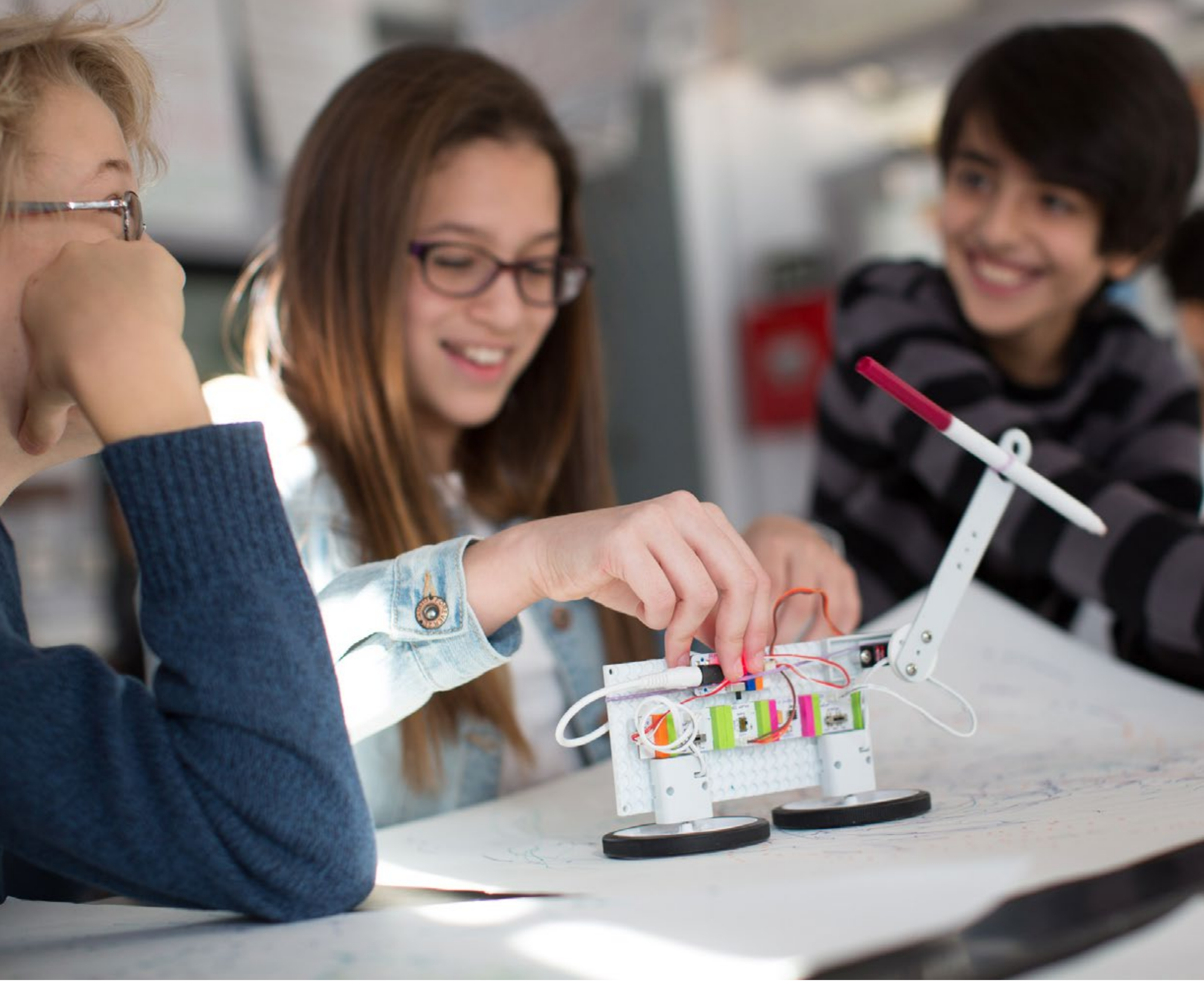

littleBits education

HOW TO START AND SCALE A SUCCESSFUL STEM PROGRAM

WHITEPAPER

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INTRODUCTION

According to the Department of Labor, more than 65 percent of today's students will grow up having careers that do not exist yet. Today, more than ever, it is crucial to prepare our students to be future-ready and have the confidence to invent the world they want to live in. To do this, many schools and districts are increasingly looking to teach their students key 21st century skills like science, technology, engineering, art, and math (STEAM).

A staple in many of schools' STEAM programs is littleBits, a platform of easy-to-use electronic building blocks that empowers everyone to create inventions, large and small, like a self-driving car, art-drawing robot, or even a prototype of a prosthetic arm.

Over the past six years, the littleBits team has worked with thousands of educators around the country to implement hands-on STEAM and coding programs. From schools that are very new to STEAM to schools and districts that are fully immersed in STEAM education, littleBits helps educators to find the best strategies to scale their unique programs. Before sharing some of our learnings in the field, let's take a step back and ask "why."

Why is it important for all of our students to have a chance to participate in STEAM education?

WHY STEAM EDUCATION?

While we continue to navigate an uncertain future, one thing we can count on is that the work of tomorrow will be tied intrinsically to a proficiency in STEAM fields. Just look at how quickly STEAM is taking hold. Already, employment in STEM occupations is growing much faster than employment in non-STEM occupations. Despite only representing 6.2 percent of the U.S. workforce, STEM workers boast wages that are 29 percent above the national average and demonstrate above-average growth.

An important point to make here is that the goal of STEM education is not to turn every student into a programmer or an engineer. The world needs diversity, after all. Instead, the goal is to give every student an opportunity to learn about the technologies they use, and more importantly, to help them identify themselves as innovators and changemakers that can take active roles in inventing solutions for problems they care about.

The world used to be static, and so were the building blocks our students used to make sense of that world. Today's world is highly interactive; technology is integrated with all aspects of our lives, from our social interactions to the most private aspects of our life. To make sense of this new world, our students need to be comfortable with technology, have a good understanding of how they work, and have ideas of how to innovate in a tech field.

By adding art into STEM education (STEM + A = STEAM), not only are we making the program relatable to more students, both girls and boys, but we are also giving them the opportunity to engage in creativity and to express themselves through their projects while tinkering, making, sharing, and playing.

STEM/STEAM IN SCHOOLS

There are three main questions in educators' minds when planning an effective STEM/ STEAM program: **(1) WHERE TO START**, **(2) WHAT ARE THE BEST IMPLEMENTATION STRATEGIES** for an effective and accessible STEAM program, and **(3) HOW TO SCALE**.

Recently, littleBits launched littleBits Education Solutions, a program through which schools receive free consultation on how to start and scale their STEAM programs. As a result of this comprehensive consultation, the littleBits team will compile a customized solution that is curated for each school's unique needs and implementation stage. Together, littleBits empowers educators to make a sizable impact with the resources they have available.

1 WHERE DO I START?

Many successful programs start with one enthusiastic teacher, librarian, or media specialist who believes in the power of STEAM. These educators take an active role in introducing hands-on project based engineering, coding, and robotics into their schools. Here are some characteristics of successful STEAM proponents:

- **START SMALL.** From a simple challenge for the students in their classroom or a project at a center in their library, educators need to make sure they have the buy-in required from their schools and districts to be successful. They understand that students may take some time to get used to the program, so they carefully examine what works and what might need some tweaking before they take on larger projects. Then, they work their way up to more complex implementations and lessons.

- **START SIMPLE.** Successful STEAM programs keep it simple and they make use of tools and materials with which kids are already comfortable. By integrating interesting technology that is accessible to everyone, is easy to use, and can be integrated with other crafts materials in their classroom or library, they can help ease students, other educators, and administrators into STEAM.

- **START AND FAIL FAST, IMPROVE, AND KEEP ON GOING.** Failing fast and forward is interwoven with maker and STEAM education culture. Educators who take an active role in starting STEAM programs embrace this culture by trying different tools and programs, failing, and learning from their failures. This cycle of invention encourages them to try new methods and ultimately come up with a solution that works for them.

2 WHAT ARE THE BEST IMPLEMENTATION STRATEGIES?

Every school is unique with its own needs; however, there is a lot we can learn from other educators about the specific STEAM strategies that have worked for them.

IMPLEMENT TOOLS AND PROGRAMS THAT ARE ACCESSIBLE AND GENDER INCLUSIVE.

Every successful STEAM program should be accessible to every student, no matter their background, gender, or comfort level with the technology. The key is to implement tools that have "low floors," meaning they are easy to pick up and start using without the need for extensive training. These tools should also be gender inclusive and instead of dictating what girls or boys should like, allowing students to bring their own characters and personalities into their projects.

One great example is the Bitsbox challenge at the Marymount School. Students were challenged to come up with their own wearable-tech designs and showcase them at their school's "fashion show" (See FIGURE 1). Many students successfully incorporated littleBits into their design visions, proving how they can leverage STEAM tools to bring their imagination into reality without being governed by what's applicable for girls vs. boys.

Another great example is the three-year research project, interactive sensory objects for and by people with learning disabilities at University of Reading: Berkshire, England. As part of the study, researchers collaborated with people with learning disabilities to find out what makes visiting museums most interesting for them. The team explored ways to make objects in museums interactive using electronics and sensors, with a focus on multi-sensory art workshops. As part of the project, the team used littleBits in developing tools to use with the co-researchers in workshops to allow participants to be more engaged and independent. More specifically, they used littleBits to develop ideas for triggering sounds, smells, and vibrations in objects, allowing new ways of experiencing art for people with disabilities.

IMPLEMENT TOOLS THAT ARE CROSS-PLATFORM, REUSABLE, AND CAN BE INTEGRATED WITH OTHER MATERIALS.

An important element of creative thinking is being able to come up with new ways to use the tools and objects around us. Therefore, the materials we choose for our makerspace and STEAM programs should allow for remixing, taking apart, reusing, and repurposing.

In every guided project and lesson, littleBits encourages students to take apart, mix, and remix their Bits to come up with new inventions. For example, students can use the same combination of Bits to invent a bubble machine, a fortune teller, or an interactive wearable! Students are also encouraged to think of different ways they can use a particular circuit – for example they can use a power button and a buzzer as a doorbell, a game buzzer, or to orchestrate a handshake prank.

In addition to reusing and remixing affordances, the tools in makerspaces should be easily integrated with arts and crafts materials and other tools in the space to allow for maximum "making" opportunities. For example, students can use an adapter to attach their littleBits electronic Bits to their LEGO builds to make them interactive. A great example can be found in the Spinning Replicator that one of our community members invented. Students can also use cardboards and variety of other arts and crafts materials to customize their projects and come up with new inventions.

FIGURE 1 MARYMOUNT "FASHION SHOW"

INTEGRATE STEAM AND CODING WITH OTHER CORE SUBJECTS.

Taking on an interdisciplinary approach helps students to prepare for learning and to deepen their understanding of the concepts – whether in math, science, social sciences, language arts, or music. An interdisciplinary approach also makes it easy for educators to find time for hands-on STEAM projects, a challenge for many educators with limited time throughout the day.

A great example of an effective interdisciplinary approach is the Novel Engineering Project from Tufts University. The project is a five-year research project funded by National Science Foundation to design an integrated approach to teach engineering and literacy. Here's how it works:

- Students read a book and identify problems in the book through group discussions.
- They then scope the problems, brainstorm solutions, and use materials and tools in their classroom to build prototype of those solutions.
- They finally share their solutions, receive feedback, and improve upon them.

This project not only gives the chance to students to have a hands-on engineering experience, but also help them to improve their literacy skills through reflections, discussions, and presentations.

CONNECT STEAM PROJECTS WITH COMMUNITY AND REAL-WORLD PROBLEMS.

Identifying a problem, scoping it, brainstorming solutions, prototyping, sharing, receiving feedback, and improving forward are the stages of every invention cycle and the cornerstones of every STEAM program. The key to keeping students engaged is to help them focus on problems they care about and those they can relate to. These programs also become much more meaningful and impactful if they are focused on solving real problems in students' communities.

littleBits embodies this idea through its Invent for Good challenge, which empowers kids to invent the world they want to live in by asking them to create inventions that make a difference in someone's life. It can be as simple as creating an alarm clock to remind friends to take medication or fabricating a bionic arm out of Legos.

One student invented SocialCat to help the more than 1.5 million cats every year who get euthanized in shelters. One of the main reasons a cat doesn't get adopted is because it is scared of humans and may not be friendly. SocialCat solves this problem by helping cats to associate human voices with the positive experience of eating. It does this by playing calming human voices and soothing music while the cat eats. With the help of SocialCat, cats become friendlier and more social when interacting with humans and increase their chances for adoption.

3 HOW CAN YOU SCALE YOUR STEM/ STEAM PROGRAM?

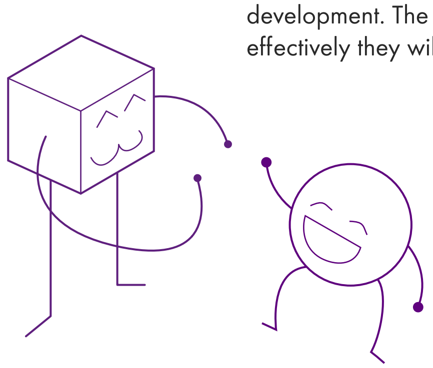
Unfortunately, many innovative STEAM practices start – and stop – with a lead educator. To fully immerse an entire school or district in maker and STEAM education, lead educators need the buy-in from their admins, and admins need the buy-in from all their teachers, even teachers who are not tech-savvy.

Here are few practical tips to help educators get buy-in across the whole school or even a district:

CREATE A CULTURE AROUND STEAM AND MAKING.
Many lead educators who successfully scale their innovative practices have done so by creating a movement behind their initiative. Having an end-of-the-year competition across the school, showcasing students' projects at various school events, and celebrating students and teachers who make a difference in STEAM every day are great ways to cultivate the culture of making and innovating.

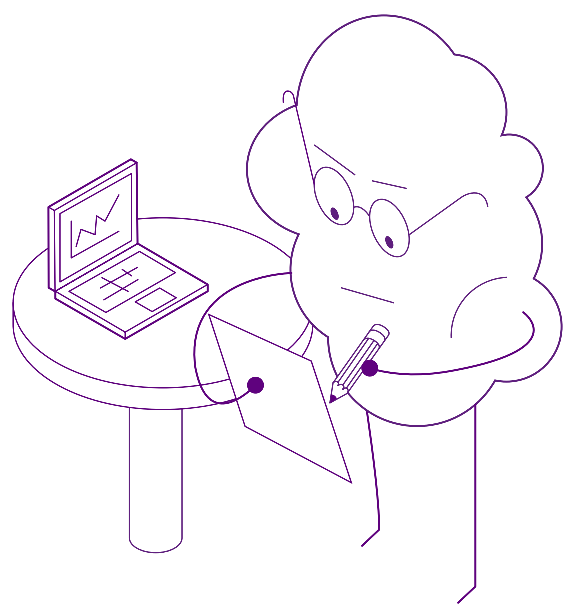
Some schools also bring students from upper grades and lower grades together to create a community around the passion for making. For example, New Jersey educators Laura Fleming and Billy Krakower paired up high-schoolers and elementary students. Fleming's high-school students developed an activity for Krakower's third- and fourth-grade students using littleBits Code Kit. The elementary students went through the activities, ranging from inventing Hot Potato of Doom game, a cool keytar, or synching coded pixel art animations and music, and worked with their older peers to test, refine, and debug the projects. Their feedback and collaboration helped improve the projects.

PROVIDE RESOURCES FOR PROFESSIONAL DEVELOPMENT.
Teachers are on the front lines every day – responsible for training students for the future of work. Often, these teachers have not had any formalized STEAM training, themselves. Principals and district admins can set these teachers up for success by ensuring that any STEAM program they are looking to integrate includes professional development. The more teachers know, the more effectively they will be able to instruct students.



MAXIMIZE COLLABORATION OPPORTUNITIES AMONG TEACHERS, LIBRARIANS, AND MEDIA SPECIALISTS.
Educators love to share their knowledge and are keen to hear from other educators about best practices. That's a great opportunity for school and district admins to facilitate ways for their lead tech-savvy educators to share their success stories with STEM and spread the excitement among their colleagues.

Classroom Coaching is a great example of methodology to bring together educators as partners to support impactful use of technology. Stanford University's Center to Support Excellence in Teaching conducted a literature review on the effects of coaching on educator practices and student achievement. The study suggests that coaching can indeed have positive effect on successful implementation of technology, provided that coaches, teachers, and principals all view coaching as a partnership. Coaching, unlike a single day professional development session, provides continuing support and collaboration, as well as a chance to help educators learn by doing and to receive feedback when they need it.



STEM/STEAM IMPLEMENTATION MODELS

When implementing STEAM into your school programs, it is important to define the implementation model for your program so that you can frame your strategy for scale. In this section, we provide an overview of three highly effective models:

ARIZONA STEM NETWORK STEM IMPLEMENTATION GUIDE

Science Foundation Arizona (SFAz) and the AZ STEM Network created the STEM Implementation Guide as a “how-to checklist” for implementing the four models found in its STEM Immersion Guide: **EXPLORATORY MODEL**, **INTRODUCTORY MODEL**, **PARTIAL IMMERSION MODEL**, and **FULL IMMERSION MODEL**.

1. In the **EXPLORATORY STAGE**, STEM-related activities are offered to students as extra-curricular opportunities in addition to the regular school day. These extra-curricular activities are offered as part of after-school programs, summer clubs, lunch time, or special events.
2. In the **INTRODUCTORY STAGE**, the STEM activities are more integrated into the school day. Programs are offered as additional units, supplementary stand-alone learning units, or units delivered once the state testing is complete.
3. In **PARTIAL IMMERSION STAGE**, STEM experiences are integrated into the current curriculum in some content areas. Teaching year-long integrated project-based learning units, teaching dual-enrollment programs, or integrating enquiry-based learning into science curriculum are examples of partial immersion model.
4. In **FULL IMMERSION STAGE**, STEM experiences are fully integrated in ALL aspects of the school experience in all subject areas. Full Immersion schools resemble 21st Century workplace environments rather 20th century K-12 school environments. Curriculum is designed based on problem-based instructional models. Students are active agents of their community, constantly thinking and working on real-world authentic problems, brainstorming solutions in collaboration with others, designing, testing, refining prototypes, and sharing with the larger community.

Each of these four stages requires careful planning of tools, professional development, and programs to integrate STEM as part of core academic subjects. To make it easier for educators to plan each stage with littleBits, we have designed four Education Solutions mapped to each of these implementation stages: Starter Solution, is great for exploratory and introductory stages. Starter Solution includes all materials that are needed for a class of 9-18 students, covering hands-on engineering and design in addition to coding. Educators have access to lesson plans and guides on how to start their program.

Classroom Solution is designed for schools at partial immersion stage, including complete set of materials for a class of 24 students to integrate hands-on STEAM and coding in a whole classroom instruction. Educators have access to online professional development, lesson plans and guides on how to implement classroom-wide programs.

littleBits’ School Solution and District Solution are designed for fully-immersed STEM schools or districts. These solutions offer complete set of materials and resources to integrate STEM experiences in all classrooms and other spaces in schools such as makerspaces and libraries.

To promote innovation and help schools to implement high-quality STEM and STEAM implementation, the Ohio Department of Education has designed the Quality Model. This model also includes four levels of integration.

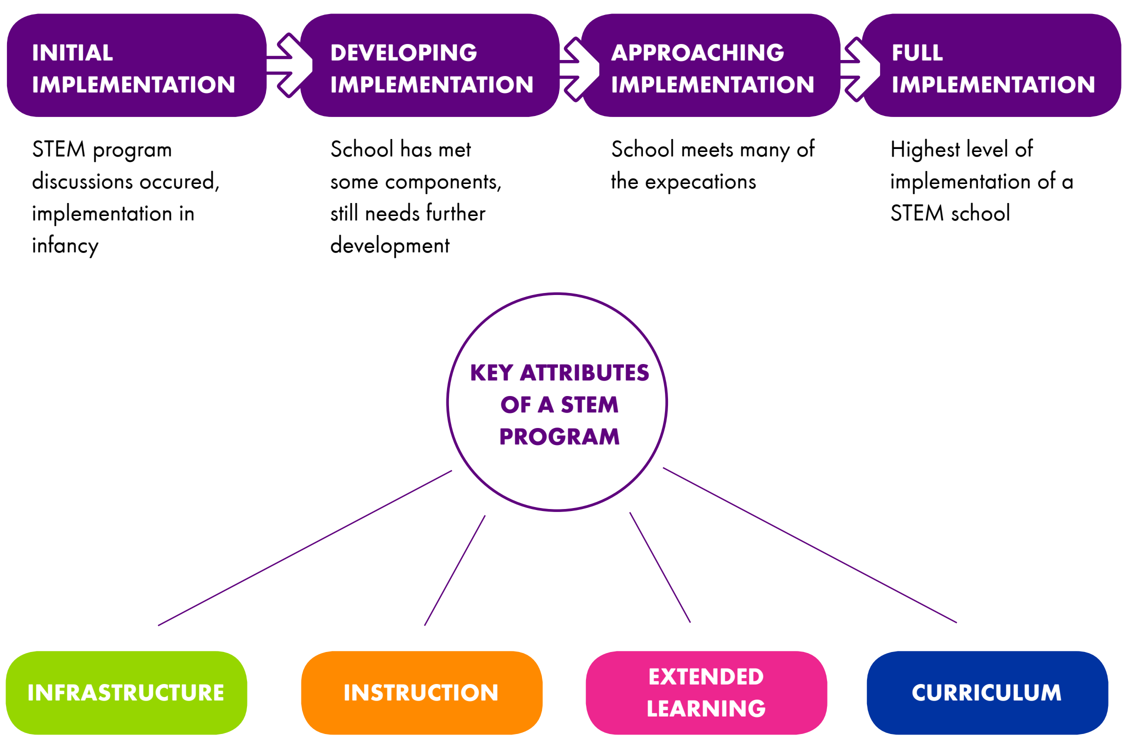
1. Integration of STEM topics within STEM courses or extracurricular activities
2. Integration of STEM into all subjects within a specialized program
3. Integration of STEM as part of all subject areas throughout the school – but not necessarily using a whole-instruction approach for problem-based learning
4. Problem-based learning and STEM integration defines the instruction model for all subjects in the school and the mindset transcends beyond the school boundaries into the community at large

Drawing on this model, littleBits Starter Solution is a great fit for the first level of STEM integration in Quality Model; littleBits Classroom Solution aligns with the second level; and School Solution and District Solution are perfect for third and fourth levels at the school and district scale.

INDIANA'S DEPARTMENT OF EDUCATION STEM EDUCATION IMPLEMENTATION RUBRIC

This rubric provides an outline for the implementation of STEM attributes in schools, again with four levels of implementation: initial implementation, developing implementation, approaching implementation, and full implementation (See FIGURE 2). The rubric covers detailed requirements for key elements of implementation at each level: structure of leadership teams at the district and school levels, school schedules, community engagement, school environment, technology resources, data usage to guide instruction, evaluation, instructional programming and strategies, curriculum integration, professional learning, and equity.

FIGURE 2 INDIANA'S DOE STEM RUBRIC



FINAL REMARKS

It is encouraging to see more school districts and states now integrating STEM/ STEAM and coding programs into their offerings. Although there are many similarities in the way each education system approaches STEM and coding integration, there are also many differences and unique requirements – that is why we, at littleBits, believe each implementation solution is unique and must be tailored to a school's or a district's particular approach.

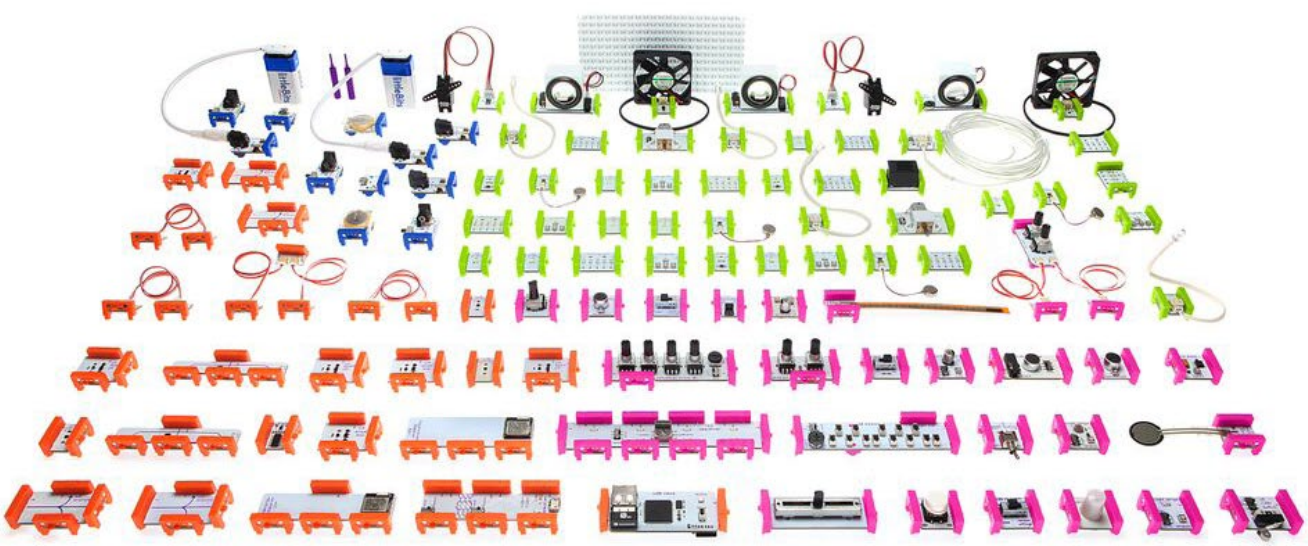
Whether you are an enthusiastic educator taking an active role in introducing STEAM and coding into your school, or a leader accepting the challenge to scale a successful implementation beyond one classroom and into a whole school or district, it is important to plan not only for the tools, but also for professional development, and integration into core subject areas, extracurricular activities, and after school programs. littleBits Education Solutions are a direct response to each of these needs – helping all educators to successfully start and scale an impactful STEAM program for all.

ABOUT AZI JAMALIAN, PHD

Azadeh (Azi) Jamalian, PhD, is the Head of Education Strategy at littleBits. Azadeh has a PhD in Cognitive Studies in Education from Teachers College Columbia University, and has published journal articles and book chapters on a broad range of topics such as designing learning platforms for children, emerging educational tech, game design, mathematical education, and cognition. Dr. Jamalian has received numerous awards including "IES Prize for Excellence in Research on Cognition and Student Learning" and "The Cooney Center's certificate of innovation in Children's Learning".

ABOUT LITTLEBITS

littleBits designs 21st century tools for invention-based learning. The easy-to-use electronic building blocks snap together with magnets empowering everyone to create inventions, large and small. Each color-coded Bit has a specific function (e.g. lights, sensors, internet connectivity) and is reusable. With endless inventions, guides, and resources, educators and students can engage in increasingly complex challenges and grow their **TECHNOLOGY LITERACY**, **CRITICAL THINKING**, **CREATIVE CONFIDENCE**, **CODING** and **STEAM SKILLS**.



THANK YOU.