National Inventors Hall of Fame®

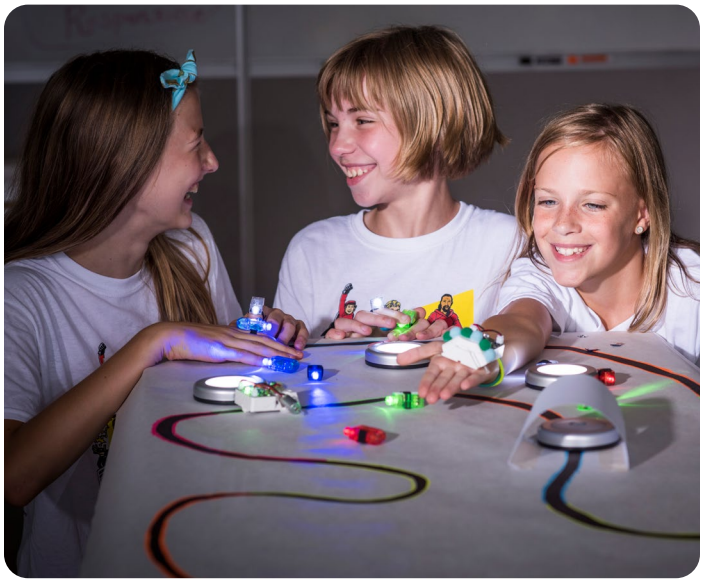
HOW TO ADDRESS GAPS AND BUILD A STRONG STEM PIPELINE

The STEM (science, technology, engineering and mathematics) fields not only represent a growing and essential part of our economy but also provide critical innovations that move society forward.

It's for this reason that as a part of its national education policy, the United States has long maintained the importance of helping students pursue careers in these fields. In the 1970s, educators and policymakers began visualizing the path a student takes from elementary and middle school to an eventual degree and career in STEM as a pipeline. While there exist different designs and forms, wholistically this "STEM Pipeline" depicts a series of linear steps that cultivate an interest in these areas throughout a child's education.[1]

While the levels of diversity within STEM fields for historically disadvantaged and underrepresented groups continue to lag behind that of other populations,[2] to improve these statistics and to help children develop and maintain their interest in these subjects, it can be helpful to identify a few key reasons why students might lose interest over time.

Finding and fixing the gaps that can form in the STEM pipeline can go a long way in helping students develop a passion for these fields and benefit from developing skills they can apply throughout their lives.[3]



Three children collaborate to test their designs at Camp Invention.

STEM Pipeline Gap: Anxiety and Misconceptions

How students are introduced to and interact with STEM, especially at the K-12 level, can have a significant impact on their perceptions and interest. While many educators are familiar with sometimes having to defend the relevance of their respective fields, those who teach math and science are at times confronted with the need to help overcome students' intimidation and anxiety associated with the subjects.

A child enjoys developing engineering skills with hands-on curricula from the National Inventors Hall of Fame.

In an article published by the Harvard Business Review, Sian Leah Beilock, cognitive scientist and president of Barnard College, explained that according to her research, math anxiety begins in both boys and girls as early as the first and second grades. Her study found that nearly half of the students she surveyed indicated that they were either "moderately nervous" to "very nervous" about math.[4]

This problem persists at the collegiate level as well. According to an article published by the New York Times, it is estimated that a quarter of students attending four-year colleges in the United States experience moderate or high levels of math anxiety.[5] The problem is so serious that one study published in the Journal of Counseling Psychology found that 11% of American university students had such a severe case of math anxiety that it warranted counseling.[6]

Fear of science is also well documented in academic literature. In an article published by Forbes, Marshall Shepherd, a leading

1. Metcalf, H. (2010). Stuck in the pipeline: A critical review of STEM workforce literature. InterActions: UCLA Journal of Education and Information Studies, 6(2). https://doi.org/10.5070/d462000681
2. Nadeem, R. (2021, April 1). STEM jobs see uneven progress in increasing gender, racial and ethnic diversity. Pew Research Center Science & Society. Retrieved January 13, 2023, from https://www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/
3. The National Inventors Hall of Fame. (n.d.). What is the innovation mindset? National Inventors Hall of Fame®. Retrieved January 13, 2023, from https://www.invent.org/blog/trends-stem/innovation-learning-skills
4. Beilock, S. (2022, October 17). Americans need to get over their fear of math. Harvard Business Review. Retrieved January 13, 2023, from https://hbr.org/2019/10/americans-need-to-get-over-their-fear-of-math
5. Klass, P. (2017, April 24). Fending off math anxiety. The New York Times. Retrieved January 13, 2023, from https://www.nytimes.com/2017/04/24/well/family/fending-off-math-anxiety.html
6. Suinn, R. M., & Winston, E. H. (2003). The Mathematics Anxiety Rating Scale, a brief version: Psychometric Data. Psychological Reports, 92(1), 167–173. https://doi.org/10.2466/pr0.2003.92.1.167

international expert in weather and climate and director of the University of Georgia's Atmospheric Sciences Program, explained that science anxiety is something he has witnessed in many of his students, and even their parents.

> "I am always concerned when I hear a parent say, 'I am not a science person nor is my kid,'" said Shepherd. "Such statements train the child to succumb to parental insecurities or biases while setting up a self-fulfilling prophecy."[7]

Fear, of course, is not the only force driving students away from STEM subjects. Sometimes, the way in which the subject matter is presented is simply uninteresting.

Carolyn Bertozzi, National Inventors Hall of Fame® Inductee and recipient of the 2022 Nobel Prize in Chemistry, said as much in a 2022 interview on "Science Friday," explaining that a lack of interest in science fields might be a self-inflicted problem.

> "I think the misconception of chemistry being boring might be our own fault," Bertozzi said. "Because I think chemists teach students in a somewhat boring way during their first exposure in high school."

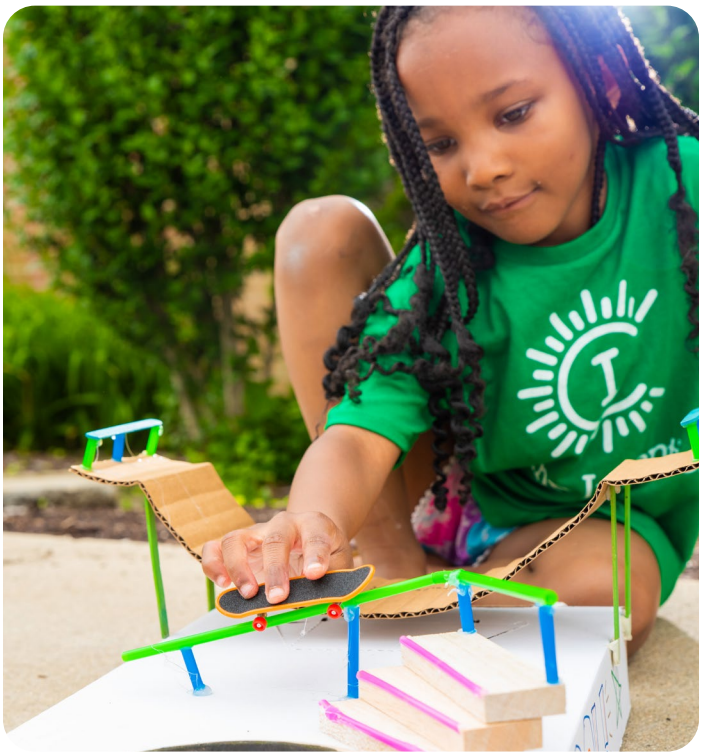
Carolyn Bertozzi gives an acceptance speech at the 2017 NIHF Induction Ceremony.

Later in the interview, Bertozzi admitted that even she did not appreciate the subject's relevance when she was introduced to it in high school. However, she stuck with it and after taking organic chemistry in college, she realized how central the field was to biology and biomedicine. She subsequently fell in love with organic chemistry and would later revolutionize it entirely.[8]

Solution: Implementing Invention Education

One effective way to address both STEM anxiety and a lack of interest in these fields is to embrace a pedagogy known as invention education, which invites students to solve real-world problems by designing and creating their own prototypes.

This hands-on approach to learning is not only fun but also empowers students to build confidence in an inclusive and supportive environment, and allows them to authentically tap into their interests and passions by giving them agency over how they want to learn.



A child explores physics concepts using a fingerboard at Camp Invention.

STEM Pipeline Gap: Lack of Diversity

A strong STEM pipeline is inclusive and embraces ideas from people of all backgrounds. This is far more than a moral issue. In addition to simply needing more professionals to enter these fields, to stay innovative and competitive with other countries around the world, we also need to ensure our STEM workforce becomes more diverse.

Research has shown that teams composed of a diverse combination of inherent traits (traits people are born with) and acquired traits (those gained from experience) are 45% likelier to report growth in market share year over year and 70% likelier to capture a new market.[10]

Intuitively, this makes sense, as individuals with different backgrounds and experiences can introduce unique ideas and considerations that might have been left dormant otherwise.

In the medical field, the lack of gender diversity can have more serious consequences, as bias (implicit or otherwise) can lead to negative health outcomes. One study published in Academic Emergency Medicine found that women had to wait almost 33% longer in an emergency room setting than men with identical symptoms.[11]

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7. Shepherd, M. (2019, May 28). 4 reasons people fear science. Forbes. Retrieved January 13, 2023, from https://www.forbes.com/sites/marshallshepherd/2019/05/26/4-reasons-people-fear-science/?sh=2993f7b452c0
8. The National Inventors Hall of Fame. (n.d.). NIHF inductee Carolyn Bertozzi reflects on her career. NIHF Inductee Carolyn Bertozzi Reflects on Her Career | National Inventors Hall of Fame®. Retrieved February 7, 2023, from https://www.invent.org/blog/inventors/carolyn-bertozzi-reflects
9. The World Intellectual Property Organization. (n.d.). Global innovation index 2022: Switzerland, the U.S., and Sweden lead the Global Innovation Ranking; China approaches top 10; India and Türkiye ramping up fast; impact-driven innovation needed in turbulent times. WIPO. Retrieved January 13, 2023, from https://www.wipo.int/pressroom/en/articles/2022/article_0011.html
10. Hewlett, S. A., Marshall, M., & Sherbin, L. (2014, August 1). How diversity can drive innovation. Harvard Business Review. Retrieved January 13, 2023, from https://hbr.org/2013/12/how-diversity-can-drive-innovation
11. Chen, E. H., Shofer, F. S., Dean, A. J., Hollander, J. E., Baxt, W. G., Robey, J. L., Sease, K. L., & Mills, A. M. (2008). Gender disparity in analgesic treatment of emergency department patients with acute abdominal pain. Academic Emergency Medicine, 15(5), 414–418. https://doi.org/10.1111/j.1553-2712.2008.00100.x

Another study published by McKinsey found that women treated by female doctors were more likely to survive a heart attack than women treated by male doctors.[12]

These troubling findings highlight the very real consequences that can occur from a lack of diversity. And yet, despite making up almost 50% of the U.S. workforce, women only represent 27% of all STEM workers.

The statistics are even worse for Hispanic workers, who represent 17% of the U.S. workforce but only 8% of STEM workers, and Black workers who constitute 11% of the country's workforce, and 9% of STEM workers.

Paired with longstanding implicit biases[13] that exist within these fields, this lack of diversity and representation can make it difficult for these same underrepresented populations to feel that they belong in STEM careers.

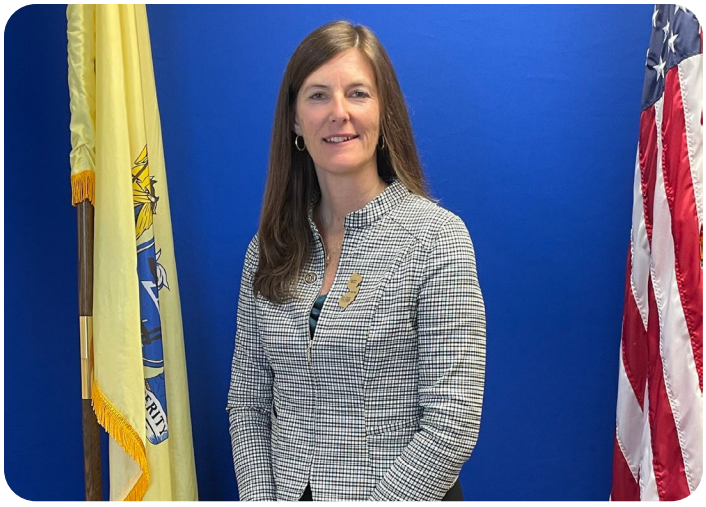
Solution: Introducing Diverse STEM Role Models

To address the persistent lack of diversity within these fields, STEM pipelines that involve curricula designed to introduce diverse STEM role models can make a significant impact in helping students realize what they too can achieve.

A groundbreaking study from Opportunity Insights, a research institution based at Harvard University, supports this and found that exposure to innovation significantly increases the likelihood that children will innovate as they age.

> "If girls were exposed to female inventors during childhood at the same rate that boys are to male inventors, the gender gap in innovation would fall by half," said the researchers.[14]

STEM Pipeline Case Study: How Christine Girtain Helped Her School District Build a Strong STEM Pipeline



Christine Girtain was named the 2022-23 New Jersey State Teacher of the Year.

Christine Girtain, director of Authentic Science Research at Toms River High School North and Toms River High School South in New Jersey, has developed an effective K-12 STEM pipeline for her district by using the Camp Invention® program as its foundation.

Camp Invention is the flagship summer STEM program from the National Inventors Hall of Fame®, which has provided transformative hands-on learning experiences to K-6 students across the country since 1990.

In an interview with the National Inventors Hall of Fame, Girtain, the 2022-23 New Jersey State Teacher of the Year, described how her own children's positive experience with Camp Invention inspired her to nurture and cultivate interest in STEM among her district's students.

> "In the fall of 2014, I was looking for an engaging summer program for my daughter who was in fifth grade and for my son who was in second," Girtain said. "That's when I came across Camp Invention and decided to bring it to my school and be the Director for our program. The first year we had 105 kids and because it attracted kids from other school districts, eventually Camp Invention spread to several other districts in my county."

As Girtain continued to direct her district's Camp Invention, the children who attended her camp grew and progressed through elementary school. Along the way, she let children know about her high school-level research class and how she would love for them to one day become her students.

At the same time, Girtain began developing a connection with Cold Spring Harbor Laboratory, a lab in Huntington, New York, that offers program DNA Learning Center camps for students in middle school through college. Through this relationship, she was able to create her own summer camp program using similar lab techniques.

Over the years, Girtain continued to raise money and partner with sponsors like the U.S. Navy NJEA, Sustainable Jersey for Schools, and MiniOne to offer a variety of science-themed camps including an Intro to Biotech camp and World of Enzymes camp for grades 6-9, and BioCoding and DNA BarCoding for high school students.

To her great delight, in her high school research class, Girtain began recognizing students she had first met at Camp Invention, who had succeeded in maintaining their passion and excitement for STEM.

This culminated in a special moment in 2022, when a former Camp Invention camper, Bisola Fasakin, who had become a sophomore from Girtain's research class, spoke at a ceremony commemorating her State Teacher of the Year Award.

> "I've known Mrs. Girtain since I arrived in this country and I couldn't wait until I could attend her research class," said Fasakin. "I can't remember a time when she hasn't been in my life."

12. Berlin, G., Darino, L., Greenfield, M., & Starikova, I. (2022, February 28). Women in the healthcare industry. McKinsey & Company. Retrieved January 13, 2023, from https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/women-in-the-healthcare-industry
13. Columbia University in the City of New York. (n.d.). Implicit bias in STEM. Implicit Bias in STEM | Academic Affairs & Diversity. Retrieved January 13, 2023, from https://diversity.ldeo.columbia.edu/implicitbias
14. Bell, A., Chetty, R., Jaravel, X., Petkova, N., & Reenen, J. V. (n.d.). Who becomes an inventor in America? Retrieved January 13, 2023, from https://opportunityinsights.org/wp-content/uploads/2021/12/inventors_summary.pdf

Christine Girtain posing with her student Bisola Fasakin during a ceremony celebrating her 2022-23 New Jersey Teacher of the Year award.

> Girtain shared, "I was super proud of that moment because of the relationship I built with Bisola over the years – through Camp Invention and the middle school camps. She is now looking into gel electrophoresis and plans to do something with genetics for her research project."

Though she did not originally set out to create a K-12 STEM pipeline in her district, Girtain's gift of building connections, her desire to give her students the best chance to succeed and her commitment to education combined to form an encouraging pathway for students to foster their interests in STEM.

When asked why Girtain has continued to use Camp Invention as the base of her STEM pipeline for the past seven years, she explained that the consistent quality and evolution of the curricula keep her and her colleagues coming back year after year.

> "The curriculum is amazing. Every year when you think it can't get any better, it does," Girtain said.

Additionally, she appreciates how receptive the National Inventors Hall of Fame is to feedback and ideas for improvement.

> "I love that NIHF listens to teachers. Over the years, when they get feedback from us, I saw it being implemented the next year," Girtain said.