Problem-Based Learning

EDITOR’S NOTE
Problem-based learning ignites hands-on exploration, ignites curiosity, and sparks lifelong problem-solvers. This Spotlight will help you learn how virtual reality can be used for unique problem-solving and engagement; explore how students are publishing their research in peer-reviewed journals; uncover how after-school programs are helping students explore real-world problems; discover how to apply problem-based learning in math and science classrooms; and more.

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How This Teacher Tapped Virtual Reality to Pump Up Student Engagement

By Alyson Klein

Philadelphia—

Justin Kosek’s 6th graders usually find the water cycle a somewhat dry topic. (Pun intended). Could adding dragons to the mix help?

That’s what Kosek, a teacher in the West Allis-West Milwaukee school district in Wisconsin set out to answer when he turned the science unit into a virtual reality, project-based learning experience. The assignment: Use VR tools, including a headset and coding program, to create an educational game about the water cycle.

Over about three weeks, students worked in teams and dreamed up all sorts of imaginative scenarios, Kosek said. For instance, one group, whose work Kosek shared during a session at the International Society for Technology in Education’s annual conference here this week, created a game in which a fire-breathing dragon disrupts the water cycle. Players must complete a series of tasks and answer questions about the inner workings of the water cycle to stop the dragon and save the day.

To create that game, students not only had to master the ins and outs of the water cycle, they had to “do such an immense amount of problem solving, collaboration,” Kosek said.

They seemed to enjoy it. In fact, Kosek got calls from parents curious about what had gotten their kids coming home so excited about school, a rarity in the high-poverty community where he teaches.

“I saw higher attendance, I saw students just more actively engaged and wanting to know more,” he said in an interview after the panel.

To be sure, “there are some tech issues,” including connectivity problems, Kosek said. But they weren’t as disruptive as he feared they might be.

The students “wanted so desperately to try [the VR technology] that they were so patient,” Kosek said.

Students at his middle school are also among the most likely in the district to break or lose technological devices, but in this case they took “great care” of the VR headsets because they were eager to use the tech again.

A couple of students got headaches after using the VR headsets, a problem that sometimes happens for people using virtual reality. Kosek urged them to take a break when that happened. And the school generally urged students not to spend too much time navigating in virtual reality environments, since it can cause sensory overload.

Those challenges are common when schools try VR.

Though some ed-tech experts predict VR will be used more widely in schools in the near future, the technology can be glitchy and difficult to manage. Kosek spent up to an hour getting each of his 15 VR headsets ready for classroom use.

Virtual reality devices can also be pricey. (Meta’s Quest VR 3 headset retails for about $500.)

But West Allis-West Milwaukee received a roughly $100,000 grant to help kickstart some of its VR work. And it snagged refurbished VR headsets from Meta, the company that owns the social media platforms Facebook and Instagram.

Kosek and others also got professional help from Kwaku Aning, the director of innovation at San Diego Jewish Academy, a private school in southern California, who has significant experience with education technology, including VR.
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Student Scientists Are Publishing Their Research In This Peer-Reviewed Journal

By Sarah Schwartz

There’s a consensus in science education that science should be something students actually get to do—that learning how to employ investigative methods to test hypotheses is just as important as understanding the periodic table or being able to diagram a cell.

A group of professional researchers is now working to support that goal, giving teenagers the opportunity to publish their own scientific papers.

The Journal of Emerging Investigators, an open-access publication that publishes original research from middle and high schoolers, was started in 2011 by Harvard University graduate students who thought there should be a way to document the work that school-age researchers were submitting to science fairs. The journal now publishes students from at least 20 countries and is available to read for free online.

The process—of conducting research, getting feedback from working scientists, and seeing one’s own findings in print—is transformative, said Grace Kim, a first year student at Emory University who published her research on COVID’s impact on students’ social, mental, and physical health in JEI in fall 2021. Kim is now an outreach coordinator with the journal.

Before she started her project, she’d had the idea that publishing was something that only adults or doctoral students could do. “You have to research in a university and find these grand results—new things—and share with the world,” she said.

Submitting to JEI showed her that wasn’t the case.

“I was excited to know that I could do something on my own,” she said.

Supporting the thrust of new science standards

The journal also helps support the goal of many states’ expectations for student learning in science. Inquiry and engagement in the scientific process are key parts of the Next Generation Science Standards, released in 2014 and in use in about 20 states. They require that students learn science and engineering practices alongside content knowledge.

Teachers have said that finding ways to have students authentically practice science in class can be challenging—even as science education organizations and curriculum companies put out new materials designed to align to the NGSS.

This year, the journal is on track to publish about 175 papers from middle and high school students in the United States and internationally, said Scott Soldat-Valenzuela, JEI’s executive director.

The submission guidelines for the journal are broad: Any hypothesis-driven experimental research is fair game.

Many of the papers are in natural sciences, but not all, said Soldat-Valenzuela. Earlier this month, for example, they published a paper on socio-economic status correlates with Indian teenagers’ physical activity. “We really want students to write about something that they’re passionate about,” he said.

Opportunities for feedback, collaboration

Students must be in 6th-12th grades when they submit their work, and they need to have a mentor—whether a teacher, parent, or other adult. JEI provides a guide on how to prepare an academic paper, covering details like hypothesis design and how to format figures and tables.

Volunteers—graduate students, post-doctoral students, and other science professionals—review the submissions and provide feedback.

“It’s an advanced experience, but it’s also really educational for them,” said Soldat-Valenzuela. “They’re getting real feedback from a real reviewer.”

The process also puts students in conversation with professional researchers, said Kim. Her 2021 paper presented survey research that Kim conducted with students at private international schools in South Korea, one of which she attended. Reviewing other literature allowed her to contextualize and compare her results, Kim said, noting the differences in student experiences across countries and socioeconomic statuses.

Kim sought JEI out. She knew she wanted to get more involved in the science community, and she was looking for a way to publish her research. That’s how most submissions come to the journal, said Soldat-Valenzuela. Now, he said, the team is trying to broaden its outreach to more teachers and students, especially in lower-income communities. It’s started to offer seminars to prepare middle and high schoolers for the submission process and answer any questions. They want to make it clear that anyone with a hypothesis to test can conduct research.

“We’re really focused on the student writing, and learning how to publish their work, and how to communicate their science to other students,” Soldat-Valenzuela said.

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Problem-Based Learning

What 3 After-School Programs Are Doing to Prepare Kids For the Future of Work

By Lauraine Langreo

A robust STEM education is becoming increasingly important as more jobs require higher levels of competency in these areas, especially technology.

One place to support students’ STEM learning is through after-school programs, which “complement what’s possible during the school day, including offering more flexibility and time for hands-on learning to explore career paths and gain workforce skills,” said Maud Abeel, a director for Jobs for the Future, a national nonprofit that develops programs and public policies that increase college and career readiness.

Students participating in STEM after-school programs have reported increased interest in STEM careers. And though not all students are interested in pursuing STEM careers, they still benefit from this kind of knowledge and skills, which are in high demand in today’s workforce, Abeel said.

Education Week identified three after-school programs that are expanding as they try to meet the demand for new, tech-driven skills.

Making a splash with underwater robots

When Santi Criado was younger, he thought he wanted to follow in his mom’s footsteps and become a dentist. Now as a rising senior at Thomas Jefferson High School for Science and Technology in Alexandria, Va., he knows he wants to study engineering like his father. Criado credits the change to his exposure to a SeaPerch after-school program during middle school.

SeaPerch is an underwater robotics program from nonprofit RoboNation, which provides hands-on experiences to empower students to find solutions to global challenges. SeaPerch provides students, educators, and parents with kits to get started on their underwater robots. It also provides lesson plans and educator training, and there are also regional and international competitions for students to show off their engineering skills.

“We’ve structured the program activities so it is flexible to fit into existing structures,” said Lindsey Groark, the vice president of programs for RoboNation. “So whether that is a full semester or a yearlong class in high school, or a two-week unit in the classroom or an after-school club, or summer camp, or even just a weekend community event where students come out with their parents—you can dive into the program as deeply as you want to.”

For Groark, the hope is that being part of a SeaPerch program will introduce students to the engineering design process and engineering careers.

“Ocean engineering is one of the more obvious [career] connections,” she said. But the program is focused on “multidisciplinary engineering.” Kids learn about circuitry, electricity, naval architecture, and even aerospace topics. Students have gone on to study computer science, mechanical engineering, electrical engineering, systems engineering, and other technical fields, Groark said.

One school district that participates in SeaPerch is the Wahkiakum district, in Cathlamet, Wash. The district’s robotics team took first place in the open division of the International SeaPerch Challenge in May.

Ron Wright, the STEM coordinator for Wahkiakum, said he’s seen the after-school robotics program change students’ lives and “redirect kids who were struggling in school...
The program began in 2016 and operates in-person “learning labs” in New York City, Detroit, and Oakland, Calif., where students can tinker with coding tools, meet each other, and meet Google mentors. There’s also an online program for students who don’t live in those cities. (Dominguez attended Code Next in Oakland).

“The program seeks to provide students with the skills and the social capital needed to pursue rewarding careers in technology,” said Kyle Ali, the lead senior program manager for Code Next.

Students learn the fundamentals of computer science and different coding languages, through a mix of direct instruction and team-based activities. For 11th and 12th graders, there’s an incubator program where students come up with an idea and try to have a tangible product by the end of the program that might be ready to be pitched, or even funded.

“One of the things that we are proudest about is, as we see so many of our students that have gone through the program and have ultimately gone on to college or university, they’re coming back to us and wanting to help the students that are coming through the program,” Ali said. And a majority of students who have gone through the program are continuing their computer science education in college.

For Dominguez, one of the biggest highlights of the program was meeting the people who created the products he uses daily and learning how they do it. All it takes for an after-school program like Code Next to be successful is “the right volunteer” who’s “really passionate” about coding and “makes it exciting and interesting.” Now as a Code Next intern, he hopes to be one of those impactful volunteers for the students growing up in the same community.

Exploring careers in virtual reality

In Indiana, students have access to hands-on career exploration simulations in an after-school program, thanks to a partnership between the Indiana Alliance of Boys and Girls Clubs and the immersive learning startup Transfr.

Using virtual reality headsets, kids get exposure to different skills that they didn’t necessarily know about and how those skills are used in the real world. Some professionals students learn about in the virtual world include first responders, robotics specialists, health care, automotive service technicians, manufacturing, crane operator, plumbing, and more.

“Many of our clubs already have VR systems for gaming, so this was just another opportunity to expand into the needs, the interests of the kids,” said Lana Taylor, the executive director of the Indiana Alliance of Boys and Girls Clubs. Right now, 31 Boys and Girls Clubs in Indiana participate in the Transfr program, with many others on the waitlist.

When students put on the VR headset, they’re dropped into the environment of the career simulation they picked and have to follow instructions to learn a skill. For example, if they picked a lineworker (who installs and fixes overhead cables and electrical systems), they would see the power lines and they’d have to climb to the top and follow step-by-step instructions on how to fix whatever is wrong with the lines.

The Boys and Girls Clubs supplement what students are seeing in the VR headsets with a career exploration curriculum that builds on students’ math, reading, science, and civics skills. And after a simulation, students talk about what they like or didn’t like about the job, their takeaways, and whether they’d like to do the job in the future. Older students are also encouraged to work on certifications and credentials.

“It’s about getting them set up and ready for a career and I think this is one of the more fun pieces that we can use,” said Jon York, the CEO of the Boys and Girls Club of Rush County in Indiana. “It used to be guest speakers and watching DVDs. Now we’ve moved all the way so they’re immersed inside the skills. It goes over better with our kids when they are in charge and in control [of their learning].”
For science teachers, the past few years have offered no shortage of real-world lessons. The pandemic presented opportunities to talk about epidemiology and health communications. Natural disasters, from hurricanes to wildfires, left teachers to explain the effects of a changing climate and its impact on communities.

At a SXSW EDU panel this week in Austin, educators and experts said that seizing those moments and helping students make sense of them can engage students in science classes. Panelists focused on public health specifically, discussing how the subject could broaden students’ understanding of who scientists are and what they do. They also offered tips on how to weave the subject into the standard course progression.

Public health topics—like the opioid epidemic, racism, and measles vaccinations—are “all things that have been really prominent in the news, that are impacting our youth today,” said Kelly Bloodworth, an epidemiologist at the U.S. Centers for Disease Control and Prevention.

Developing this relevance also aligns with many states’ science standards.

One driving goal behind the Next Generation Science Standards, which have been adopted by 20 states and the District of Columbia, was to make the subject feel more pertinent to kids’ lives. Developers of the standards have said that kids should be able to see the connections between what they’re learning in science classes and how it will affect their families and their communities.

These are four tips from the panelists on how to embed public health lessons into coursework.

1. **Start with student questions**
   
   When Kelsey Fusco, a science teacher and department chair at South Forsyth High School in Cumming, Ga., came back to campus in August 2020, her students had a lot of questions.

   The district didn’t mandate masks, so kids wanted to know why—and why other districts around the country did. They also didn’t fully understand the purpose of quarantining, Fusco said.

   When the teenagers in her class were told they had been exposed to someone with the coronavirus and had to quarantine, they didn’t understand why they couldn’t get out of the requirement right away with a negative test.

   “Having to explain what infection period meant, and incubation period—all of these terms became a daily context for them,” Fusco said. “The need was so present to be able to explain some of that content to them, because it was so relevant to their daily lives.”

   Fusco worked some of these topics into her science lessons at the time. She also planned some cross-curricular instruction—with topics like epidemic curves. The graphic representations showed the number of cases in an outbreak over time, and learning about them requires marrying math and science concepts, Fusco said.

2. **Teachers don’t need a public health course to teach public health topics**
   
   Fusco embeds related lessons into her core science classes, like 9th grade biology. “It’s using what you already know, the standards you already know, and making this more authentic for student learning.”

   **KELSEY FUSCO**  
   Science Teacher  
   Cumming, GA
“Too often, we teach everything like it’s history,” Loehr said. “We’re never talking about how those discoveries, that knowledge, still is impacting us in the real world today.”

3. Make connections to ideas students already understand

Educators can use analogies to simplify complex science topics, said Rishi Desai, a pediatrician and the chief medical officer at Osmosis, a health education platform created by the publishing company Elsevier.

Osmosis partnered with the CDC to create content for a public health-related middle and high school curriculum.

He gave an example of fetal development. During pregnancy, fetal cells get signals to grow different body parts—fingers on hands, toes on feet, for instance. How do the cells get these messages?

“We use this beautiful diagram that I think is quite simple, that talks about it in the context of mail,” Desai said.

In the U.S. Postal Service, mail carriers know where to deliver items based on the address that’s on the envelope. This system in the body works in a similar way, Desai said. This kind of analogy can help foreign-seeming processes click for students, he said.

4. Show how classroom learning can lead to future career options

In her high school classes, most students come in thinking that the only science careers are nurse, doctor, or engineer, said Fusco.

Teaching about public health gives her the opportunity to present kids with other options: infectious disease specialists, epidemiologists, health communications experts, and lab specialists.

“It answers the lifelong question of students in the classroom: ‘When are we going to use this?’” Fusco said.
Students Need Better/More Data-Science Skills. Here Are 5 Ways Schools Can Help

By Lauraine Langreo

It’s almost impossible to go anywhere or do anything in today’s world without experiencing the impact of data science: from streaming apps’ recommendations to product placements in stores to election predictions.

And the rise of generative artificial intelligence—technology that’s reliant on the data it’s trained on—will only make data-science skills more relevant and important for all jobs, experts say.

“This is not at all relegated to Silicon Valley or traditional technology jobs,” said Zarek Drozda, the director of Data Science for Everyone, a national initiative advocating data-science education to be included in K-12.

“It’s hard to name a sector without data science today, and every job—whether it’s the top of the corporate ladder or it’s an entry-level position—will need to be using data more intensively to make decisions on a daily basis.”

In fact, a majority of senior business leaders from the biggest global companies predict that “big-data analytics” will be the No. 1 job creator in the next five years, according to the World Economic Forum’s 2023 Future of Jobs report.

“It is increasingly obvious that every student needs the basic fundamentals of digital skills, data analysis, and ability to navigate new and emerging technology tools,” Drozda said.

Yet students’ basic data-science skills have been in decline. Over the last decade, scores in data analysis, statistics, and probability on the National Assessment of Educational Progress in mathematics dropped 10 points for 4th grade students and 17 points for 8th grade students.

To address those shortcomings, more states are adding data-science education in their K-12 curriculum. The number of states with K-12 data science programs increased from one to 17 over the past three years, according to Data Science for Everyone.

In some school districts, data science is an elective course for high school students; in other places, it’s incorporated into the math curriculum; and in others, it is integrated throughout the K-12 curriculum.

So what do schools need to do to prepare students for jobs and careers that will rely heavily on data-science skills? Here are five steps educators and data-science advocates say schools should take:

1. Invest in professional learning

The most-mentioned action step is for schools and districts to invest in professional learning for educators. Many teachers—sometimes even those who focus on math—are uncomfortable teaching data-science concepts because they don’t have the background for it and weren’t properly prepared in college, according to educators and data-science education experts.

“To my knowledge, nobody is graduating with a degree in data-science education,” said Kevin Dykema, the president of the National Council of Teachers of Mathematics and an 8th grade math teacher in Michigan.

“So it’s people who are teaching other content areas that are being told, ‘Hey, you’re now going to teach a data-science course.’ But that wasn’t their background and that wasn’t necessarily their knowledge set, so there’s a need for some professional development.”

Virginia, which is in its second year of piloting its new data-science standards, provided a three-day professional learning event for teachers who are part of the pilot program, said Deb Crawford, the lead for the state’s data-science course-development and pilot team. During those three days, secondary math or computer science teachers were im-

KELSEY FUSCO
Science Teacher
Cumming, GA

It’s using what you already know, the standards you already know, and making this more authentic for student learning.”
mbersed in learning the standards and the tools they can use to teach the content. Teachers also received vetted resources, as well as ongoing support throughout the school year.

2. Focus on real-world applications

Educators and advocates underscore the importance of using curricular resources that give students the opportunity to apply what they’re learning to real-world situations.

Students will be more engaged in the learning if the curriculum uses data that are relevant to their interests, said Maud Abeel, a director for Jobs for the Future, a national nonprofit that develops programs and public policies to increase college and career readiness.

Teachers who let students choose the topics of their data-science projects, whether it’s Spotify trends or March Madness or mental health, find that “students work through the data-science courses faster than anticipated,” Drozda said.

Joy Straub, who taught a dedicated data-science high school course at the Vista Unified school district in California for six years, said the best practice is to make the class “exploratory.” Teachers should give the students the skills to analyze data, “but let them ask the questions. Let the students dig and dig deeper and deeper.”

3. Partner with higher education institutions

School districts can’t do this work alone, educators and advocates say. Colleges and universities have a part to play.

For instance, colleges and universities could partner with their local K-12 schools to help train teachers in data science and develop locally relevant curriculum. Higher education institutions could also ensure that students receive college credit for data-science courses they take in high school, experts suggest.

“This could be one of those areas where the higher ed. community already has probably a pretty strong understanding of what’s important to teach in data science,” Abeel said. “Those partners could help bring data science into the K-12 world.”

Colleges of education and other teacher-preparation programs also need to better prepare future educators to teach data-science skills, experts say.

Tyler Haslam, who is one of 60 high school math teachers across Utah who are piloting a new data-science course and pathway, said that when he was studying to be a teacher, data science and statistics weren’t “heavily focused on for a math teacher.” It wasn’t until he got his master’s degree that he took more advanced statistics courses, which made him feel better prepared for teaching AP Statistics, and now, data science, too.

4. Look for industry partners, too

Businesses and organizations should work with K-12 schools “to create better alignment” between what students are learning and what employers are looking for, Drozda said.

Dykema, the president of the National Council of Teachers of Mathematics, said companies should continue “to beat the drum, saying, ‘We need this. Here’s what schools need to better prepare our current students for the future world.’” Businesses should push lawmakers to fund teacher professional development for data science or create data-science standards for K-12, he added.

Business partners, in turn, can provide resources: internships and credentials for students, curricular materials, and technology tools. For instance, in Virginia, Amazon and NASA are among the partners helping to provide training and materials to data-science teachers, Crawford said.

5. Seek support from policymakers

A lot of the aforementioned steps are difficult to do without funding and without the backing of state standards, according to educators and advocates. Most states don’t have K-12 data-science standards, so educators can’t put much emphasis on the subject, even if they think it’s important.

“We need to find opportunities to update and modernize state standards that are aligned to the skill sets that students need today and will definitely need five or 10 years from now,” Drozda said. “It’s a challenge that state standards update every 10 years and ChatGPT updates every two to three weeks.”
HOW INVENTION EDUCATION BENEFITS SARA STALEY’S STUDENTS

“By investing in National Inventors Hall of Fame education programs, we are preparing our students for real-world opportunities. They have to problem solve, collaborate and communicate with their groups, and take ownership of the work and products they are completing.”
— Sara Staley, Sunnyvale Intermediate School principal

On a warm Monday morning last November, the students at Sunnyvale Intermediate School in Sunnyvale, Texas, were on a mission.

As newly initiated members of the Rescue Squad®, each had accepted the task of completing a series of challenges related to saving Earth’s vulnerable ecosystems.

That day, they were tasked with first building a Squad Pod out of accessible upcycled materials and then using it to transport their Animal Avatars and Cargo Crates filled with crucial supplies by zipline.

In what’s become a tradition, teachers at the school have transformed this experience, part of a larger Invention Project® module, by running strings from their second-floor balcony to the ground floor and challenging students to race their Pods to the bottom.

“It’s been a tradition every single year that our students look forward to,” Sara Staley said in an interview with the National Inventors Hall of Fame®. “We buy trophies for them and make it a big deal.”

The entire school came together to watch the race, and the excitement was palpable.

“Let’s go, Blue! Let’s go, Yellow! Let’s go, Turquoise!” they yelled, their voices echoing throughout the building.

“The program definitely sparks joy in students and teachers — you can see it on their faces,” Staley said. One new teacher this year made the comment, “I wish my son would have been able to attend when he was in third through fifth grade because this is amazing.”

A New Building and a New Way to Learn

Staley was first introduced to the National Inventors Hall of Fame and its style of hands-on STEM (science, technology, engineering and mathematics) and invention education just a few months after her school opened in the fall of 2019.

Designed specifically to support the interaction of Sunnyvale students and teachers, the 75,000-square-foot space features a large, central open learning area and dedicated spaces for art, science, music and special education.

“We definitely designed the building for collaboration and innovation; that was our top priority,” Staley said.

However, finding a reliable education partner to match the energy and excitement of opening the new school was not easy. While Staley knew she wanted to establish a weekly STEM extension for her students, she wanted to avoid curricula that were textbook- or computer-heavy.

She wanted a program that gave students the opportunity to experience hands-on learning in ways that engaged their curiosity while maintaining high academic expectations.

The more Staley learned about the National Inventors Hall of Fame, the more interested she became. She was impressed with the nonprofit’s proven track record of developing hands-on STEM...
Over 30 years, programs have been developed using lessons from the world’s greatest inventors: Hall of Fame Inductees.

Additionally, she appreciated the programs’ convenient implementation.

“There are often a lot of materials needed for STEM programming, and the Hall of Fame provided everything in one nice little package,” Staley explained. “I didn’t have to make a list and get everything off Amazon, shop at different places or beg our parents. Everything came in an individual bag.”

This ease of implementation would prove crucial to Staley’s decision to bring Invention Project, the Hall of Fame’s customizable PreK-8 program, to her school for the first time in 2020.

One of the primary reasons for Staley’s commitment to invention education is her confidence that students of all abilities and skill levels benefit academically, as teachers can naturally differentiate the Hall of Fame’s program experiences in ways that best meet their students’ needs.

This is because, unlike more traditional pedagogies, invention education invites students to develop their own solutions to real-world problems by constructing prototypes. Mirroring complex situations they will need to navigate once they enter the workforce, students are given the autonomy to overcome challenges in ways they feel most comfortable.

“I have over 100 special education kids, over 100 gifted and talented kids, and then around 200 who are somewhere in the middle,” Staley said. “Every kid should be able to be a part of STEM – even our nonverbal students participate and love the program.”

Some common misconceptions are that this type of learning lacks rigor, or that it is impossible to fail. But Staley believes that this could not be further from the truth. She believes the National Inventors Hall of Fame’s ability to create supportive environments where it’s OK to make mistakes is one of the nonprofit’s key strengths.

The importance of challenging students and providing opportunities to experience failure was made clear to Staley when she attended a recent student panel at Baylor University. There, two former Sunnyvale students expressed that at times, they felt they did not experience enough failure, and this made inevitable setbacks in college more difficult for them to handle.

For Staley and her fellow administrators, this was an eye-opening experience. It solidified the importance of incorporating programs like Invention Project that teach students failure is simply a part of the learning process. Often, this means working together in groups to resolve conflicts and find the best solutions.

“I tell students all the time, ‘Go ahead and try it this way first,’ and if that doesn’t work, we move on to the next person’s idea,” Staley said. “Invention Project teaches them how to collaborate and get along with each other. Whatever they choose to do, these are the skills they will need to have.”

In October 2023, the superintendent of the Sunnyvale Intermediate School District asked Staley to present a Future Ready Superintendent Leadership Network learning session focused on the topic of “profound learning.”

During her presentation to the superintendents and school administrators in attendance, Staley shared her experience successfully implementing National Inventors Hall of Fame curricula over the past four years and explained how actively engaging students through invention education is an ideal way to cultivate profound learning environments.

“I shared reasons why I believe in the programs,” Staley said. “What I wanted them to see is that the curricula involve much more than just doing a project – it’s an all-inclusive package, from the digital slides to the Inventor Logs and all the materials you need.”

Making an Impact for All Students

In October 2023, the superintendent of the Sunnyvale Intermediate School District asked Staley to present a Future Ready Superintendent Leadership Network learning session focused on the topic of “profound learning.”

The school’s library features a two-story slide and a large open space perfect for large gatherings.

The Sunnyvale Intermediate School was designed to enhance student and teacher collaboration.

Natural Differentiation and the Importance of Failure

Fast forward to today and Staley has become a passionate advocate of invention education. Through the years, she has implemented additional National Inventors Hall of Fame programs including Camp Invention® and Club Invention®, as well as professional development for her teachers.
As a busy principal herself, Staley understands how the last thing an administrator needs is one more thing to do. However, she is adamant about the importance of school administrators advocating for the programs and resources they believe in, and she recommends schools look out for grants, fundraising opportunities and community partnerships to help fund high-quality education programs.

When asked what she would say to an administrator interested in trying National Inventors Hall of Fame education programs, she recommended starting small and observing its profound impact on students.

“I would encourage any administrator to start implementing their program,” Staley said. “There are many options to choose from, and different ways to implement it. We started with one grade level, and it took one session to see how hooked and engaged our students were and to know we had to find a way to make this a schoolwide program. I advise you to start small and watch the excitement for learning take place. It won’t take long, and you will also want to find a way to impact all students.”
Trouble Getting Students Interested In STEM? These Teachers Figured It Out

By Lauriane Langreo

Jobs in STEM fields are expected to grow twice as fast as those in non-STEM fields by 2029, and millions of those jobs are expected to go unfilled in the near future, according to the U.S. Bureau of Labor Statistics.

To help spark students’ interest in those fields, educators provide hands-on learning experiences and bring in professionals to talk to students about their careers. But often, resources are hard to come by. Schools are not flush with funding, and teachers don’t always have the connections they need to bring in professionals.

In an interview with Education Week, two teachers talked about how they use free resources from Engineering Tomorrow, a national nonprofit that aims to increase awareness and exploration of engineering, to engage their students in STEM skills.

Everton Henriques is an engineering and technology teacher at Staten Island Technical High School in the New York City Public Schools, and Tess Carlson is a chemistry and biology teacher at Raoul Wallenberg High School in the San Francisco Unified School District.

These interviews have been edited for brevity and clarity.

Why do teachers need engineering resources beyond what is available from their schools?

Carlson: I know in the Next Generation Science Standards there’s information about engineering, but engineering is not my background at all. I am from a pure chemist background. I’ve tried to do design challenges here and there, but I’ve never felt competent in my engineering lessons. To have an organization that has pre-made labs and lessons for you that are really focused on the engineering design process, I thought that was really exciting and something that would be amazing to bring to my students. A lot of them come from backgrounds that would be underrepresented in STEM, so to expose them to engineering in high school and give them a formative experience, that maybe this is something they want to explore in the future and help them feel confident in that field, I was really excited about that opportunity.

What were your classes like before you had these additional hands-on materials?

Henriques: We were rarely getting engineers in. When [my class] looked at engineering fields, it was mostly students looking up the ABET-approved engineering programs—the organization that accredits engineering programs—seeing what’s out there, and then doing the research and getting in touch with college alumni and learning about the field that way. It was a lot of work, not necessarily structured. With Engineering Tomorrow, somebody can speak to them. We don’t have to have kids get rejected when they’re trying to talk to an engineer or even college students.

How do you incorporate hands-on lessons into your class?

Carlson: A couple of weeks into the school year we did our first engineering design challenge. We did the water treatment lab [which teaches students the science behind water filtration and purification], which is a really nice one to kind of ease into it because it’s material that I sort of knew. It’s not too complicated of a build for the students. It was a cool way for them to get lab experience because sometimes at the start of the school year, it’s hard to give students a real concrete lab experience because they haven’t learned the concepts that build up to those lab experiences yet. That was exciting for them to do something with their hands and with their group members and feel accomplished that early on in the school year.

How do students feel about the labs?

Henriques: During remote learning, having [Engineering Tomorrow] materials distributed was great. Students were able to be a part of the labs virtually and still gain an interest. Some of those students, now that they’re back, have been like ‘that saved me during COVID.’ ‘That prevented me from going too crazy.’ ‘Now I have some things that I’m interested in. I know kind of where to tailor my education.’ And that was the big one for me. It doesn’t really do it justice describing it, but if you could see it, you could tell that it was very important.
Carlson: They love having access to these materials. We can finesse some stuff here, we can spend small amounts of money on lab materials and lab kits, but for them to have real solar panels and LEDs and fans and generators, they’re amazed and excited to get their hands on this stuff. It’s a break from the hardcore chemistry concepts, the abstract world of chemistry, and it’s a chance to apply this abstract stuff that they’ve learned into something that they could actually see themselves doing. They like talking to college mentors and real engineers. It’s helped with that identity piece, to see students who are studying engineering but don’t seem all that different from them.

Are students now inspired to become engineers?

Carlson: When I first introduced the engineering process to them, I asked them if they could ever see themselves being an engineer and a lot of kids were like ‘I don’t even know what an engineer does.’ Now I think kids have a concrete idea of what an engineer does, and they’ve talked to real engineers and heard about their day-to-day lives. Now kids have an idea that this pathway is available to them. I’ve definitely seen that identity shift in students going from just being students in a science class to feeling like real scientists, feeling like real engineers because of these labs that we’ve been doing.
How can project-based learning be used in math class?

Project-based learning is a popular instructional strategy for many subjects, though it is not used as much in math.

Today, two math teachers share how they have successfully applied PBL in their classes.

Open-Ended Questions

Bobson Wong and Larisa Bukalov teach math at a New York City public high school. They are the authors of The Math Teacher’s Toolbox: Hundreds of Practical Strategies to Support Your Students (Jossey-Bass, 2020):

One of the greatest challenges of teaching during the pandemic has been the limited contact that we have with our students. Since students are forced to work more independently, many teachers have turned to project-based learning, an inquiry-based educational approach in which students work on complex, authentic tasks that lead to a public product. Recent research, including four new studies from the Lucas Foundation, have shown that using projects can improve academic outcomes.

The effect of projects on math learning are less clear. Teachers may feel that project-based learning is difficult to implement in a math class. As math teachers ourselves, we know firsthand the pressure we face to teach the many procedural skills that are emphasized in local and state standards. Many math teachers believe they don’t have time to incorporate projects. They also feel that projects are better suited for social studies or science.

However, most math teachers use elements of project-based learning in their daily instruction. In all subjects, including math, students learn how to gather evidence and recognize patterns in order to make a conclusion. We think of project-based learning as a way for students to learn how to make connections and solve problems. The main difference between math and other subjects is that we primarily use numbers, variables, and diagrams as our artifacts.

Preparing Students With Open-Ended Questions

To successfully implement project-based learning, we start by training students to answer the open-ended questions typically found in projects. Research suggests learning that emphasizes open-ended problems may be more effective than direct instruction in boosting students’ academic achievement.

We start with smaller examples, such as a problem-based introductory activity for a lesson or discovery-based homework. Many of these questions don’t have a real-world context—they simply ask students to find a pattern or make a mathematical connection. These questions are small enough that they can easily be incorporated into our everyday lessons or assigned as homework. Here are some examples of open-ended questions:

- Ratios: Use information from a newspaper or the internet to calculate and compare the unit prices of items sold at different supermarkets. Determine which supermarket offers the best deal.
- Common multiples: List the first 10 multiples of 6 and the first 10 multiples of 9. If you list all multiples of 6 and 9 that are less than 100, how many numbers appear on both lists? What other patterns do you see?
- Transformation of trigonometric functions: Graph the equations $y = \sin x$, $y = 2 \sin x$, $y = 3 \sin x$, and $y = 0.5 \sin x$. For the equation $y = a \sin x$, explain the effect that changing the value of $a$ has on the graph.

To help students ask and answer open-ended questions, we often use a strategy called Notice and Wonder (sometimes called What Do You Notice? What Do You Wonder?). Students look at a prompt (such as a picture or word problem) and state what they notice and what they wonder about it. To guide students, we sometimes provide additional prompts like “What relationships do you see?” or “How else can you represent the given information?” The Notice and Wonder routine is similar to a Think-Pair-Share, as described in the following directions:

1. Think silently about the prompt for a minute.
2. Write down three things that you notice and three things that you wonder.
3. Turn to a partner and briefly discuss and refine your ideas.
4. Modify your writing based on your discussion with your partner.

5. Be ready to share your ideas with the rest of the class.

Notice and Wonder helps students understand the context of the problem, explain it in their own words, identify what they need to find, and give a reasonable estimate for the answer. This strategy can also help them generate “what-if” questions for larger projects.

To give students feedback, especially as we teach remotely, we rely on online whiteboard tools like Geogebra and Desmos. These tools allow students to explore mathematical phenomena by manipulating animations. For example, students can change the size of a circle whose circumference and diameter are automatically measured. By answering questions like “As you change the size of the circle, explain what you notice about the relationship between its circumference and diameter,” students can develop a better understanding of π. The teacher dashboards on these sites enable us to view student progress in real time, write comments, and share student work.

**Giving Longer Assignments**

As students become more comfortable with answering open-ended questions, we assign longer assignments that span one or two days. They typically ask a series of questions that guide students through a lesson with minimal help from us. Eventually, we give more complex projects that are done over several weeks. We create an outline that includes milestones—important stages or accomplishments for the project. Examples of milestones include sections of a written report (such as an abstract, introduction, data, analysis, limitations, and conclusion) or drafts of a presentation.

We provide direct instruction before starting a project or as students work on it to make sure that they have enough background knowledge. This instruction can range from a short explanation at the beginning of the period (if the project is relatively self-explanatory) to several days or weeks (if the project is a summary of a unit). Throughout this instruction, we point out how the lesson relates to the project.

We give additional support to ensure that students use their time more effectively and post due-date reminders online. In class, we frequently mention upcoming deadlines and ask students about their progress in class. To limit the possibility that students get overwhelmed, we reduce the amount of homework that we give while students work on projects. If necessary, we provide additional instruction on any technology that they may need, such as managing shared documents online.

Here are some examples of assignments that can be done over several days:

- **Ratios:** Find the location of local community resources (such as schools, hospitals, or firehouses). Combine it with demographic data to determine the population density of resources. Determine if the community has adequate resources.

- **Measurement:** Design a plan to retrofit an existing local building to meet Americans with Disabilities Act regulations. Include scale diagrams of ramps with an appropriate slope and pathways with appropriate measurements.

- **Constructions:** Create artwork (or re-create teacher-drawn artwork) using geometric constructions with a compass and straightedge.

**Conclusion**

Incorporating projects into everyday instruction has several limitations. Writing the open-ended questions used in project-based learning takes a great deal of time and effort. To make the workload more reasonable, we collaborate with colleagues to create new activities or modify existing ones (Desmos and Geogebra have many premade activities).

Despite these limitations, we feel that the benefits of projects outweigh the drawbacks. In our experience, doing projects even once or twice a semester provides a welcome break from our regular routine. Even if we don’t assign a large project, we find that regularly asking open-ended questions strengthens students’ critical-thinking and problem-solving skills. Projects also give opportunities for students to build their self-confidence and demonstrate skills that they can’t show on a traditional assessment.

Thanks to Bobson and Larissa for their contribution!

Larry Ferlazzo is an English and social studies teacher at Luther Burbank High School in Sacramento, Calif.