PRAISE FOR THE SECOND EDITION OF *STEAM MAKERS* BY JACIE MASLYK

In the new edition of *STEAM Makers*, Maslyk shows us how we can bring in curiosity, creativity, problem-solving, self-directed learning, and a failure mindset into our classrooms and schools while addressing curriculum standards and literacy skills. The book provides everything you need to get started or level up your existing STEAM practices. As a former teacher-librarian, I also really appreciated the comprehensive ideas around children's books, which can be used to set the stage for projects, and also how libraries can support teachers on their journey. *STEAM Makers* centers student choice and voice with the educator as amplifier and facilitator and lists ideas for community involvement, all of which are necessary in a world where information can be accessed so easily. This book is a must-read!

—Jennifer Casa-Todd
Faculty Lecturer
Lakehead University, Ontario

The insightful brilliance of Jacie Maslyk returns in an inspiring, updated edition of *STEAM Makers*. Just as STEAM evolves and sparks continuous growth, Jacie expands her vision, serving as both mentor and motivator for educators seeking innovative ways to ignite learning. Far beyond a how-to manual, this book vibrantly pulses with actionable ideas and heartfelt wisdom, encouraging a culture of creativity, collaboration, and curiosity. As a principal and educator, I found myself continually inspired, nodding along to Jacie's passionate, crackling prose. Truly, this new edition is an essential anthem for anyone eager to amplify innovation in the schoolhouse through the powerful lens of STEAM.

—Sean Gaillard
Principal of Charles England Elementary School, NC

In the second edition of *STEAM Makers*, Dr. Jacie Maslyk uplifts the power of creativity, innovation, and authentic learning experiences for each of our students. This resource amplifies what's possible when we foster curiosity, student agency, and real-world problem-solving. Jacie's work is a true celebration of community-driven, transformative education—and a must-have for educators who believe in empowering learners to lead the future.

—Sarah Thomas, PhD
Founder of EduMatch

STEAM Makers is more than a book—it's a blueprint for reimagining learning. It empowers teachers, librarians, and school leaders to design inclusive spaces where creativity thrives and student voice leads the way. Whether you're launching a makerspace, designing hands-on PD, or connecting curriculum to global goals, this guide offers practical tools and powerful inspiration. It helps cultivate the kind of curiosity and innovation today's students need to become tomorrow's changemakers!

—Jennifer Womble
Chair of Future of Education Technology Conference/District Administration, FL

This is a great book for any educator looking to add more STEM to their classroom. It's filled with quick ideas and guiding principles, and the included profiles of STEAM leaders are terrific examples of what to aspire to as a STEAM Maker.

—Chris Woods
Teacher, DailySTEM

STEAM Makers

Second Edition

To my Mom for inspiring me to write and always telling me
I could do anything I put my mind to.

STEAM Makers

Fostering Creativity and Innovation in the Elementary Classroom

Second Edition

Jacie Maslyk

CORWIN

CORWIN

FOR INFORMATION:

Corwin
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(800) 233-9936
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1 Oliver's Yard
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Visit
www.STEAM-Makers.com
for downloadable resources.

Preface

Depending on the decade in which you were born, you probably remember playing with Erector sets, Lincoln Logs, LEGOs, or K'NEX. You may have had a Lite Brite, Easy Bake Oven, or Shrinky Dinks. As a child, I remember building forts in my backyard, sewing blankets for my dolls, and growing vegetables in my grandfather's garden. "Kids have always made things—tree houses, skateboards, soapbox cars, doll houses, forts, and igloos" (Martinez & Stager, 2013, p. 29). This kind of learning is fun! These early childhood activities are a bridge connecting science, technology, engineering, art, and math.

John Dewey, philosopher and education reformer, advocated that students actively engage in authentic interdisciplinary projects connected to the real world. The implementation of STEAM and making embrace Dewey's thinking. Elementary schools across the country are exploring a variety of models as they infuse STEAM and making into their programs. This book will provide rich examples of the enthusiastic teaching and learning that is going on in innovative school districts. It is based on the idea that the maker movement combined with STEAM education empowers students and helps to build skills to create a more productive and sustainable global culture. *STEAM Makers* connects disciplines, bridging learning styles by naturally engaging young people as they apply learning in creative ways.

STEAM Making continues to gain momentum across the country, but it is especially thriving in my hometown of Pittsburgh, where there is a unique vibrancy. In Pittsburgh, formal and informal educators are working together to design unique learning pathways for children and young adults. Once a steel town known for blue-collar workers, Pittsburgh is still a city with a hard-working mentality. Now a cultural center embracing music and the arts, the city is home to theaters, museum, galleries, and makerspaces. Add the premier institutions of higher education and major corporations and Pittsburgh is poised to be a leading city of learning. Cathy Lewis Long, executive director and president of The Sprout Fund, says that Pittsburgh has a "secret sauce" (C. Lewis Long, personal communication, March 2015) that makes the region a hot bed for innovation.

Throughout my journey in writing the first edition of this book, I had the opportunity to talk with educators at the leading edge of creativity and innovation. At networking events and school visits, I was able to learn about the tremendous efforts that schools are making toward the future. As I prepared for the second edition, I reached out to my vast network of amazing educators. Through Zoom calls, conference meet-ups, and site visits, each conversation led to more conversations at museums, libraries, and schools. Every chat with a maker, school principal, or superintendent led me to another organization or individual in the connected web of innovators. I learned so much from amazing educators working in K–8 classrooms and was completely inspired by the leadership from superintendents, technology directors, librarians, and principals who are supporting these practices in their schools. I was lifted up by the forward-thinking museum educators, foundation leaders, business owners, and those in higher education who are working to push this initiative to the forefront.

When I began my book journey back in 2013, I met with Gregg Behr, executive director at The Grable Foundation, who succinctly summed up our common goal: "We need to think differently about educating young people. We need to light them up on a learning pathway." STEAM Making is a way to show young people the possible learning pathway, while also allowing them to create their own.

As we continue to "light up" our students on a pathway to the future, perhaps we need to consider some new routes, expanding opportunities for young people. Gregg Behr suggested "a concierge in their life to direct them on whatever their pathway is." Perhaps you are the concierge to a young maker or a group of students. Consider the ways that you might support them on their STEAM Making journey.

Acknowledgments

This book would not exist without the network of STEAM Maker educators across the globe. I continue to appreciate the collaborative spirit of passionate people who strive to provide creative and engaging opportunities to students. The knowledge that the education community shares continues to inspire me.

A special thanks to my family and friends for their ongoing encouragement. To my sons, Caden and Tanner, thank you for your patience and understanding as I travel for work and spend time writing. I hope that you both find a career path that excites you the way education has for me. Most of all I want to thank my husband and teammate, Christian, for always supporting me and my commitment to education.

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Teacher
Munising High School
Munising, MI

Catherine Hernandez
Trashy Treasures Teacher
Detroit Public Schools
Detroit, MI

Jane Hunn
Sixth-Grade Science Teacher
Tippecanoe Valley Middle School
Akron, IN

Nina Orellana
Title 1/MTSS Coordinator
Palm Bay Academy Charter School
Palm Bay, FL

Jason Thompson
Assistant Principal
Jefferson Elementary
Schenectady, NY

Barbara L. Townsend
Reading Specialist
West Side Elementary School
Elkhorn, WI

About the Author

Jacie Maslyk, EdD, has served in public education since 1997. During that time, she has served in many roles. As a classroom teacher and reading specialist, she worked in both inner city and suburban school districts. She served as an elementary school principal and director of elementary education for ten years, with extensive experience in curriculum, assessment, and instruction. A successful school leader, she was recognized as a National Distinguished Principal finalist in Pennsylvania in 2013 and 2014. Dr. Maslyk worked in district administration as an assistant superintendent before moving into her current role as an instructional coach and education consultant, supporting schools through professional learning and job-embedded coaching. She provides workshops (onsite and virtual), model lessons, and curriculum support to school districts and education organizations across the country.

In addition to *STEAM Makers: Fostering Creativity and Innovation in the Elementary Classroom,* Dr. Maslyk has also published *Connect to Lead: Power Up Your Learning Network to Move Your School Forward, Remaking Literacy: Innovative Instructional Strategies for Maker Learning, Unlock Creativity: Opening a World of Imagination With Your Students,* and *All In: Taking a Gamble in Education.*

Connect with Jacie on Bluesky (@jaciemaslyk.bsky.social), X (@DrJacieMaslyk), Instagram (@jaciemaslyk), or email her at jaciemaslyk@gmail.com.

Introduction

STEM, STEAM, and maker education have evolved in the last decade. Once a topic that only some schools were tiptoeing into, it is now a mainstay in most school curricula. Embracing engineering, design, and problem solving, schools have expanded STEAM Maker learning in meaningful, student-centered ways. Through emerging technologies and attention to future readiness, the second edition of this book offers readers new lessons, new resources, and new examples from schools and organizations who are leading with innovation.

Since the publication of the first edition of *STEAM Makers: Fostering Creativity and Innovation in the Elementary Classroom* in 2016, interest in STEM, STEAM, and maker initiatives has continued to grow. Schools across the globe are embracing the integration of science, technology, engineering, art, and mathematics (STEAM) and creating spaces for hands-on maker learning. Students are excelling in areas like robotics, video game design, and digital fabrication. They are excited to try new and innovative ways to collaborate with peers and create new things. Teachers and school leaders have embraced this forward-focused instructional approach.

STEAM Maker thrives in learning spaces where students say

- I wonder how that works?
- What if we combined these two materials?
- Can I try that?
- What can we create together?

As we work to foster a STEM mindset in our students, we welcome these questions of curiosity and exploration. We invite students to get messy, learn new things, and explore new materials. Through their exploration, a mindset of discovery and creativity will thrive!

This updated and upgraded new edition will provide fresh ideas and new inspiration for educators. It will reinvigorate them to continue pushing the creativity and critical thinking of their students. Readers will gain insight into what is happening in

schools across the globe and find practical activities to try in their classrooms tomorrow.

Each chapter includes a new STEAM Maker story highlighting an educator, school, district, or organization who exemplifies the chapter topic. Some chapters include multiple stories to showcase examples across the globe as well as the United States.

STEAM and making can happen in small ways and with minimal supplies. If you don't have a lot of time with students or the ability to engage students in larger scale, long-term projects, you might want to try STEAM Maker Starters. You will find these activities throughout the book.

Through a lens of diversity, equity, and inclusion, this edition amplifies examples that provide access to learning for *all* learners. The book highlights inclusive programs and those that embrace individuals with disabilities. It showcases schools and districts in which students of color excel through STEAM Maker learning opportunities and learners from all backgrounds have the chance to engage in meaningful, connected learning.

This upgraded second edition also embraces new technologies, responds to relevant global issues, and resets the educational trajectory toward the future of work. Here are some of the threads you will notice throughout the book:

- **Emerging Technologies**

  With the power of technology in the palm of our hands (and our students' as well), educators have worked to skillfully incorporate digital tools into their classrooms. Emerging technologies include powerful digital tools that have transformed the ways that students communicate, collaborate, and bring creative ideas to life. Immersive technologies—virtual reality (VR), augmented reality (AR), mixed realty (MR), and artificial intelligence (AI)—are changing education. These emerging technologies provide learners with opportunities to explore new tools and apply them in the classroom. Digital fabrication labs, e-sports programs, and coding courses are offered in elementary, middle, and high schools across the globe.

- **Diversity, Equity, and Inclusion**

  Makerspaces have always represented a place where all learners can succeed. STEAM Maker learning provides pathways for every student to access new ideas through their strengths. STEM labs and makerspaces are places where learners of all abilities, from any language or

background, can enter into hands-on exploration of interesting topics and new tools. This edition highlights places and spaces where diverse learners are thriving through STEAM, where outreach programs are ensuring access to experiences in STEM and STEAM, and where inclusive practices are aligning with hands-on learning.

- **Global Impact**

  Students are engaging in STEAM learning and maker education in their classrooms, libraries, and makerspaces. They are participating in engineering challenges in science classes and in afterschool programs. As students have developed a growth mindset for perseverance and flexible thinking, they have also begun to develop an expanded worldview. No longer satisfied with learning and working within the four walls of their classrooms, students are now exploring ideas far beyond their schools. Students engaging in the engineering design process and design thinking practices are creating solutions to global problems. They are utilizing the skills that they have developed in STEAM and maker education to create for social good.

- **Environment and Sustainability**

  As many states revise their standards, a new emphasis on the environment and sustainability is evident. In turn, school districts are making changes to their curricula to include projects on climate, clean water, and energy. Schools are adopting programs to promote ideas like hydroponics, conservation, and civic action. Many schools are utilizing the United Nations Sustainable Development Goals (SDGs) as a roadmap for teaching these critical topics.

- **Entrepreneurship**

  The ability to seek out problems and design new solutions has also led students into entrepreneurship. Realizing that their creative ideas have value, young people are capitalizing on their STEAM Maker skills to propel themselves into successful small businesses and long-term careers. Our students are the innovators of the future, creating new inventions and designing new processes to improve life and work.

- **Literacy**

  Clear connections between STEAM and literacy have been established, ensuring that student learning in science,

technology, engineering, art, and math is grounded in reading, writing, speaking, and listening. The alignment between STEAM and literacy can be enhanced through an integrated instructional approach. An updated list of recently published children's literature is included in this edition (see Appendix G).

Throughout the last decade, the demand for scientists, engineers, and designers has increased. The need for students to be not just proficient readers and writers but also literate in science, technology, engineering, art, and math is more evident than ever. Schools, libraries, community groups, and institutions of higher education have embraced this trend and infused new opportunities into their programming. These types of programs have increased student skills in the four C's: creativity, collaboration, communication, and critical thinking. These are future-facing dispositions that young people need to possess.

Subjects in school cannot be addressed in isolation. The integration of concepts is an important prerequisite for students going to college and entering careers. Innovation is not exclusive to scientists, programmers, and engineers; it requires input from artists, designers, and creative problem solvers as well. Tapping into innovation and creativity, STEM has shifted to STEAM, adding the *A* for the arts.

Elementary students are naturally curious and often willing to engage new ideas. Implementing STEAM and making is a natural fit for students at this age. These types of learning experiences can be powerful learning opportunities for children. STEAM and making are on a rising trajectory. Some schools have redesigned spaces in their buildings; others revamped their curriculum to include programming, robotics, and digital media. Young learners need to engage in authentic tasks: brainstorming, setting goals, gathering materials, sketching, questioning, constructing, and fixing things, which can happen in and out of schools.

Chapter 1 provides a brief history of STEM and its transformation into STEAM. The maker movement will be discussed as well as the mindset needed to engage in this type of work. The connection between the two forms the integrated model of learning called STEAM Making. With many schools embracing this learning model, we move into the future with wonder, considering the possibilities that STEAM and making hold for students.

In Chapter 2 we see examples of how districts are thriving as they build STEAM and maker learning programs in

their schools. New learning ecosystems are being created, fostering learning in unique ways. With support from parents, schools and communities come together around creativity and innovation. With the rise of gaming and e-sports, we see examples from schools that are making a difference.

Examples of growth and adaptability are shared in Chapter 3. Responding to the changing times and the dynamic needs and interests of students, educators have adapted their instruction and found ways to pull students in. STEAM Making as an all-inclusive practice is explored, with examples regarding students with learning disabilities, speech and language impairments, and those with autism. Adapting to new technologies, including AI, is also a feature of this chapter.

Creating connections between STEAM and making is explored in Chapter 4. This chapter highlights teachers and librarians who are designing connected learning experiences for students. The chapter also explores projects that connect to community and amplify global issues. The importance of literature connections are featured in this chapter, which includes book lists and challenge ideas.

In Chapter 5, the concept of learning as an invitation is shared. We invite students and teachers into STEAM and making by creating learning spaces that welcome students in to discover new materials and explore new ideas. This chapter shares stories of collaborative schools who are inviting all educators to the table. We'll also look at programs that quite literally put food on the table. Inviting students to use their voices through podcasting and other student-centered projects is highlighted. This chapter is full of activities that invite students to think, design, and make in a variety of ways.

The importance of having partners in this work is shared in Chapter 6, including different types of partners and the organizations that we can collaborate with. Examples of local, regional, and global partnerships are provided along with inspiring stories about schools that have connected with local artists, corporations, and higher education as part of their STEAM Maker journey.

Chapter 7 extends beyond those just starting their STEAM Making journey to ways that programs are expanding and evolving. Growing both people and programs is important. In this chapter, we see ways that districts are continually building their programs in response to their students. The expansion of STEAM and making in our classrooms, libraries,

and makerspaces isn't stopping any time soon. It is an exciting time to pursue new ideas using grants or established partnerships.

If you haven't found your place in what I call STEAM Making, this book will provide insight into these instructional shifts. To help readers find inspiration in the schools and organizations that are transforming pathways for young people, links and resource lists have been interspersed throughout the book. In addition, my website (www.STEAM-Makers.com) houses additional resources.

CHAPTER 1

Wonder

As knowledge increases, wonder deepens.

—Charles Morgan

Imagine a school where students build the classroom furniture, design outdoor landscapes, launch rockets, and create inventions to improve everyday life. What if school learning spaces were designed with comfortable corners for collaboration and areas to foster informal learning? What if students were given the opportunity to learn what they wanted to, pursuing their own interests during the school day? What if students could design video games and apps, host their own podcast, or start their own business? We don't need to wonder about these scenarios any longer. These shifts in education have taken place over the last ten years as innovative classrooms have become spaces that transform teaching and learning. Schools across the globe have embraced creativity and hands-on learning, confirming the belief that learning should be active with students constructing their own knowledge.

Knowledge, new technologies, and creative ideas are opening opportunities for students like never before. From learning spaces focused on e-sports to classrooms with hydroponic systems and makerspaces in schools, libraries, and communities, schools have capitalized on this need for creativity and innovation in education. Educators are utilizing resources in ways that captivate learners and activate their curiosities in school.

Although the COVID-19 pandemic created many limitations on hands-on learning and collaboration, there is now a resurgence with creative opportunities in teaching and learning. Though resistance to this approach may remain, STEAM Maker learning can be observed across the globe. Despite the ongoing push for rigorous content and standardized assessments, many schools are forging ahead with efforts to include STEAM and making into their practices.

Educators have learned more about the value of STEAM education in the last decade. As they have deepened their understanding of STEAM and making, it has driven their curiosity to learn more, expanding their students' opportunities for innovation. STEAM Making is experimental and playful at times, but it connects critical academic content, as well. As an instructional practice, STEAM Making represents the belief in new possibilities. These possibilities, presented to children, allow them to engage in creating, designing, and pursuing learning that is interesting to them and has value outside of the school walls.

HISTORY OF STEM

Many point to the Sputnik and the Space Race as the turning point for science education in the United States. Others connect the turning point to poor science and math scores in U.S. schools, as highlighted by *A Nation at Risk* (U.S. National Commission on Excellence in Education, 1983). Now driven by business demands and advances in technology, STEM learning has been a prominent buzzword in education.

In the early 2000s, The National Science Foundation (NSF) coined the term *STEM*: learning based on the idea that science, technology, engineering, and math are interrelated and should be taught in an integrated way. Traditional teaching in these subjects is often presented as a silo model, with each being taught in isolation, which prevents students from seeing the connections between the content learned in these subjects.

Responding to the need for instruction in STEM, schools began designing programs and creating instructional plans for STEM learning. Educational companies started creating STEM curricula and offering resources to schools who were adopting this practice. States looked at revising their standards to reflect engineering and design practices and other tenets of STEM education. Now there are specialized STEM schools at every level preK through 12+ across the globe. Once thought to be an educational fad, STEM is now a prominent component of most school systems. The expansion of STEM, STEAM, and maker learning will continue as long as educators continue to wonder about new and exciting opportunities for their students.

WHAT ARE THE JOBS OF THE FUTURE?

When I was an elementary student, I wondered what job I might have in the future. I loved photography and dancing. I also liked hands-on learning and helping people. In the 1980s,

those interests might lead a young person to art school or a career in nursing. The idea that professions in the 2000s would include video game designers, drone pilots, or wind turbine technicians would've seemed unimaginable. Today, young people can explore jobs across hundreds of different fields, including those connected to STEM. The jobs that our students will hold in the future may not be invented yet, but we can help to prepare them for the unknown by building critical skills and dispositions that will help them no matter what career path they pursue.

Integrated STEM learning has become a requirement to create the kind of workforce needed in the United States and across the globe. In 2014, STEM Education News (http://www.stemeducationnews.com) reported, "By 2018 there will be 1.2 million job openings in science, technology, engineering, and math (STEM) fields. Due to a significant projected shortage of qualified applicants, many of these will go unfilled. The job market is demanding students increase their knowledge in STEM fields. In order to prepare students for this future, STEM education is building rapidly and transforming as it progresses."

Today, the need for knowledge in STEM continues to grow. The National Science Foundation (2024) reported that in 2021, "24% of the U.S. workforce worked in STEM occupations," representing about 36.8 million workers. The U.S. Bureau of Labor Statistics (2025) projects that by 2033, employment in STEM jobs will increase another 10.4%, doubling the pace of growth in all other occupation areas.

It is clear that STEM is not a trend that will soon fade away. It is a powerful vehicle to prepare our students for the global challenges in their future. As we know in education, though, things don't remain the same for very long. Once the importance of STEM was established, the idea began to transform.

ADDING THE *A*

As STEM began to take hold, schools and other educational organizations began to put their own spin on it by adding the *A* for the arts or incorporating an *R* for robotics or research or religion. The integration of subjects allowed for more meaningful connections for students, but also for teachers. Recognizing that creativity and design are powerful opportunities for learners, schools have included other areas in STEM learning to expand student knowledge while making connections to college and career pathways.

In *The STEAM Journal*, Henriksen (2014) writes, "STEAM must become an essential paradigm for creative and artistically infused teaching and learning in the sciences" (p. 1). I would argue that STEAM is a meaningful spin-off, especially in the elementary grades. The integration of arts into the STEM fields takes learning to a whole new level. The arts help to develop creativity, imagination, and collaboration (Sousa & Pilecki, 2018). Adding these components to STEM learning enhances the existing opportunities for critical thinking, problem solving, and communication. By allowing for creativity and critical thinking, teaching and learning move away from convergent thinking to divergent thinking. But beware: This is hard for teachers! Fostering divergent thinking means that there is no longer one correct answer to every problem. It means that we need to look beyond the manual and the answer key and encourage kids to come up with their own questions and answers.

Henriksen (2014) also suggests that arts-based teaching leads to more motivated, engaged, and effective learning in STEM subjects. Adding the A to STEM doesn't mean just art. It is not an add-on that is merely decorative (Beckman, 2010). The arts should be an essential part of the process and could encompass drawing, painting, sculpting, music, movement, and video, just to name a few. In their book, *Invent to Learn*, Sylvia Libow Martinez and Gary Stager (2013) state, "Combining the arts with STEAM means that children can express themselves in even more variations" (p. 55). The arts provide numerous creative pathways to learning. In their book *From STEM to STEAM*, Sousa and Pilecki (2018) share research-based reasons to integrate the arts, including the alignment of STEM and the arts. Creativity, problem solving, self-direction, and collaboration are all necessary skills in both art and science. The infusion of the arts into STEAM engages the young brain, helps to develop cognitive growth, and improves long-term memory (Sousa & Pilecki, 2018). Favoring STEAM over STEM offers learners a variety of ways to demonstrate their understanding through the arts. In addition, integrating the arts as a part of teaching and learning promotes motivation, stimulates positive feelings, and increases curiosity (Nutov, 2021) not only for students, but also for teachers.

One of our goals should be to break down the barriers between creative subjects like art and music and more traditional subjects like science and math. This infusion of subjects will support learning for those who are creative *and* logical-mathematical, unlike the silo model that isolates these topics. Developing creativity by integrating the arts makes a huge impact on student learning. The multisensory, hands-on activities that the arts can bring to STEM lessons helps students to connect to the content.

Learning becomes more personal when students include an artistic component. An artistic representation of ideas and solutions is a valuable way to make learning personal. Infusing the arts may enable students to envision things in a different way.

LEFT BRAIN VERSUS RIGHT BRAIN

Are you left-brain or right-brain oriented? (If you aren't sure, here's a free online test to try: https://testyourself.psychtests.com/testid/3178.) How about your students? Left brainers possess strengths in sequential thinking and critical details. These learners are logical, analytical, and driven by facts. For them, traditional teaching in science, technology, engineering, and math make sense. Those with inclinations toward the right brain are more creative in nature. They don't think in a linear fashion. Some may be daydreamers, letting their imaginations run wild. This group is visual and artistic. STEM learning works just fine for left-brain learners, but it often excludes those that are creative and artistic.

STEAM embraces the arts and provides opportunities for both sides of the brain to engage. After all, shouldn't a well-rounded student develop both sides of the brain? Students can develop strategies and define patterns (left brain), and represent ideas spatially through color and design (right brain) all within a STEAM Making lesson. Developing both sides of the brain means incorporating options for learners to access their strengths within the classroom, but also encouraging learning activities from their non-preferred side.

THE MAKER MOVEMENT

Whether it's remodeling and flipping houses, selling homemade goods on Etsy, or crafting items that were inspired by pins on Pinterest, people *are* making. This do-it-yourself (DIY) era was stronger than ever during the pandemic, as people were at home for extended periods of time. We saw an upsurge in knitters, gardeners, home cooks, game designers, and content creators, all sharing what they made. The maker movement continues to sweep across the nation in big cities, small communities, school systems, and online. This return to DIY, hands-on creating has spurred its own magazine, initiated makerspaces in libraries and community centers, and altered the way schools are looking at learning.

In 2005, the maker movement began building momentum when Dale Daugherty launched *Make* magazine (http://makezine.com). Twenty years later, the magazine is still going strong,

connecting people from a variety of disciplines and developing a common ground for making. In 2006, the first Maker Faire© was held in San Francisco. A venue for crafters, tinkerers, and programmers, this event has continued each year, expanding to more and more cities. In 2025, these festivals for all things maker will take place in Mexico, Germany, Egypt, Belgium, and hundreds of other cities across the globe.

MAKER EDUCATION INITIATIVE

The celebration of making continuing to grow as organizations, foundations, and grassroots groups are popping up across the globe. The Maker Education Initiative (MEI) (http://makered.org) is one that works to build confidence, foster creativity, and spark interest in science, technology, engineering, math, and the arts, while creating opportunities in making. Their mission is to provide resources to educators so that they are able to facilitate meaningful making experiences (see Image 1.1). MEI builds capacity within organizations so that young people can engage in making in both formal and informal environments. MEI seeks to equip communities so that kids and young adults from any background have access to making opportunities. The maker movement aligns with the need to increase STEAM education, as making embraces a similar philosophy of generating new ideas, engaging in hands-on/minds-on work, collaborating, and the integration of different fields.

IMAGE 1.1 ● STEAM Maker Learning in Action

Photo Credit: Kristin DeLaTorre

Once a developing initiative in pockets across the country, STEAM and making are now integral in the daily work of educators and those who work with children and young adults. Elementary, middle, and high schools have created unique spaces within their schools to develop STEAM learning. Community libraries and community centers have welcomed artists, designers, and programmers into their buildings to provide hands-on activities not previously experienced in these spaces. Schools of higher education have designed STEM courses and certification programs. Businesses and other organization have expanded the concept even further, opening makerspace storefronts, maker kit at-home subscriptions, and even maker-themed children's birthday parties. From painting and woodworking to brick-building and slime-making, the hands-on engagement of maker learning has infiltrated homes, schools, and communities in ways that bring people together and foster a sense of enthusiasm for creativity.

FIVE PILLARS OF STEAM AND MAKER EDUCATION

STEAM and maker education represent an opportunity. It is the opportunity for learners to find their place in school through the integrated, hands-on learning that STEAM and Making offer. This approach invites students to try new things and pursue their interests, acknowledging that strengths and differences are expected and accepted. STEAM Maker learning spaces are open and flexible with options for learners to explore in ways that work best for them. Here, student become experts and leaders in ways that aren't based on their grade point average or their address. It is more important than ever that we ensure that our school spaces and educational programs are created through a lens of diversity, equity, and inclusion so that all students know they have a place in STEAM Maker learning. We must build experiences in which they can build knowledge and gain skills that will benefit them in school and in life. Giving students a voice in learning will help them as they navigate career pathways, higher education choices, and beyond. It all starts with the experiences that we offer them in their K–5 education.

1. **Equity:** All learners need access to innovation and the opportunity to reach their full creative potential.
2. **Diversity:** Every learner can see themselves represented in STEAM and Making and know that their strengths and interests are valued.

3. **Inclusion:** All learners are welcomed to engage in hands-on, multisensory experiences.
4. **Engagement:** There are high levels of student interest and interaction in thought-provoking, open-ended, collaborative experiences.
5. **Future Focused:** Students are building the skills and dispositions required for a successful future.

WHAT DOES MAKING LOOK LIKE IN SCHOOLS?

STEAM Maker learning comes in many different forms. Making can mean sewing, sawing, and sculpting or robots, rewiring, and recycling. Making invokes creativity, design, and imagination. It can be personal or collaborative. It is a learning pathway that schools have incorporated in ways that allow students voice and choice in their experiences. Some schools create amazing learning spaces with grant money, while others may not have a physical space at all. Some educators purchase online lessons and others create their own. Some STEAM Maker learning is heavy on the technology tools while others prefer low-tech maker tools and materials.

In working with dozens of schools across the country, I've observed engaged and curious learners in all of the above situations. I've supported schools to design and build brand new makerspaces with robust budgets and I've guided teams as they took an empty classroom and created a colorful space where students thrived. I've also worked in community makerspaces where visitors are welcome to drop in and use tools for creative thinking in ways that speak to them.

Maker learning means giving learners the tools to try something out and then giving them the encouragement to do it. Spaces for making can look like a low-tech workshop or a high-tech fabrication lab. Makerspaces can include hand tools, cardboard, and craft supplies or laptops, robots, and 3-D printers. Some may have areas for tinkering and others may focus on design. Some spaces have zones designated for different materials and different types of learning while others may be more open concept. The type of space, the materials inside it, and the ideas that students explore certainly vary from school to school or makerspace to makerspace. The one thing that all spaces have in common is the ability to stimulate curious minds and invite learners in to create something amazing!

FIND IT! (SPACE)

Making can happen just about anywhere, but lots of schools are creating makerspaces or mobile making carts to facilitate these practices. Wherever the space—a room, the hallway, or outside—it needs to be accessible to everyone. Schools embracing STEAM and making have designed and redesigned classrooms and libraries to serves as creative spaces for students to build, code, design, color, and craft.

FILL IT! (MATERIALS)

STEAM Maker materials have evolved over the last decade. Some makers embrace reusable materials and clean recyclables like cardboard and duct tape. Others favor tech tools like laser engravers, vinyl cutters, 3-D printers, and immersive devices. With parent and community donations, smaller items can be easily added, such as fabric scraps, buttons, needles, thread, old magazines, cardboard, plastic containers, and simple hand tools (hammer, screwdriver, etc.). With some funding, add sewing machines, hot glue guns, soldering irons, batteries, and motors.

Educators often reach out and ask for a list of materials when they're getting started with a makerspace or STEM/STEAM program. I often hesitate to provide a list because I believe every space should be unique. Because I've visited lots of spaces, I know each is a bit different—different set-up, different areas of interest, different feeling. That's what is great about a space that allows you to connect, collaborate, and apply your creativity in different ways.

After the startup of STEAM Maker spaces that I worked on, I learned one important thing: that the materials you put in your space should be based on the needs and interests of your students. The ideas and experiences should be co-created with the students you serve.

Whether starting a new makerspace in your school or developing learning centers or stations for your classroom, having a basic materials list is helpful (especially for those writing grants or vying for budget items from school and district leaders). In collaboration with colleague and STEM expert Chris Woods, we developed a list with a wide variety of items that we know kids love and educators need (see Figure 1.1). It includes consumable items like glue and markers, as well as donated recyclable items like cardboard and plastic containers. The list also includes tools and tech items, like Hummingbird robotics and Makedo. This list can be a starting point for new STEAM Makers and a resource for anyone looking to add more hands-on opportunities into their learning space.

FIGURE 1.1 ● Makerspaces A–Z

STAFF IT! (PEOPLE)

Providing access to making is important, but who is going to do all that work? Over the course of the last ten years, educational leaders have witnessed the imagination come alive in their students when given the opportunity to engage in STEAM Maker learning. They have observed the connections between learning in the makerspace and college and career opportunities for young people. In response, many schools now fully staff their learning spaces with creative and enthusiastic STEAM teachers and maker librarians. Building expertise among teachers is key, but this takes time. Providing professional development is one way to start.

BUILD CURIOSITY AND WONDER

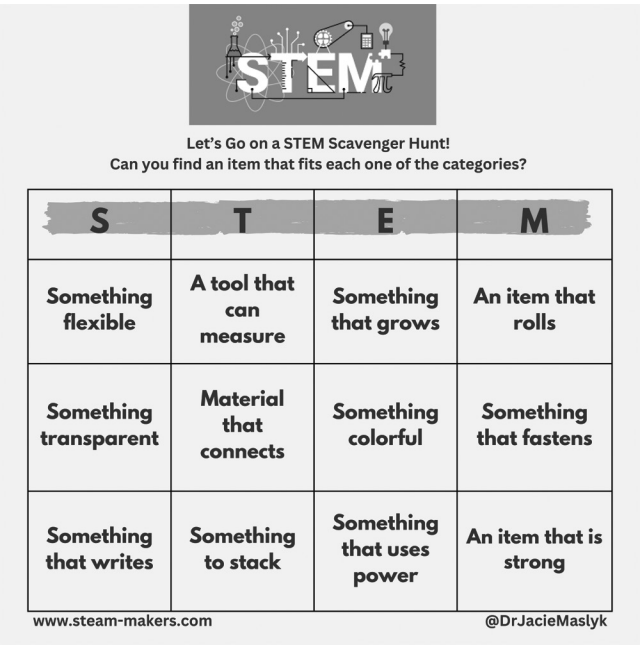
If STEAM and maker learning are going to thrive in any system, then we need to build curiosity and wonder—both in our students and our educators. Professional development for teachers (and leaders) must include the same kinds of hands-on, open-ended experiences that we want for our students. We need to equip educators with the ideas, resources, and experiences to make learning engaging for students. Designing meaningful lessons for our students can only happen when we have experienced those same feelings of wonderment, frustration, and success evoked by engineering challenges, experiments, and design activities. Here are some goals to consider when planning professional learning:

- Get teams excited.
- Build their knowledge.
- Engage them in hands-on learning that includes a productive struggle.
- Provide time to reflect.
- Create plans of action.

Sparking curiosity with new materials or projects or building excitement with scavenger hunts or other active experiences are part of classroom instruction, but they are also quality professional development. Activities like scavenger hunts can be useful when students or educators are kicking off a new school year or visiting a newly established makerspace for the first time. The scavenger hunt in Figure 1.2 goes beyond just finding materials and getting acclimated to a STEM space; it also forces participants to think flexibly about different items and how they can be used. Consider using this as a partner or small

group challenge, setting a time limit for the hunt and establishing parameters for how groups should move through the space as they look for items. Once the items have been found, ask students to share their ideas, providing a rationale for why their items meet the description. It can be surprising what participants come up with!

FIGURE 1.2 ● STEM Scavenger Hunt



STEAM Maker professional learning is for all educators. This approach to learning is not just for "STEM teachers." It welcomes in the expertise of librarians, math teachers, educators from the music department, instructional assistants, reading specialists, science teachers—everyone. It is the kind of learning that requires active thinking and participation. Learning activities should amplify the 4 Cs—creativity, collaboration, critical thinking, and communication—fully engaging participants in the experience. This is not your usual "sit and get." If we want educators to approach teaching and learning differently, the professional development that we offer needs to look and feel different. STEAM Maker professional learning introduces educators to new materials, emerging technologies, and unconventional techniques. Whether constructing musical instruments from recyclable materials, experimenting with augmented/virtual reality (AR/VR), or designing marble runs, teacher development should give educators the time and space to try new things and think about the ways they might incorporate them

into their content areas. We want teachers leaving professional learning with the knowledge to share new ideas with students and the excitement to implement them in meaningful ways. If we design professional learning that mirrors the learning we want in our classrooms, then we are setting up teachers and students for success.

THE MINDSET

Embracing STEAM Making does require a certain mindset. This mindset is flexible and curious and is often thought of as "outside the box" thinking. As learners wonder about problems that aren't always easily solved, they develop curiosity and expand their thinking. It includes things like combining ideas to create new things and taking apart things to find out how they work.

This mindset is not something that you can force upon learners, but rather something that you guide students toward. With support, we can encourage our learners to explore new materials, tackle big challenges, and extend their thinking beyond what is possible.

Developing a mindset for STEAM Maker learning can be difficult for some, both students and teachers alike. It requires grappling with ideas and experiencing failure, things that are not comfortable for many. As learners encounter setbacks, they build resilience, rebounding into new learning. As teachers experience challenges, they rethink their instruction and reimagine ways to engage students in learning.

A mindset to support STEAM Making can be defined within the four Ps:

- People
- Personalization
- Persistence
- Play

In schools where STEAM and making are growing, it is due to the *people*: teachers, principals, superintendents, and other school leaders who are fostering this mindset. STEAM and making thrive not just because of the people leading it but because of the sharing and collaboration that happen among makers. When young people and adults are engaged in making, they share expertise and connect with others. This connection happens face to face in makerspaces but also online through a growing community of bloggers, podcasters, and social media users.

STEAM and making are strategies that make sense for different types of learners. *Personalization* makes that possible. The hands-on nature of this work lends itself to true student-centered learning. When students have a choice in what they are working on, engagement is high and students are focused. Enter a makerspace and watch students as they select materials or work on projects. Their personal interests drive their decision making. (You'll hear from students in Chapter 4 as they describe why personalization transformed their interest in school.) Traditional teaching and learning place teachers at the front of the room delivering content to students. When learning is made personal, the teacher can facilitate individual interests and foster the work initiated by children.

How often do you set your students up to fail? Probably not a question you've been asked before! Failure is an important component of *persistence*. Acquiring knowledge in STEAM Making comes through inquiry and exploration, as opposed to direct instruction or mastery learning. This takes time and effort. In schools where students engage in STEM learning, things don't always turn out the way they were planned. And that is OK! Groups of students engage in an engineering design challenge or conduct an experiment—sometimes it works and sometimes it doesn't. STEAM learning can be messy and unconventional. It may require trial and error. Students may encounter obstacles or find shortcuts. It is likely that at some point, they will fail. How students respond to that failure is a part of the STEM mindset.

John Dewey said, "Failure is instructive. The person who really thinks learns quite as much from his failures as from his successes." This is a tough lesson for kids to learn. Failing and bouncing back from that failure is critical to a STEM mindset, and to life.

Take a design challenge, for example. Students are given some materials, criteria for building, and time to work. The design process requires them to devise a plan—a plan that may or may not work. The plan may be revised or completely thrown out the window. The students might try several iterations of a model to meet the design criteria. This work can be frustrating for kids, especially for those who need instant gratification and validation. (Does this cover many of the kids that you know?) Developing a maker mindset means that teachers and students build qualities of perseverance and persistence in the face of challenges.

The last P is for *play*. STEAM learning and making are fun approaches to classroom instruction. Tasks tap into student curiosity and allow creativity to shine. Student makers tinker

and explore with a variety of materials in a variety of spaces. STEAMers build and design in ways that challenge the mind and brighten the spirit. STEAM Makers combine to form a model of learning that is truly student centered and fun.

For some students, STEM experiences give them the chance to thrive. It is when they get to try new things (and then try some more). It is often when students get to access different types of learning modalities, beyond what occurs within traditional courses. The nature of STEM learning represents possibilities for creativity and innovation.

STEM learning is meant to be open ended, which is why learners encounter stumbling blocks and experience failed experiments or designs. In authentic STEM experiences, there shouldn't be one anticipated endpoint or product of this learning. It is what the learners construct it to be.

WHY IS THIS IMPORTANT?

Twenty-first century students want active, relevant learning. They want to be connected to their peers, those in and out of school. They want to pursue their interests and have a choice in their learning. Although this may be out of the comfort zone for some educators, there are many potential benefits to implementing this in the classroom. As we know, success beyond school requires more than basic knowledge and skills. Want students to understand content more deeply? Want them to retain what they've learned? Interested in seeing them build their confidence and solve complex problems? If we want to truly reach our students and help them to become thinkers, questioners, and innovators, then this is worth a shot.

BUT WHAT ABOUT STANDARDS AND STATE ASSESSMENTS?

State testing continues to be a driving force in education. With ongoing pressures to increase student performance on these tests, it is tempting to let these distractions lead us to "teach to the test" and overwhelm our students with test prep workbooks, worksheets, and practice tests. At some point we need to ask ourselves, What is really best for kids? Do we want to create a generation of good test takers? Do we want students who can click on a circle with proficiency? Or do we want students who can think for themselves, communicate with others, and successfully work with a team?

The Common Core State Standards' (CCSS) emphasis on real-world application of knowledge and skills, push for competencies in critical thinking, use of relevant technology and media, and focus on student collaboration fit well within the framework for STEAM education and the maker movement (see Table 1.1). The rigor and relevance that these newly adopted standards require can be addressed through hands-on/minds-on learning that happens in schools embracing STEAM Making. Students develop an in-depth content knowledge of the material they are learning about. They focus on the process of completing a task, not just the product. Engaging in problem-solving tasks, students learn how to reason and persevere when the answers are not right there in front of them. These experiences offer students the opportunity to build independence but also work collaboratively with others. The CCSS require students to investigate topics, analyze data, cite evidence, and present information. Isn't this what we want our graduates to do?

TABLE 1.1 ● Correlations of Standards

NEXT GENERATION SCIENCE STANDARDS: SCIENTIFIC AND ENGINEERING PRACTICES	COMMON CORE STATE STANDARDS	ALIGNMENT WITH STEAM AND MAKER MINDSET
1. Asking questions (for science) and defining problems (for engineering)	**Speaking and Listening:** Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.	**Personalization**
2. Developing and using models	**Standards for Mathematical Practice:** Model with mathematics.	**Persistence**
3. Planning and carrying out investigations	**Standards for Mathematical Practice:** Look for and express regularity in repeated reasoning.	**Playful**
4. Analyzing and interpreting data	**Standards for Mathematical Practice:** Look for and make use of structure. **Standards for Mathematical Practice:** Reason abstractly and quantitatively.	**Persistence**
5. Using mathematics and computational thinking	**Standards for Mathematical Practice:** Make sense of problems and persevere in solving them. **Standards for Mathematical Practice:** Attend to precision.	**Persistence**

NEXT GENERATION SCIENCE STANDARDS: SCIENTIFIC AND ENGINEERING PRACTICES	COMMON CORE STATE STANDARDS	ALIGNMENT WITH STEAM AND MAKER MINDSET
6. Constructing explanations (for science) and designing solutions (for engineering)	**Speaking and Listening:** Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. **Standards for Mathematical Practice:** Construct viable arguments and critique the reasoning of others.	**Playful**
7. Engaging in argument from evidence	**Writing:** Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. **Reading:** Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.	**People**
8. Obtaining, evaluating, and communicating information	**Writing:** Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.	**People**

Because STEAM and making take an integrated approach to learning, students gain a more comprehensive understanding of topics and how the topics relate to the real world. The CCSS aren't the only standards that need to be considered, though. The Next Generation Science Standards released in 2013 also align with STEAM and making.

NEXT GENERATION SCIENCE STANDARDS

With the release of the Next Generation Science Standards (NGSS), this is a critical time to engage students in STEAM fields. "Science, engineering, and technology permeate nearly every facet of modern life, and they also hold the key to meeting

many of humanity's most pressing current and future challenges" (National Research Council, 2013).

The NGSS include a framework for science learning that includes components of STEAM and making and was developed through a partnership between the National Research Council (NRC), National Science Teachers Association (NSTA), American Association for the Advancement of Science (AAAS), and Achieve (an educational, nonprofit reform organization). Twenty-six states collaborated with these partners to create them. These standards recommend that science be built around the following three major dimensions: (1) scientific and engineering practices, (2) crosscutting concepts, and (3) core areas.

SCIENTIFIC AND ENGINEERING PRACTICES

Scientists engage in certain practices as they investigate the world around them. Engineers also employ these practices as they design and build models. A strong foundation of both skills and knowledge are needed to develop these practices. With an emphasis on engineering, the NGSS stress the formulation of problems that can be solved through design. It is this type of learning that will clarify for students the relevance of science, technology, engineering, and mathematics beyond school.

What does this look like in the classroom?

- Students ask questions as they plan and carry out investigations.
- Learners develop and use models to solve real problems.
- Classrooms are engaged in gathering, analyzing, and interpreting data as they construct explanations and design solutions.
- Groups of students engage in computational thinking and use evidence to build and defend an argument

CROSSCUTTING CONCEPTS

The NGSS define the crosscutting concepts as those that have application across all domains of science. These include patterns; cause and effect; scale, proportion, and quantity; systems; energy and matter; structure and function; and stability and change. Some of these concepts are applicable to math, technology, and the arts as well.

CORE AREAS

The core areas, as defined by NGSS, are physical science; life science; earth and space science; and engineering, technology, and application. These areas were selected because they are important across multiple disciplines. In the general curriculum, these domains are taught over multiple grade levels at increasing levels of depth.

The three dimensions of the NGSS provide a framework for the K–12 standards in science and engineering, but combined with the CCSS, these also align with the four components of STEAM and the mindset for makers. The connection to the CCSS includes not only the Standards for Mathematical Practice but also the individual standards from within the English Language Arts Standards (reading, writing, speaking, and listening).

This is by no means a comprehensive analysis and alignment of the standards but rather intends to show the multiple connections between the two sets of standards and their alignment with the principles of STEAM and maker education. As you develop learning opportunities in STEAM and making in your school, you will certainly find additional connections to relevant standards.

EXPANDING STANDARDS

Over the last ten years, the number of standards has increased. Many states have added standards for areas like digital citizenship, computer science, and STEM. Most recently, in places like Pennsylvania, Maryland, and Missouri, standards have been added to promote environmental literacy and awareness around relevant, global science concepts. As many states revise their standards, a new emphasis on the environment and sustainability is evident. In turn, school districts are making changes to their curriculum to include projects on climate, clean water, and energy. Schools are adopting programs to promote ideas like hydroponics, conservation, and civic action. Many schools are utilizing the United Nations Sustainable Development Goals (SDGs) as a roadmap for teaching these critical topics.

As we support students in the integration of STEAM subjects, many SDGs can also be incorporated into our work. Developing content knowledge in science and engineering can connect to student projects designing sustainable cities and solutions for clean energy. Students can pursue topics like food insecurity,

sanitation, and renewable resources through STEAM learning and apply that knowledge as they design possible solutions through making.

UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS (SDGS)

1. No poverty
2. Zero hunger
3. Good health and well-being
4. Quality Education
5. Gender equality
6. Clean water and sanitation
7. Affordable and clean energy
8. Decent work and economic growth
9. Industry, innovation and infrastructure
10. Reduced inequalities
11. Sustainable cities and economies
12. Responsible consumption and production
13. Climate action
14. Life below water
15. Life on land
16. Peace, justice and strong institutions
17. Partnership for the goals

WHAT DOES IT MEAN TO BE CREATIVE IN A STANDARDS-BASED SYSTEM?

Young children are instinctively creative: building with blocks, finger painting, using their imaginations, and exploring the world around them. STEAM education and the practice of making embraces this idea and enhances creativity beyond the general curriculum. In Yong Zhao's *World Class Learners*, the author discusses the fact that schools do not encourage creativity but instead "prepare good employees" (2012, p. 15). He advocates that education should never suppress curiosity and imagination. Taking that a step further, I would argue that schools should create opportunities to foster curious minds and pursue imagination, both in their students and teachers.

The freedom and flexibility to explore STEAM and making can be a challenge in a standards-based, accountability-driven educational system. It is a challenge that schools are taking along with community partners, libraries, parents, and corporations, positioning STEAM Making as a viable solution for positive educational change. This change is echoed by Sir Ken Robinson, ultimate supporter of creativity and innovation in schools.

In his 2006 TED Talk, Robinson implored educators to accept this changing paradigm and begin thinking about a new approach to teaching. His talk attained close to thirty-two million views on YouTube. He asserted that schools kill creativity and spoke about the uncertainty of the future. We know now that STEAM and the maker movement have forged ahead as a means to develop creativity and innovation in our students. Are you ready to accept this change and embrace the opportunities that come with STEAM Making in your classroom?

Summary

As we look ahead to what the future holds for education, it is filled with possibilities. What topics are you wondering about? How will you deepen your knowledge and expand your imagination? Creative educators are utilizing resources and aligning standards to design engaging instruction and ensuring access for all students. With wonder and excitement we continue to build engaging learning environments and offer innovative learning tools that will compel our students to imagine, reprogram, and make!

Expanding Your Thinking

How does my instruction activate wonder and imagination in my students? _____

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In what ways do I promote and honor both left-brain and right-brain thinking in my teaching? _____

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How might I increase access to materials and resources to prompt creative thinking in my students? _____

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