littleBits™ education

HOW TO START A STEAM PROGRAM IN YOUR SCHOOL

TABLE OF CONTENTS

INTRODUCTION

IN TODAY'S EVER-CHANGING WORLD, educators have quite a role to play: making sure students complete their K–12 schooling well-prepared for college and careers, even though their career choices are as yet undefined. They are constantly reminded that the jobs of today's grade-schoolers haven't been invented, and that the days of keeping the same job for decades are long over. The target moves as technology advances.

BUT ONE THING IS FOR SURE: The jobs of tomorrow will require creativity and innovation. As author Daniel H. Pink describes, "the future belongs to a different kind of person with a different kind of mind: designers, inventors, teachers, storytellers: creative and empathic 'right-brain' thinkers whose abilities mark the fault line between who gets ahead and who doesn't."

While the STEM movement—a call to elevate the studies of science, technology, engineering and mathematics as a national priority—began to take shape in 2006, a separate push to add the arts to that equation, transforming STEM to STEAM, followed soon after.

John Maeda, then president of the Rhode Island School of Design, championed the STEAM movement. **"DESIGN CREATES THE INNOVATIVE PRODUCTS AND SOLUTIONS THAT WILL PROPEL OUR ECONOMY FORWARD,"** Maeda said, **"AND ARTISTS ASK THE DEEP QUESTIONS ABOUT HUMANITY THAT REVEAL WHICH WAY FORWARD ACTUALLY IS."**

WHY STEAM?

"DESIGN IS NOT JUST WHAT IT LOOKS LIKE AND FEELS LIKE. DESIGN IS HOW IT WORKS."

- **STEVE JOBS,** former CEO of Apple, Inc.

BY INTEGRATING ART AND DESIGN WITH STEM SUBJECTS, schools are working to strengthen students' abilities to be creative and flexible problem-solvers, to explore different ideas, to recognize failures as opportunities for discovery and to communicate well with others.

The arts in various forms—from music to dance to sculpting to creative writing—also challenge students to explore the human condition; to be attuned to the emotional, social and cultural world around them, and in doing so, to learn to feel empathy toward others. This becomes an important aspect of problem-solving by not only helping them learn how to collaborate well with others, but also to feel driven toward developing solutions the world needs. Building these types of human connections are what spark true innovation.

With STEAM projects, students learn by inventing, creating and designing—and understanding the true meaning of design. As Steve Jobs once said, "Design is not just what it looks like and feels like. Design is how it works."

RESEARCH ON THE IMPACT OF ARTS INTEGRATION ON LEARNING

"IF WE'RE NOT CREATING SOMETHING WITH OUR KNOWLEDGE, WE'RE JUST MEMORIZING IT AND NOT APPLYING IT IN ANY REAL WAY."

- **LINDSEY OWN,** Lead Teacher of Makerspace at the Evergreen School in Shoreline, Washington

BECAUSE THE STEAM MOVEMENT IS RELATIVELY NEW, not many studies exist that directly address its efficacy, but there are numerous studies that demonstrate the importance of arts integration in schools to critical thinking skills and academic achievement.

A study on the effects of the arts on at-risk youth by the National Endowment for the Arts (2012) revealed that teenagers and young adults of low socioeconomic status who were exposed to a high level of arts study performed better academically and had higher rates of college enrollment than those who did not.

Several studies reveal that arts integration can positively impact long-term retention of content across disciplines. Findings by the Neuro-Education Initiative of the Johns Hopkins University School of Education suggest that arts-based pedagogy can lead to deeper engagement, better retention of content, greater emotional involvement in learning and a stronger ability to apply principles across disciplines.

STEAM ON THE RISE IN SCHOOLS

ACROSS THE COUNTRY, schools are taking notice of the STEAM movement and responding with innovative programs and spaces that are inspiring a new generation of designers and inventors. Teachers who were once siloed within their disciplines are collaborating on projects, finding unique ways to encourage creative problem-solving.

Using their imaginations, students create an idea, prototype it, test it, receive feedback from peers, revise it and develop a final design for it, taking notes in a journal along the way.

The approach to STEAM varies from school to school, depending on each district's appetite for integration. Some schools fully immerse the arts in STEM subjects, developing a full year's STEAM curriculum to accompany every lesson unit. Other schools pick and choose projects to integrate throughout the year.

Many schools are creating physical spaces, often called "makerspaces," as a home base for STEAM. Similar in vibe to a lab or studio, these makerspaces are often converted storage closets or computer labs. Students can work in these makerspaces on STEAM projects independently, in small groups or with a whole class. Typical materials and devices in a makerspace run the gamut:

- **3D PRINTERS**
- **LASER CUTTERS**
- **ROBOTICS KITS**
- **ELECTRONIC INVENTION KITS SUCH AS THOSE FROM LITTLEBITS AND MAKEY MAKEY**
- **COMPUTERS**
- **CRAFT SUPPLIES**
- **HAMMERS, NAILS AND SAWS**
- **SEWING MACHINES**
- **FABRIC**

When there's no room available, schools create mobile makerspaces—carts equipped with 3-D printers, Legos, littleBits and robots that are wheeled into various classrooms throughout the day.

Some schools and districts host STEAM conferences as a way to educate their communities about the movement and what their students are learning, and then offer workshops on subjects such as 3D printing and robotics to their community members.

Still other districts host STEAM competitions at either the school, district or regional levels, allowing students to put what they've learned to work, to share their ideas with others and to work as teams to find inventive solutions to local or global problems.

During the school day, some programs routinely offer STEAM challenges during a portion of their lunch periods, allowing students to explore and invent independently during the school day. After-school programs with STEAM-related classes are also popular in some schools and districts, allowing students to take their learning one step further while also providing a source of revenue for the STEAM program, as schools charge students to participate.

Much depends on the level of buy-in from teachers, the amount of funding available and the level of support from district administrators.

ELEVEN TIPS FOR BRINGING STEAM TO YOUR SCHOOL

If your school is considering starting a STEAM program, there are several things to keep in mind, say experts from various schools that have successfully integrated arts into STEM disciplines.

1. **HAVE A CLEAR VISION OF WHAT YOUR STEAM GOALS ARE, AND BE REALISTIC.** To launch a STEAM program successfully, all stakeholders must agree on what they hope to accomplish, and build a timeline. Some districts wants to fully integrate STEAM across all lesson units, in all schools, and for these districts, substantial planning and PD time are required. Other schools prefer to infuse the arts into STEM subjects wherever possible, in a more organic way. This method also requires time for educators to collaborate on a regular basis and to be flexible with the time taken on lesson units. Whichever route you take, make sure you devote enough time and resources to make it happen the right way.

2. **GET CREATIVE WITH FUNDING.** Costs for a STEAM program can add up quickly, so schools find funding in a variety of ways. Some ideas to consider:

- Start a campaign on DonorsChoose.org and rally your community to support it.
- Apply for grants at the local, state and national level.
- Reach out to local businesses and organizations for sponsorships or donations. The Collier County Public Schools in Florida, for example, received a substantial investment in its program from the local credit union in town. Chambers of Commerce and organizations such as Kiwanis, Lions and Rotary clubs also may be interested in contributing.
- Offer STEAM-based, after-school classes. The fees charged to families for these programs can be used to pay for your STEAM program's costs.

3. **ENSURE TEACHERS HAVE THE TRAINING THEY NEED TO UNDERSTAND THE CONCEPT.** For many teachers, the STEAM idea won't be second nature. "Sometimes people think STEAM just means adding paint to science projects; it's not," says Lesa Wang, of the Marymount School. "It's about mixing the left brain and the right brain, making the study of math and science more visual and creative, and seeing things more openly." To achieve buy-in, you must allow them to see the benefits it has for students, and the creativity and fun it can add to their lessons. Provide training from STEAM professionals if possible to help your staff visualize the possibilities, and encourage them to stay abreast of STEAM-related trends on the Web and via the Twitter feeds of @artseducation, @steam and @stem.

4. **GIVE TEACHERS TIME TO TINKER, AND COLLABORATE.** Just as students need to learn by doing, so do teachers. At Fox Meadow Elementary in Scarsdale, N.Y., teachers take home robots and littleBits products, small electronic building blocks that snap together with magnets, making it easy to invent gadgets with sensors, fans, lights and more. Teachers of the Marymount School in New York City took a field trip to the littleBits headquarters recently, so that they could learn more about the product, and the school now provides littleBits Kits to every student in grades 3–5. And teachers of the Colonial School District in Pennsylvania frequent NextFab in Philadelphia, a workspace that offers maker classes that are both traditional (jewelry-making, sewing) and digital (laser-cutting, 3D-printing).

5. **QUICKLY FIND YOUR "POLLINATORS," AND EMPOWER THEM TO PUSH THE MOVEMENT FORWARD.** It takes just a few maker-type teachers to inspire a whole team, says Lesa Wang of the Marymount School. Once you identify them, keep them involved in the planning process; they will share their enthusiasm and ideas with others.

ELEVEN TIPS FOR BRINGING STEAM TO YOUR SCHOOL

6. **BRING THE OUTSIDE IN.** You may be surprised by the number of experts you have at your fingertips—engineers, architects, scientists, entrepreneurs, artists, designers among your parent body and the community at large. Parents interested in STEAM can be a tremendous resource. At Fox Meadow, parents volunteer to run a lunchtime STEAM club every day in the winter, entirely on their own, handling the sign-up and the projects undertaken by the students. In Collier County, Florida, the school district partners with the local university, companies and organizations to host an annual STEM conference and competition, raising awareness of the school's program and the importance of creative learning in general.

7. **INSTILL A GROWTH MINDSET IN STUDENTS AT ALL TIMES.** The biggest hurdle students face in a maker environment can be failing at a project, so it's essential that they be encouraged to adopt a "growth mindset"—the belief that they can build and strengthen their abilities through hard work. Those with a growth mindset see failures as opportunities to learn more, and not proof that they are "not good at" the task. Likewise, teachers also need to instill a growth mindset through the integration of STEAM, as they, too, may face obstacles as they test out new approaches in their lessons.

8. **BUILD STEAM PROJECTS AROUND REAL PROBLEMS THAT NEED TO BE SOLVED.** When students are charged with designing something that will help the world in some way—whether it's building safer playground equipment, creating devices for fellow students with disabilities or designing solar homes—they tend to be more invested in the learning process.

9. **DESIGN A WELCOMING SPACE WHERE STUDENTS WILL WANT TO COME TO INVENT.** If there's room in your school to build a devoted makerspace, get creative with it. "Make sure it's not a stereotypical engineering space," says Lindsey Own, lead teacher of the makerspace at the Evergreen School in Shoreline, Washington. "Our space is very soft; while we do have hammers here, we also have fabric, crafts and a sewing machine. It's important to make it welcoming to all kids."

10. **CELEBRATE STEAM INVENTORS AND INVENTIONS WHENEVER POSSIBLE.** Maker fairs at the school, district or regional levels give students the opportunity to exhibit their inventions and explain the thought processes behind their designs. These types of events also help the community better understand the value of STEAM education.

11. **STAY TRUE TO THE DISRUPTIVE NATURE OF THE STEAM MOVEMENT AS MUCH AS YOU CAN.** The very idea of blending the arts and sciences is a disruption from the traditional siloed disciplines. And disruption can bring positive energy, says Duncan Wilson, principal of Fox Meadow Elementary. "We haven't gone to the 'curriculumification' of this, where all second graders will do this or that," he says. "We don't want to turn 3D printing into the birdhouse project, where everyone's looks the same. Sometimes you have to just let a project grow on its own."

EXAMPLES OF STEAM IN ACTION

PERSONAL CORE VALUES THROUGH METAPHORIC ARTWORK

Eighth-graders at The Evergreen School in Shoreline, Washington, expressed their personal core values in language arts class through metaphoric artwork. One student used a laser cutter to design a maze, incorporating robotics and sensors at various points in the paths to represent things important to him.

THE STUDY OF CRAFTSMANSHIP DURING COLONIAL TIMES

Fourth-graders at Fox Meadow Elementary School in Scarsdale, New York studied the ultimate maker period of American history—colonial times. "If you didn't make it back then, you didn't have it," Principal Duncan Wilson says. The students examined objects from the time period, such as wooden tools and twists of tobacco, questioning the design of the objects and the materials used to build them. They then used balsa wood, Model Magic and paint to design their own models of colonial items, such as public stocks and spinning wheels, to gain a better understanding of the craftsmanship required of Americans during that point in history.

PROTECTING THE JEWELS, AND LEARNING LOGIC

Second-graders at Fox Meadow Elementary School in Scarsdale, New York are learning about sequencing and logic through a fun design project: they are creating jewelry boxes with theft detectors built in. The students are designing the jewelry boxes and using littleBits electronic building blocks to install sensors and alarms in the boxes. "What I like about littleBits is that it teaches them basic logic around circuitry, and makes it really easy for them to join the Bits together themselves," says computer teacher Peter McKenna.

FASHION DESIGN WITH A GREEN TWIST

Sixth-graders at the Marymount School in New York City combined their studies of recycling and fashion design by creating dresses out of recycled or repurposed materials. One student designed a dress made only of old subway MetroCards; another used just airline boarding passes. The students modeled their creations at a fashion show attended by designer Betsey Johnson.

POETRY AND CIRCUITRY, SIDE BY SIDE

Also at Marymount School in New York, teachers used littleBits electronic building blocks to show the school's board of directors the importance of STEAM education. A language arts teacher broke down a poem into fragments, then sequenced the words together to reveal the beauty of the words when placed together. She then sequenced littleBits modules together to create a machine. The symmetry of the words and modules helped the board members and teachers grasp the benefits of intertwining disciplines.

CELEBRATING INVENTION WITH THE COMMUNITY

For the past three years, students from 50 K–12 schools gather at the campus of Florida Southwestern College for Collier County Public Schools' iSTEM competition. High school teams compete in a geocaching event, and middle-school teams compete by building and racing solar cars. Elementary student teams participate in a littleBits competition, using the electronic building blocks to build a device with multiple functions. The students work with littleBits throughout the school year. "littleBits allows students to easily meet success as they learn about circuitry and how to bring that into real-world problem solving," says instructional technology specialist Lindy George. "They feel so accomplished and excited by what they can do."

EDUCATING THE COMMUNITY ABOUT STEM

COLLIER COUNTY PUBLIC SCHOOLS
NAPLES, FLORIDA
GRADES: K–12

FOR TWO DAYS DURING THE SCHOOL YEAR, the city of Naples, Florida gets to see firsthand how passionate its students and teachers are about STEM education. The Collier County Public Schools hosts two events that bring the community together–the iSTEM conference in October, and the iSTEM competition in May. The two events each draw hundreds of community members to learn about how the schools are taking a hands-on approach to the study of science, technology, engineering and math.

Both events are funded in large part by the foundation of a credit union in Naples.

The conference includes workshops on STEM subjects and also a "STEM Village," in which members of the community and education partners of the district, like littleBits, host booths to allow people to experiment with the learning tools that students are using in school.

The district's May event, the iSTEM competition, gives students from its 50 schools the chance to take what they've learned in the classroom and put it to use in a friendly, team-building, yet competitive environment. The day-long event is held at nearby Florida Southwestern College, and that alone is a thrill for Collier County students, says instructional technology specialist Lindy George.

"Sixty percent of our students are on free and reduced lunch," George says. "For many of the kids this is their first experience on a college campus. They feel so special representing their schools at this kind of competition, and using all the knowledge they've built and applying it to a new situation."

Elementary students compete in the littleBits competition that begins at the school level. Students break into teams of four in their classroom and then compete in the challenge, which is to build a device that performs multiple functions using only littleBits electronic building blocks. The winning teams from each class compete against each other to earn the school title, and then those winners compete at the district competition.

The students enjoy using littleBits throughout the school year, and the competition in late spring is a nice culmination of what they've learned.

"littleBits allows students to understand circuitry and easily meet success, and to understand how to bring circuitry into real-world problem-solving," George says. "They feel so accomplished and excited by what they can do."

Middle school students compete in a solar car competition, in which they build and then race their inventions. And at the high school level, students compete in a geocaching event, using GPS to search for and find clues. All of the clues are STEM-related.

"At the end of the day it's not about winning," George says. "It's great when they do, of course, but really it's about the fact that every child has the ability to be a STEM leader."

WHAT FULL IMPLEMENTATION LOOKS LIKE

COLONIAL SCHOOL DISTRICT
MONTGOMERY COUNTY, PENNSYLVANIA
GRADES: K–12

ON A REGULAR BASIS, teachers of the Colonial School District make the trip after work to nearby Philadelphia to try their hand at jewelry making, laser cutting, 3D printing, digital embroidery and other classes. The district holds a membership at NextFab, a makerspace in the city, and it encourages teachers to try out the same types of courses it is offering its own students.

Colonial has adopted a full-blown implementation of technology education in grades K–12. Students in K–8 work with various tools to study the following areas:

- **DIGITAL CITIZENSHIP**
- **CODING AND PROGRAMMING**
- **DIGITAL STORYTELLING**
- **CREATING AND DESIGNING**
- **COMMUNICATION AND COLLABORATION**

All students in grades 2–8 use littleBits as part of their curriculum, starting with simple circuit projects and building upon them each year, eventually adding wireless and MP3 Bits. By fifth grade, the students use their Bits to create an invention that will help students with disabilities.

"littleBits is extremely scalable; students never hit a plateau," says Sergio Anaya, supervisor of instructional innovation for the district. "We also never make it so much about littleBits as it is about the problem that needs to be solved."

At the high school level, students are hands-on in the study of subjects such as product design, computer-aided drawing, animation and engineering technology. The high school now has an "EDI" department, which stands for entrepreneurship, design and innovation. Art, tech education, business, computer science and TV production teachers all work together to develop a cohesive department curriculum.

"It just makes sense because that's what the industry does," Anaya says. "They break down the silos and we want to break down the silos as well."

"For every grade, the district remains consistent in approaching tech education with an engineering design approach," Anaya adds.

"The students keep a journal, and they learn how to solve problems, brainstorm ideas, prototype them, test them, redesign them and make them better," he says. "The engineering design process is pretty much the backbone for all that they're doing."

BALANCING INDEPENDENT STUDY WITH INTEGRATED CURRICULUM

FOX MEADOW ELEMENTARY SCHOOL
SCARSDALE, N.Y.
GRADES: K–5

IN A MODEST-SIZED SPACE formerly known as the school library's storage room, inventions of all kinds are in the making. A desktop 3D printer buzzes away, busily executing a student's precise CAD design, layer by layer. The product in progress is obvious to all who see it—a miniature Taj Mahal.

This is the STEAM haven of Fox Meadow Elementary, the school's much-loved Makerspace, and the little Taj Mahal in the making is a student's independent project. Makerspace serves both as a studio for students with their own ideas of invention as well as curriculum-tied projects led by teachers.

Computer teacher Peter McKenna, who manages Makerspace, collaborates with teachers regularly on ways to incorporate STEAM activities into their lessons. For example, he and fifth-grade teacher Kate Marshall recently came up with a design challenge after Marshall's class read "The Big Orange Splot," a book about a group of neighbors who paint their dreams on their houses. Students designed their unique houses with the software Sketchup, then printed them on a 3D printer. They then used littleBits to prototype the circuitry and electrical design of their homes.

Similar projects are happening at Scarsdale's four other elementary schools, all of which have some version of a makerspace. The schools have relied on various sources of funding, from local grants to contributions from a foundation made up of local parents, to purchase the equipment. Fox Meadow also offers STEAM-focused after-school programs, which help keep Makerspace funded. Parents pay for their students to participate in these clubs, which cover everything from Lego robotics to wearable electronics to Scratch game design.

An active parent community has made all the difference for the STEAM movement in Scarsdale, says Fox Meadow Principal Duncan Wilson. In the winter, parents run regular lunchtime STEAM projects in the cafeteria completely on their own, to give students a fun, free alternative to recess in the cold weather.

"Any kid who wants to get involved in STEAM, there is a way," Wilson says. "Our parents are savvy, and they think, my kid has an interest in this just like others have an interest in athletics or music. So let's help create a space for them."

"THE STEAM MOVEMENT ISN'T A TREND– IT'S A NECESSITY."

MARYMOUNT SCHOOL
NEW YORK CITY
GRADES: PRE-K–12

Arts teacher Lesa Wang remembers when she first began student teaching, and the big catch phrase she and other students heard repeatedly was "multicultural."

"Everything was about that—making sure our teaching was inclusive and multicultural," Wang recalls. "Now, we don't even talk about that anymore. It's just a natural part of how we teach. STEAM is going to be the same way. The STEAM movement isn't a trend—it's a necessity."

Wang is STEAM coordinator and arts teacher at The Marymount School, a preK–12 girls' school in New York City that firmly believes that the arts need to blend with STEM subjects in order to prepare students for their roles as global citizens. The school opened a Fab Lab (digital fabrication space) in 2012 and now has four different labs for students to design and prototype solutions to real-world problems. All students in grades 3–5 are given their own customized littleBits Kits, creating mobile makerspaces as they travel from class to class to use on projects throughout the year.

Marymount students are constantly tinkering, drawing up prototypes, recording their findings and presenting inventions to their class and the community at large—in this case, Manhattan.

During a yearlong study of design, sixth-graders were challenged to create an item of clothing out of recycled materials. One student made a skirt of only subway Metro Cards, while another made an outfit solely of airline boarding passes. Another student used her old collection of comfort toys and made a plush toy dress. The project took flight to the point where students wound up modeling their designs at a fashion show attended by industry experts Betsey Johnson, Hal Rubenstein, Mario Sorrenti and *Teen Vogue* editors.

Meanwhile, fifth-graders noted their love of the show "Cake Boss" to Wang, who used the show as a STEAM inspiration. The students studied cake design and created unique and intricate multi-tiered cakes, which were then displayed in a classroom at the nearby Metropolitan Museum of Art. Special guests to the display included experts from the "Cake Boss" show, Bobbie Lloyd, chief baking officer of Magnolia Bakery, and Dylan Lauren, owner of Dylan's Candy Bar.

Of course, not all of Marymount's STEAM projects lead to runway shows or museum exhibits; the main focus is giving girls the confidence in their ideas and exciting them with the possibilities of designing solutions that can help people. For example, fifth-graders study the tiny house movement in art and alternative sources of energy in science class, then design their own tiny homes using the resources of the school's labs. In STEAM class they design and prototype wind turbines, which are used to power the tiny houses. Second-graders hold an "invention convention," in which they invent a device that will help people. A student last year invented an arm cast with a fan and skin scratcher inside, using littleBits electronic building blocks to animate her prototype.

"What we do is all about being inspired to create," Wang says. "We want students to be engaged in real world issues, and to have their own ideas about how to solve them. To follow their passions and enjoy what they do. That is real happiness."

THANK YOU.