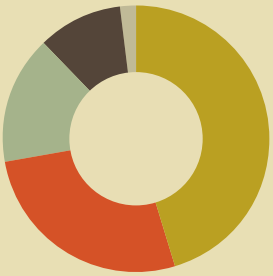
- ***Parents.*** Ask your school leadership about STEM offerings in and out of the classroom.
- ***STEM professionals.*** Volunteer as a mentor or a coach for Girls Who Code or FIRST Robotics or consider switching to teaching.
- ***Teachers.*** Find high quality and free materials at Liberty Science Center.
- ***School Leaders.*** Learn about Future Ready Schools to further your students' digital learning opportunities.
- ***Philanthropists.*** Help scale up promising practices and support research.
- ***Policymakers.*** Make STEM a priority for K–12 education in New Jersey.

Appendix

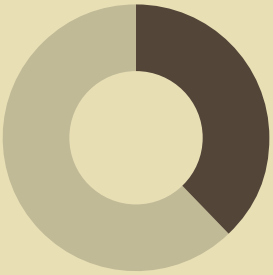
New Jersey Education Landscape and Academic Performance

STUDENT DEMOGRAPHICS, 2016–17

1,370,000 Pre-K–12 Students



45.3% White
27.1% Hispanic
15.5% Black
10.2% Asian, Native Hawaiian or Pacific Islander
01.9% Other



37.9% of students enrolled in free and reduced price lunch program

NEW JERSEY PER-PUPIL SPENDING, 2016

New Jersey had the 6th highest per-pupil spending in the United States.

Academic Performance for the U.S. and New Jersey

The U.S. education system ranks in the bottom half of 35 OECD countries on the 2015 PISA.

UNITED STATES RANKING VS. 35 OECD COUNTRIES (PISA 2015)

In the bottom 14%

31 /35 **Math**

Just above average

20 /35 **Reading**

19 /35 **Science**

New Jersey ranks high on NAEP math and reading, but average in science.

NATIONAL RANKING OF NEW JERSEY NAEP SCORES, 2015

	Math	Reading	Science
4th grade	7	4	24
8th grade	4	5	24

Despite high rankings on NAEP, New Jersey has one of the worst achievement gaps in the country. Thirty-eight percent of New Jersey students are enrolled in the free and reduced price lunch program.

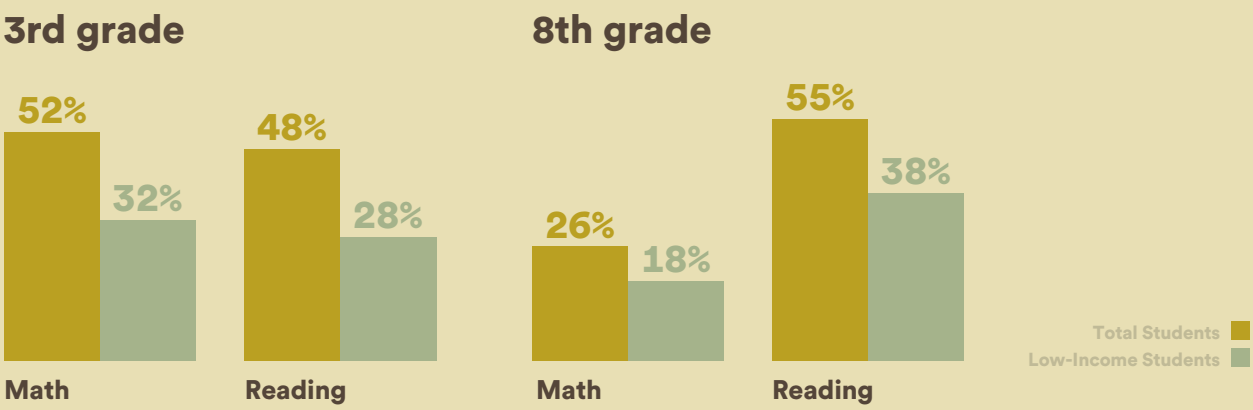
NATIONAL RANKING OF WORST ACHIEVEMENT GAPS BETWEEN LOW-INCOME AND NON-LOW-INCOME STUDENTS IN NEW JERSEY, 2015

	Math	Reading	Science
4th grade	7	4	6
8th grade	10	4	23

PERCENTAGE OF NEW JERSEY 4TH GRADE STUDENTS AT OR ABOVE PROFICIENCY ON NAEP SCIENCE, 2015

Less than half of all New Jersey students are academically proficient, as evidenced by 2016 PARCC scores, with low-income students even further behind.

PERCENTAGE OF STUDENTS MEETING/EXCEEDING PROFICIENCY STANDARDS ON PARCC, 2016



Despite New Jersey's 90 percent graduation rate and strong overall performance on the ACT compared to other states, only 45 percent of New Jersey children meet the ACT's College Readiness benchmark which is consistent with PARCC results shown above. These students may need to take remedial work in college, paying for an education they should have received in high school.

APPENDIX SOURCES

1 Programme for International Student Assessment (PISA), http://pisadataexplorer.oecd.org/ide/idepisa/.
2 National Center for Education Statistics (NCES), The Nation's Report Card, https://www.nationsreportcard.gov/.
3 New Jersey Department of Education, http://www.state.nj.us/education/data/.
4 United States Census Bureau, https://www.census.gov/content/dam/Census/library/publications/2017/econ/g15-aspef.pdf.
5 New Jersey Department of Education, http://www.nj.gov/education/schools/achievement/16/parcc/spring/.
6 New Jersey Department of Education, http://www.nj.gov/education/assessment/parcc/PARCCSpring2017results.pdf.
7 ACT, http://www.act.org/content/dam/act/unsecured/documents/cccr2017/New-Jersey-CCCR-2017-Final.pdf.
8 SAT, https://reports.collegeboard.org/pdf/nj16030301.pdf.

Endnotes

1 P21 Partnership for 21st Century Learning. "The 4CS Research Series." Accessed July 3, 2017, http://www.p21.org/our-work/4cs-research-series/

2 New American Economy. March 29, 2017. Sizing up the Gap in our Supply of STEM Workers. Available online at http://www.newamericaneconomy.org/research/sizing-up-the-gap-in-our-supply-of-stem-workers/

3 "Reports on the condition of STEM learning in the US." Change the Equation.org, Accessed August 8, 2017, http://changetheequation.org/stemdemand/

4 ISTE Connects. "Here's how you teach innovative thinking." Last modified January 19, 2016, www.iste.org/explore/articleDetail?articleid=651

5 Anthony P. Carnevale, Nicole Smith, and Michelle Melton, October 2011. STEM Science, Technology Engineering, Mathematics —Executive Summary. Report issued by the Georgetown University Center on Education and the Workforce. Accessed online at https://cew.georgetown.edu/wp-content/uploads/2014/11/stem-complete.pdf

6 Babco, Eleanor. Skills for the Innovation Economy: What the 21st Century Workforce Needs and How to Provide It. Washington, DC: Commission on Professionals in Science and Technology, 2004.

7 New American Economy. March 29, 2017. Sizing up the Gap in our Supply of STEM Workers. Available online at http://www.newamericaneconomy.org/research/sizing-up-the-gap-in-our-supply-of-stem-workers/

8 Change The Equation. "STEM Help Wanted." Accessed September 5, 2017, http://changetheequation.org/sites/default/files/CTEq_VitalSigns_Supply%20%282%29.pdf

9 Bloom, Joel. "New Jersey's Path to a Healthy Economy". Accessed July 27, 2017. http://www.njit.edu/about/features/stem.php

10 Code.org. "Promote Computer Science." Accessed August 12, 2017. https://code.org/promote/nj

11 Change The Equation. "Focus on Females and Minorities in New Jersey". Accessed September 2., 2017. www.changetheequation.org

12 Blackwell, Angela, et al. "America's Tomorrow: Equity is the Superior Growth Model." Oakland, CA: PolicyLink. 2011.

13 Dreambox. "Personalized Learning." Accessed June 13, 2017. www.dreambox.com/personalized-learning

14 Christensen Institute. "Blended Learning Definitions." Accessed June 13, 2017. www.christenseninstitute.org/blended-learning-definitions-and-models/

15 Buck Institute for Education. "What is Project Based Learning (PBL)?" Accessed June 13, 2017. www.bie.org/about/what_pbl

16 Pursuer, Ron. "Problem Based Learning." Accessed July 14, 2017. http://online.sfsu.edu/rpurser/revised/pages/problem.htm

17 Juliana Collamer, email message to author, July 6, 2017.

18 Carolyn Malstrom, email message to author, June 23, 2017.

19 Change the Equation. "Project Lead The Way." Accessed June 15, 2017. http://changetheequation.org/project-lead-way.

20 Change the Equation. "Project Lead the Way" STEM Works. Accessed July 5, 2017. http://changetheequation.org/project-lead-way.

21 Carolyn Malstrom Project Lead the Way. July 11, 2017.

22 Delta Education. "How Foss Works." Accessed July 24, 2017. https://www.deltaeducation.com/foss/how-foss-works.

23 Jennifer Slavick, personal conversation with author, July 13, 2017.

24 Valadez, J., & Freve, Y. (2001). The effect of inquiry-based science teaching on standardized reading scores. Fresno, CA: Fresno Unified School District-Urban Systemic Program.

25 Jacie Maslyk, STEAM makers: fostering creativity and innovation in the elementary classroom (Thousand Oaks, CA: Corwin/A SAGE Company, 2016).

26 Mesecar, Doug. "Middletown Personalizes Learning to Narrow Achievement Gaps." Arlington, VA: Lexington Institute. December 2015.

27 Marchese, Charlene and Pamela Haimer. Chapter 6. "Fostering Professional Growth: A Three-Pronged Approach." In Annual Perspectives in Mathematics Education—Reflective and Collaborative Processes, 77-88. National Council of Teachers of Mathematics, 2017.

28 Ross Kasun, personal conversation with the author, June 20, 2017.

29 Levy, Debv. The 6,000-Hour Learning Gap and Why It Matters." November 18, 2014. http://www.expandedschools.org/blog/6000-hour-learning-gap-and-why-it-matters#sthash.MBWwfDMm.dpbs

30 Change the Equation. "FIRST" STEMWORKS. Accessed July 5, 2017. http://changetheequation.org/first.

31 Shah Dabiri, Personal conversation with author, June 29, 2017.

32 Girls Who Code, "Clubs Program." Accessed July 2,2017. https://girlswhocode.com/clubs/.

33 Girls Who Code. "Hire Me." Accessed October 1, 2017 https://girlswhocode.com/hireme

34 Sara Thom, email message to author, July 20, 2017

35 Kadosh, Matthew. "Millburn area resident's math clubs sweeping the nation. Northjersey.com

36 Sara Thom, email message to author, July 201, 2017.

37 Liberty Science Center. "STEM Education Planning Guide." 2016-17.

38 Patrick McQuillan, conversation with author, June 28, 2017.

39 Liberty Science Center. "STEM Education Planning Guide." 2016-17.

40 Christine Arnold-Schroeder, conversation with author June 28th, 2017.

41 Tai, Robert H. "An Examination of The Research Literature on Project Lead The Way." Accessed July 5, 2017, http://www.socialimpactexchange.org/sites/www.socialimpactexchange.org/files/PLTW%20DR%20TAI%20-%20brochure.pdf

42 Yong, Ed. "How Women Mentors Make a Difference in Engineering." The Atlantic, May 22, 2017.

43 Peter Larabee, personal conversation with author, June, 2017.

44 Christopher Cerf, personal conversation with authors, May 30, 2017.

45 Newark Public Schools. "Students 2 Science." Accessed July 20, 2017. http://www.nps.k12.nj.us/13A/academics-2/stem/students-2-science/

46 Will, Madeline. "STEM Education is Facing Over 100 Challenges. Can $28 Million Solve Them?" Education Week, July 13, 2017.

47 Royal, Dawn and Art Swift. "More K-12 Computer Science Classes Teach Programming/Coding" October 20, 2016. http://www.gallup.com/poll/196511/computer-science-classes-teach-programming-coding.aspx.

48 Hull, Stephanie and Brian Hayes. "Formal Comments to Assembly Budget Committee". March 21, 2016. http://www.njleg.state.nj.us/legislativepub/budget_2017/032116/Hull_S.pdf

49 Royal, Dawn and Art Swift. "More K-12 Computer Science Classes Teach Programming/Coding" October 20, 2016. http://www.gallup.com/poll/196511/computer-science-classes-teach-programming-coding.aspx

50 Woodrow Wilson New Jersey Teaching Fellowship. "Program Update." April 2016. Riccards, Patrick, conversation with authors, June 19, 2017.

51 Riccards, Patrick, conversation with authors, June 19, 2017.

52 Hull, Stephanie, Hayes, Brian. "Formal Comments to Assembly Budget Committee." March 21, 2016. http://www.njleg.state.nj.us/legislativepub/budget_2017/032116/Hull_S.pdf

53 Riccards, Patrick, conversation with authors, June 19, 2017.

54 Center for Teaching and Learning, email message to authors, August 2, 2017.

55 Paymon Rouhanifard, conversation with author, July 14, 2017.

56 New Jersey Center for Teaching and Learning. "What is PSI-PMI?" Accessed July 28th, 2017. https://ctl.org/who-we-are/what-is-psi-pmi/

57 New Jersey Center for Teaching & Learning. "Research on CTL Program." Accessed July 28, 2017. https://njctl.org/who-we-are/research/ctl/

58 Future Ready Schools NJ, "Is Your School #Future Ready?" Accessed July 24, 2017.www.frsnj.org/get-certified.

59 Josh Koen, email message to author, July 7, 2017.

60 Jeremy Reich, email message to author, July 6, 2017.

61 Lori Howard, email message to author, June 29, 2017.

62 Barry, Marie. "Next Generation CTE: The Future is Now". October 26, 2016. New Jersey School Boards Association Workshop (PowerPoint slides). http://www.careertech.org/njdoes-marie-barry-shares-vision-for-future-of-cte-in-new-jersey-njccvts-executive-director-judy-savage/

63 U.S. News & World Report. "STEM Rankings Best High Schools" Accessed August 15, 2017, https://www.usnews.com/education/best-high-schools/national-rankings/stem

64 Barry, Marie. "Next Generation CTE: The Future is Now". October 26, 2016. New Jersey School Boards Association Workshop (PowerPoint slides). http://www.careertech.org/njdoes-marie-barry-shares-vision-for-future-of-cte-in-new-jersey-njccvts-executive-director-judy-savage/

65 New Jersey Council of County Vocational-Technical Schools. "Frequently Asked Questions" Accessed July 24, 2017, http://www.careertechnj.org/frequently-asked-questions/.

66 Barry, Marie. "Next Generation CTE: The Future is Now". October 26, 2016. New Jersey School Boards Association Workshop (PowerPoint slides). http://www.careertech.org/njdoes-marie-barry-shares-vision-for-future-of-cte-in-new-jersey-njccvts-executive-director-judy-savage/

67 Heyboer, Kelly. "Lawmakers call for major expansion of N.J.'s vo-tech schools." NJ.com, August 16, 2017.

68 Landergan, Katherine. "Sweeney says he will push for bond issue to expand vo-tech schools." August 15, 2017. Politico New Jersey Pro.
69 State of New Jersey Office of the Secretary of Higher Education. "Higher Education in New Jersey Today: Highlights of Historic Reforms, Accomplishments and Collaborations to Meet Future Needs." Accessed August 15, 2017, http://www.nj.gov/highereducation/documents/pdf/index/Highlights.pdf
70 State of New Jersey Office of Secretary of Higher Education. "Frequently Asked Questions (FAQs) New Jersey STEM Pathways Network: STEM Learning Ecosystems RFQ. Accessed September 6, 2017, http://www.nj.gov/highereducation/njstem/documents/FAQs.pdf
71 Delran STEM Pathways Network, personal conversation with author, June 6, 2017.
72 Veronica Gonzales, email communication to author, August 7, 2017.
73 Sarah Keh, personal conversation with authors, June 29, 2017.
74 King, John. "Obama Education Secretary: Expand Access to STEM, Now." OZY. http://www.ozy.com/pov/obama-education-secretary-expand-access-to-stem-now/76452
75 Socio-economic status
76 Hohlfeld, T., A. Ritzhaupt, K. Dawson and M. Wilson "An examination of seven years of technology integration in Florida schools: Through the lens of the Levels of Digital Divide in Schools.". Computers & Education (2017)
77 Barbara Martinez conversation with author, June 13th, 2017.
78 Accenture and Girls Who Code. "Women's Share of U.S. Computing Workforce Declining, but Interventions Could Triple the Pipeline by 2025, According to Research from Accenture and Girls Who Code. October 20, 2016, https://newsroom.accenture.com/news/womens-share-of-us-computing-workforce-declining-but-interventions-could-triple-the-pipeline-by-2025-according-to-research-from-accenture-and-girls-who-code.htm
79 Accenture and Girls Who Code. "Cracking the Gender Code." 2016 https://acnprod.accenture.com/t20161018T094638__w__/us-en/_acnmedia/Accenture/next-gen-3/girls-who-code/Accenture-Cracking-The-Gender-Code-Report.pdf
80 College Board. "Largest Course Launch in AP History" Accessed July 10, 2017, https://advancesinap.collegeboard.org/stem/computer-science-principles
81 College Board. "Largest Course Launch in AP History." Accessed July 10, 2017, https://advancesinap.collegeboard.org/stem/computer-science-principles
82 Irby, Kara. Florida State University. April 6, 2017. "Under Challenge: Girls' confidence, not their math ability, hinders path to science degrees." https://news.fsu.edu/news/2017/04/06/challenge-girls-confidence-level-not-math-ability-hinders-path-science-degrees/

About JerseyCAN

JerseyCAN: The New Jersey Campaign for Achievement Now advocates for all students across the state to have access to high-quality schools. We work to improve policies and programs to support equity and excellence in New Jersey education.

www.jerseycan.org

JERSEYCAN