WHAT YOUR COLLEAGUES ARE SAYING . . .

"***STEM and STEAM learning must become more than an educational 'sound bite.'*** More importantly, STEAM learning needs to be fully understood and implemented. *Step Into STEAM* examines and addresses issues regarding the importance of STEAM learning and provides the support that elementary classroom teachers and instructional leaders need to truly guide their planning, teaching, and assessment of integrated and inquiry-based STEAM instruction. What an amazing 'must-have' resource!"

—Francis (Skip) Fennell
Professor of Education Emeritus
McDaniel College
Elementary Mathematics Specialists & Teacher Leaders Project
Past President, National Council of Teachers of Mathematics (NCTM)
Past President, Association of Mathematics Teacher Educators (AMTE)
Past President, Research Council on Mathematics Learning (RCML)

"**Step Into STEAM** ***takes a sophisticated pedagogy*** from appearing as a complicated challenge to an approach that is accessible to each and every classroom. What separates this work from others? Oh, right: There are no other books like this one! The authors' practical approach to getting started and go-to resources recognize the reality of busy educators' lives. Here you'll find planning tools and examples of investigations that don't trivialize any of the STEAM subjects to merely 'cover' a subject. Rather, they integrate the subjects in a way that leverages community and societal interests; they exemplify student-driven instruction that capitalizes on learners' strengths; and they focus on equity, empathy, and experience to help learners seamlessly blend their noncognitive skills."

—Karen S. Karp
Mathematics Education Consultant, Author
Professor Emeritus, University of Louisville
Past President, Association of Mathematics Teacher Educators (AMTE)
Louisville, KY

"**Step Into STEAM** ***offers a rare opportunity*** for anyone concerned with education to consider what learning would be like with equity, empathy, and experience. By providing examples from educators who have dared to put children first, this book offers more than just a new way to teach; it offers hope for youth today. By considering what youth will need to be successful in jobs that are not yet created, Bush and Cook provide a platform for educators to create authentic, real-world problem solving in classrooms and beyond with attention on the often forgotten component of STEAM—the M! As a proponent of STEAM education, my recommendation is to grab this book and watch your students love learning again!"

—Cassie Quigley
Department Chair and Professor of Science Education,
University of Pittsburgh
Author, *An Educator's Guide to STEAM: Engaging Students Using Real-World Problems*
Pittsburgh, PA

"***While some STEM and STEAM books tend to be heavy on one discipline*** and can leave out other disciplines, this book advocates interdisciplinarity and in fact emphasizes the concept of transdisciplinarity. Transdisciplinarity is meaningful STEAM instruction that goes beyond simply connecting the disciplines but supports meaningful connections among the disciplines that creates learning beyond the disciplines themselves. This idea melds throughout the book with examples and suggestions for how to develop such a program that provides meaningful learning experiences across and among the STEAM disciplines."

—Valarie Akerson
Professor of Science Education, Indiana University
Past President, Association for Science Teacher Education
Past President, National Association for Research in Science Teaching
Bloomington, IN

"**Step Into STEAM** ***is a must-read for anyone interested in STEAM!*** Rather than supplying a set of prescribed lesson plans to follow, the authors provide guidance, practical suggestions, and thought-provoking questions to assist the reader as they successfully plan for and implement STEAM inquiries. These STEAM inquiries, which maintain a sharp focus on mathematics and science content and practices, hold the potential to highly affect learning for each and every student."

—Susie Katt
K–2 Mathematics Coordinator, Lincoln Public Schools
Lincoln, NE

"**Step Into STEAM** ***is a timely guide*** for those interested in framing their work in STEAM instruction. The authors' unique and innovative approach is transformational and takes readers on a journey into STEAM teaching and learning. Bush and Cook have written a must-read primer for everyone involved in STEAM education . . . Read this book—and learn from the best!"

—Rommel J. Miranda
Past President, Association for Science Teacher Education
Professor of Science Education, Towson University
Towson, MD

"***Through carefully crafted research-based frameworks;*** inspirational, authentic, and approachable practical strategies rooted in the reform efforts of student-centered STEAM instruction; and opportunities for professional self-reflection, *Step Into STEAM* rightfully re-elevates educators to their proper places as innovation experts and agents of change in their own classrooms, schools, districts, and communities. An inspirational step in a needed direction, Drs. Bush and Cook have carefully crafted the type of book educators have been craving: a guide to transforming ourselves, our learning spaces, and our profession."

—Richard Cox Jr.
STEM Lab Program Coordinator, The Pearl
Senior Strategist—Community and Social Impact
Atrium Health
Charlotte, NC

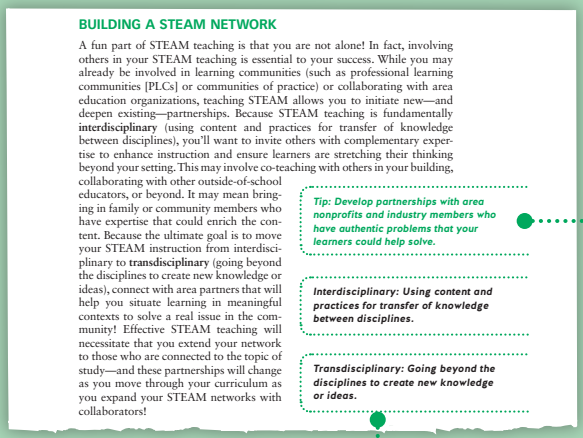
"**Step Into STEAM** ***provides a remarkable resource*** in bringing together mathematics and science learning in authentic ways that inform and reflect the world around us. This book thoughtfully integrates STEM literacy and a research-informed focus to implement content and practice standards for PreK–5 students, teachers, and leaders. Students are empowered through equitable STEAM instruction to connect their lived experiences in order to impact local communities and society at large."

—Farshid Safi
Associate Professor of Mathematics Education,
University of Central Florida
President Elect, Association of Mathematics
Teacher Educators (AMTE)
Orlando, FL

"***Every craftsperson needs a good set of tools.*** A painter needs their collection of brushes, a carpenter their assortment of saws, an engineer their pencils and scales. Each tool is related, and some may seem indistinguishable to a casual observer—but the right tool in the right hands can make a world of difference. Teachers—especially STEAM teachers—are no exception, and for them *Step Into STEAM* can be both toolbox and tool: at once an indispensable collection of ideas, guidelines, hints, and tips, and a single convenient place to find them all. You might not use every tool on every job—but when you need just the right one, you'll be glad you know where to find it."

—Alan Perez
Teacher Leader & STEAM Educator
Youth Performing Arts School
Jefferson County Public Schools
Louisville, KY

Step Into STEAM, Grades PreK–5 at a Glance



BUILDING A STEAM NETWORK

A fun part of STEAM teaching is that you are not alone! In fact, involving others in your STEAM teaching is essential to your success. While you may already be involved in learning communities (such as professional learning communities [PLCs] or communities of practice) or collaborating with area education organizations, teaching STEAM allows you to initiate new—and deepen existing—partnerships. Because STEAM teaching is fundamentally **interdisciplinary** (using content and practices for transfer of knowledge between disciplines), you'll want to invite others with complementary expertise to enhance instruction and ensure learners are stretching their thinking beyond your setting. This may involve co-teaching with others in your building, collaborating with other outside-of-school educators, or beyond. It may mean bringing in family or community members who have expertise that could enrich the content. Because the ultimate goal is to move your STEAM instruction from interdisciplinary to **transdisciplinary** (going beyond the disciplines to create new knowledge or ideas), connect with area partners that will help you situate learning in meaningful contexts to solve a real issue in the community! Effective STEAM teaching will necessitate that you extend your network to those who are connected to the topic of study—and these partnerships will change as you move through your curriculum as you expand your STEAM networks with collaborators!

Tip: Develop partnerships with area nonprofits and industry members who have authentic problems that your learners could help solve.

***Interdisciplinary:** Using content and practices for transfer of knowledge between disciplines.*

***Transdisciplinary:** Going beyond the disciplines to create new knowledge or ideas.*

Tips provide anchoring, tangible strategies, and ideas to put STEAM into action.

Glossary terms provide definitions of key ideas.

PAUSE AND REFLECT

1. When was the last time you witnessed learners persevering as they sought a solution to a challenging issue?
2. How do you address the so-what question with your learners?
3. Name a time when you integrated mathematics into science instruction to make sense of a context (not just as a tool). Why?
4. In your own words, define *interdisciplinary learning* and *transdisciplinary learning*.

TRY IT YOURSELF!

- Stop now and consider strengths and barriers you face to creating high-quality STEAM experiences for learners. Share out with a STEAM partner!

NEXT STEPS

Continue this STEAM journey with us as we explore the following questions in Chapter 2: What should be the focus of my STEAM teaching? Who should I involve? We will investigate strategies for targeting key mathematics and science learning outcomes while building in relevant technology and the arts to complement the engineering process. We will also consider potential partners with whom you will collaborate to support learning in STEAM.

Pause and Reflect sections provide critical questions for reflecting and mapping out next steps.

Try It Yourself! features help you shift into get-it-done mode with practical templates and tools for putting your instructional plans into action.

At the end of each chapter, **Next Steps** summarizes the chapter content and provides a preview for the next chapter.

Example STEAM Inquiry sections provide practical, proven, and ready-made STEAM inquiries

EXAMPLE STEAM INQUIRY

▶ Preschoolers embarked on a design challenge to figure out how to build a road on which cars would not get stuck. To set the context, the preschool teacher read the book *The Little Blue Truck* (Schertle & McElmurry, 2008) in which a truck gets stuck in the mud and friends work together to get the truck unstuck. The teacher told the learners they would be acting as engineers, and engineers have to understand the core science idea of floating and sinking to design roads and highways so that cars and trucks do not get stuck on them.

To begin, the teacher asked the learners to do some investigating about materials that sink or float. After learners determined which objects sink or float (Figure 1.3), the teacher showed them a container with a matchbox car that got stuck on a road made of gelatin. She prompted the learners with the following: "Think about how you can solve this problem of the car sinking on the road." The preschoolers worked in teams to create a gelatin road that allowed the toy car to travel across without getting stuck. Learners could use any of the available materials to add to the gelatin (Figure 1.4). Learners investigated which ingredients would help make their road as strong as possible to protect their car from sinking in the "mud." They tested their prototype to see if the toy car would be able to drive across the gelatin without sinking.

A comprehensive **STEAM Inquiry Planning Guide** provides you with a single place to capture the design, implementation, and assessment of STEAM inquiries that you have worked on throughout the book.

APPENDIX B

STEAM Inquiry Planning Guide

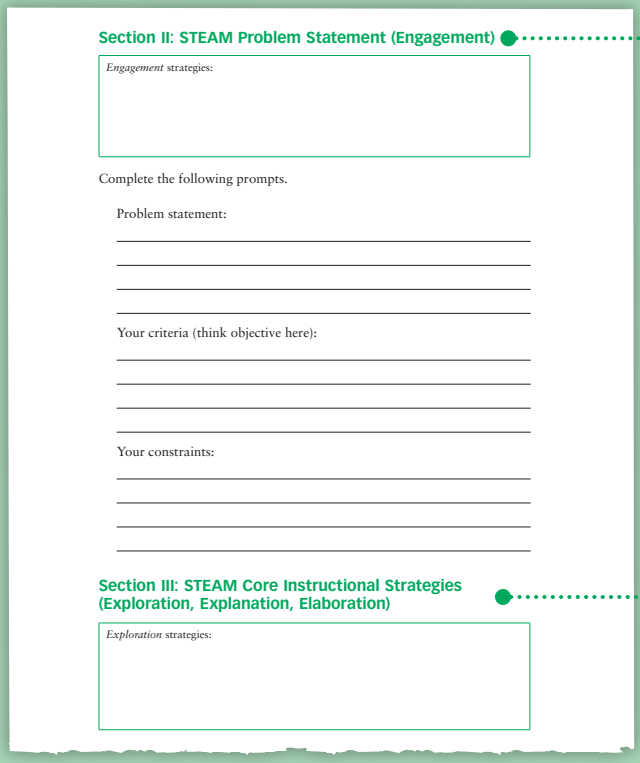
Section I: STEAM Standards Alignment

Section I of the guide focuses on standards alignment.

Complete the table by identifying all standards being assessed through this inquiry, and briefly describe *how* learners will address these standards.

Content	Standards	What Are Learners Doing?
Science Next Generation Science Standards (NGSS) or state standards (e.g., Texas Essential Knowledge and Skills [TEKS], Standards of Learning [SOL])	Content Standard(s): Practice/Process Standard(s):	
Technology International Society for Technology in Education (ISTE), Standards for Technological Literacy (STL), or state standards		
Engineering Next Generation Science Standards (NGSS) or state standards		
Arts National Core Arts Standards (NCAS) or state standards		
Mathematics Common Core State Standards for Mathematics (CCSSM) or state standards (e.g., Texas Essential Knowledge and Skills [TEKS]; Standards of Learning [SOL])	Content Standard(s): Practice/Process Standard(s):	

SOURCES: NGSS Lead States (2013); Texas Education Agency (2021;2014); Virginia Department of Education (2018); ISTE (n.d.); International Technology Education Association (2007); National Coalition for Core Arts Standards (n.d.); Common Core State Standards Initiative (2010).



Section II: STEAM Problem Statement (Engagement)

Engagement strategies:

Complete the following prompts.

Problem statement:

Your criteria (think objective here):

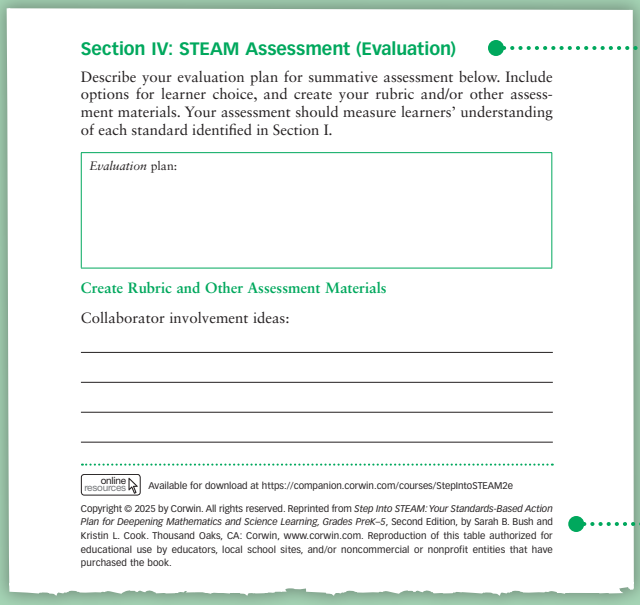
Your constraints:

Section III: STEAM Core Instructional Strategies (Exploration, Explanation, Elaboration)

Exploration strategies:

Section II of the guide helps you articulate the problem statement of your STEAM inquiry.

Section III focuses on strategy selection and the formulation of a formative assessment plan.



Section IV: STEAM Assessment (Evaluation)

Describe your evaluation plan for summative assessment below. Include options for learner choice, and create your rubric and/or other assessment materials. Your assessment should measure learners' understanding of each standard identified in Section I.

Evaluation plan:

Create Rubric and Other Assessment Materials

Collaborator involvement ideas:

online resources Available for download at https://companion.corwin.com/courses/StepIntoSTEAM2e

Section IV focuses on fine-tuning your plans for summative assessment.

An editable version is also available online as a downloadable resource.

Content we recommend that you photocopy or download is called out throughout the book.

FIGURE 3.1 Elements to Incorporate Into Your STEAM Problem-Based Learning

Core Content and Practices

- ✓ Focus on learning objectives.
- ✓ Incorporate standards-based content and practices from the STEAM disciplines.
- ✓ Embed measurable 21st century learning outcomes.
- ✓ Allow time for targeted instruction to develop key ideas.
- ✓ Connect to prior knowledge.
- ✓ Look for alternative conceptions.

Problem Statement

- ✓ It is at the appropriate level of challenge (learners maintain engagement).
- ✓ It features a real-world context.
- ✓ It has an impact in school, community, or beyond.

Ongoing Inquiry

- ✓ Plan for instruction to last several days to several weeks depending on the inquiry.
- ✓ Learners ask questions, find resources, and apply information.
- ✓ Carefully assign learners to teams–giving each learner a different role.
- ✓ Allow time for independent work, teamwork, and whole-class discourse.

Learner Choice Possibilities

- ✓ Learners select a problem-based learning inquiry question (within overarching topic).
- ✓ Learners choose roles within their team.
- ✓ Learners choose how to showcase their understanding.

Reflection

- ✓ Learners and educators assess learning.
- ✓ Learners and educators consider their areas for growth and plans for improvement.
- ✓ Learners give, receive, and use feedback to improve their process and solutions.
- ✓ Give targeted praise on specific skills.

Communication

- ✓ Solutions are displayed and/or presented to collaborators beyond the classroom.
- ✓ Opportunities are given for learners to practice communicating and establishing criteria for effective communication.
- ✓ Require learners to assume the roles of various collaborators (such as those of government officials, local business owners, caregivers, etc.).

online resources Available for download at https://companion.corwin.com/courses/StepIntoSTEAM2e

Step Into STEAM

Grades PreK–5

SECOND EDITION

Step Into STEAM

Your Standards-Based Action Plan for Deepening
Mathematics and ***Science*** Learning

Grades PreK–5

SECOND EDITION

SARAH B. BUSH | KRISTIN L. COOK

Foreword by
Christa Jackson and Margaret Mohr-Schroeder

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for downloadable resources.

FOREWORD

by Christa Jackson and Margaret Mohr-Schroeder

In our rapidly evolving world, the ability to think critically, solve complex problems, and innovate is more essential than ever before. As educators, it is our responsibility to equip learners with the skills and mindsets they need to navigate an increasingly uncertain future. STEAM education, which integrates science, technology, engineering, arts, and mathematics, provides a powerful framework for cultivating these vital capacities from an early age. Yet, the practical implementation of STEAM in elementary classrooms has often been met with uncertainty and apprehension. How can we ensure that STEAM is not merely an enrichment activity for the select few but a foundational experience for every learner? How can we seamlessly integrate STEAM into the already packed schedules of elementary teachers? And most importantly, how can we make STEAM truly meaningful and transformative for our learners?

The second edition of *Step Into STEAM* is an indispensable resource for elementary educators who recognize the transformative potential of STEAM learning experiences. The second edition embodies the evolving and flexible nature of STEAM, ensuring access to diverse learners across changing educational settings and novel tools, while providing educators guidance on creating authentic, purpose-driven inquiries to deepen application of science and mathematics concepts.

Crucially, the arts are not an afterthought within the book but are woven inextricably into the fabric of each STEAM experience. The authors recognize that the arts unlock vital modes of expression, communication, and innovative thinking—capacities that amplify and enrich learners' engagement with scientific and mathematical concepts.

The second edition of *Step Into STEAM* is for educators who desire to foster curiosity, creativity, and critical thinking in their learners, while preparing them for the complex challenges of the 21st century. Too often, STEAM is viewed as an enrichment activity reserved for "gifted and talented" learners.

This book challenges that notion, making a compelling case for why authentic STEAM education should be a core component of the learning journey for all learners. *Step Into STEAM* builds a foundation for unwavering commitment to authenticity and accessibility. The authors, seasoned educators and STEAM advocates, have distilled their years of experience into a practical, hands-on resource that is both inspiring and actionable.

What truly sets this book apart is its masterful integration of problem-based inquiry as the foundation for STEAM instruction. Rather than emphasizing a rigid set of activities with predetermined outcomes, the inquiries revolve around open-ended contexts that engage learners in the thrilling process of exploration, discovery, and iterative problem-solving. By prioritizing the process over the final product, problem-based STEAM inquiries nurture the very skills that will serve learners well in our rapidly changing world: critical thinking, creativity, collaboration, communication, and an unwavering drive to ask questions and seek solutions. The tangible examples provided offer elementary teachers a rich toolkit for implementation, complete with standards-aligned plans, materials lists, and thoughtful assessment strategies.

This new edition of *Step Into STEAM* perhaps most impressively serves as a masterclass in designing authentic, equitable STEAM education. The authors understand that true equity goes far beyond superficial inclusion; it requires creating learning environments that affirm and build on the funds of knowledge, cultural identities, and lived experiences that each learner brings into the classroom. In this regard, they situate their work in the Equity-Oriented STEM Literacy Framework (Jackson et al., 2021), which focuses on disrupting the STEM status quo and providing access and equitable opportunities to all learners.

The authors place empathy at the heart of STEAM instruction, one of the connected components within the Equity-Oriented STEM Literacy Framework (Jackson et al., 2021). In an age when societal challenges grow increasingly complex, the authors understand that lasting solutions can only emerge from a place of deep understanding, compassion, and a genuine desire to create positive change. By tapping into learners' innate curiosity and drive to make a meaningful impact, the lessons engage learners in rich, authentic tasks that resonate profoundly with their values, identities, and communities.

As the world continues to change at a dizzying pace, the importance of STEM skills and STEAM literacies will only continue to grow. The second edition of *Step Into STEAM* provides a comprehensive road map for cultivating the creativity, problem-solving abilities, resiliency, and empathy that will empower the next generation of innovators, entrepreneurs, and global citizens.

The authors recognize that no single educator can be an expert in every discipline. Collaboration is essential. They provide guidance on building professional learning communities, leveraging available resources, and fostering an ethos of collective growth and support.

In an era plagued by uncertainty and accelerating challenges, this book offers a beacon of hope—a vision of education that equips all learners, regardless of background, with the tools to ask probing questions, construct new knowledge, and develop solutions that can transform our world. The future is not something we simply predict; it is something we create. The second edition of *Step Into STEAM* is an essential guide for any educator committed to nurturing the infinite potential within every young mind. Together, with our young people, we have the power to create a future that is brighter, full of access and opportunity, and more sustainable for all.

—Christa Jackson
Professor of Math, Science and STEM Education
Director of iSCORE
Saint Louis University
Past President, School Science and Mathematics Association

—Margaret Mohr-Schroeder
Professor of STEM Education
Vice Provost of Academic Affairs and Innovation, Kansas State University
President, School Science and Mathematics Association

A NOTE FROM MATT LARSON

Seldom has a book been as desperately needed as this indispensable resource from Bush and Cook is today. STEM education is a current priority for many policy makers, business and industry leaders, philanthropic foundations, and education leaders. There are good reasons for this. Data indicate there will be continued growth in the number of STEM jobs the economy will generate, while at the same time there is concern the country is not producing sufficient numbers of STEM graduates. Whether our learners pursue a STEM career in their future or not, educators are called to support the development of STEM literacy for all.

As a result, the pressure is on educators to implement STEM programs beginning in elementary school to expose and motivate learners at a young age to pursue STEM careers. The problem is that in the rush to implement STEM programs, the effort is seldom done with the intentionality necessary to positively affect student learning. Bush and Cook solve this problem by providing elementary teachers and leaders a comprehensive road map for intentionally designing, implementing, and assessing STEAM inquiries in the classroom and beyond so that STEAM education can become the vehicle through which learners' mathematics and science achievement is increased and students develop strong positive STEM identities.

The importance of the authors' argument that all STEAM planning must begin with alignment to and focus on the mathematics and science content and practice standards cannot be overstated. In tying STEAM to foundational mathematics and science standards, Bush and Cook make the critical and frequently overlooked points that not every mathematics or science lesson has to be a STEAM inquiry, that a separate STEAM curriculum is both unnecessary and not even advisable, and that foundational mathematics and science instruction remain an essential feature of effective STEAM programs.

All too often in STEAM programs, learners randomly engage in disjointed "arts and crafts" activities involving technology that dominates rather than

complements, or merely "tinker" and "make" as Bush and Cook point out, while failing to learn necessary grade-level mathematics and science content standards or engage in the science and engineering or mathematical practice standards. No number of fun activities or shiny objects will ever overcome this fatal flaw of so many STEM and STEAM programs. The authors' approach to STEAM, with their emphasis on maintaining the integrity of the mathematics and science standards, no matter what your state or provincial standards are, is essential.

This is the book I wish I had written! I encourage you to engage with Bush and Cook's deeply insightful and proven approach to STEAM education and to heed their call to action: Leverage their approach to STEAM so that you become the educator of STEAM your learners deserve, and more importantly, your learners become inspired and creative problem solvers who are empowered to not only improve their own lives but improve the society we inhabit as well.

—Matt Larson
Past President, National Council of Teachers of Mathematics (NCTM)

PREFACE

Imagine this: An elementary teacher who has successfully taught in a traditional classroom setting for 20 years is approached by her principal. The principal explains that the school will, for the first time ever, have a STEAM lab and asks the veteran teacher to become the STEAM lab teacher. This teacher is apprehensive as she knows she is successful and comfortable in the classroom she's been in for the past twenty years. However, she also knows learners are at times disengaged and she's been contemplating whether her instruction is truly preparing learners for their future college and/or career path. She knows well that she is responsible for preparing her learners for jobs that do not yet exist. She knows they should understand that even if they don't ultimately pursue a STEAM-focused career, a STEAM mindset and STEAM literacy will be invaluable to them in their personal lives and with any career path they choose.

Fast-forward to the next school year. The teacher is now in her second semester as a STEAM lab teacher. She survived the learning curve, and she is now experiencing great success in her teaching and learner experience has transformed. She is implementing authentic, passion-inspiring STEAM inquiries. Learners are applying foundational ideas in mathematics and science and deepening their understanding and expanding their interests through STEAM. She is learning alongside learners as they solve complex and important problems to improve the world. Learners have transformed into powerful advocators, leaders, decision makers, and solution seekers. Learners' mathematics and science learning and achievement show substantial gains. All learners are engaged, challenged, and actively participating. Both the teacher and learners feel inspired at the end of each school day. This is STEAM!

OUR UNIQUE AND INNOVATIVE APPROACH

We are dedicated to meeting the needs of today's learners. Our approach to STEAM is to focus on effective and meaningful teaching and learning that has the strong potential to result in improved learning outcomes in mathematics and science and increase learners' interest in and sense of belonging in STEAM. We offer example STEAM inquiries and resources to drive

instruction that is standards based, with special attention to mathematics and science. In addition, our STEAM inquiry examples showcase how STEAM learning can be transformative as learners integrate disciplines to grapple with and solve problems that extend beyond the walls of the classroom into issues meaningful to the community. We also embed career connections throughout our discussion; not every learner is going to pursue a STEAM-related career, but each and every learner needs to be challenged with opportunities to transfer what they are learning in mathematics and science instruction to solve complex problems of today—and prepare for a future that will have challenges we can't even imagine.

This book positions STEAM education in an innovative and unique way by advocating for and placing a strong focus on:

- Building foundational STEAM inquiries starting with alignment to key mathematics and science content and practice standards
- Focusing on teaching and learning through STEAM to deepen learners' mathematics and science learning rather than on "making" and "tinkering"
- Placing a much needed (and often forgotten) focus on the *M* in STEAM
- Advocating that STEAM is for each and every learner; advocating for all learners to have access to STEAM instruction during the school day and in their at-home or beyond-the-school-day learning experiences
- Advocating strongly that STEAM is for everyone, *not* only for gifted learners or for an after-school program or summer camp
- Empowering educators and instructional leaders to develop STEAM inquiries built on the foundation of key mathematics and science content and practices rather than providing scripted curriculum
- Teaching STEAM through an approach that benefits society, local communities, and individuals

We felt compelled to create and then revise this book because our message is critical: **STEAM *is* for each and every learner and STEAM *can* and *should* be implemented to deepen mathematics and science learning**—a message we know is important for schools, districts, and other education settings across the country. In this second edition, we capture the evolving landscape of STEAM education as it expands across learning environments and grade bands.

WHAT'S IN THE BOOK?

This book is focused on learner-driven instruction. We have organized it into three parts. In Part 1, we set the stage for STEAM teaching and learning by providing important background information, including our definition

of STEAM, preparation for STEAM, and frameworks that guide STEAM instruction. In Part 2, we focus on the design, implementation, and assessment of STEAM inquiries, providing STEAM inquiry examples to guide your work framed through our STEAM Inquiry Planning Guide. In Part 3, we discuss exemplars of STEAM inquiries as well as how to create the overall STEAM learning experience and how to gather resources for STEAM.

WHAT'S NEW IN THE SECOND EDITION

In this second edition of *Step Into STEAM*, we update ideas and resources to capture the evolving landscape of STEAM education and its expansion across preK–5 learning environments and in various educational settings. Because the post-pandemic environment accelerated virtual and out-of-the-classroom STEAM opportunities, we offer tips, examples, and resources tailored to alternative learning settings, such as out-of-classroom learning environments and those designed to use within a STEAM lab and without. We also showcase at-home learning examples to inspire those facilitating STEAM outside of the classroom. To support educators working with early learners, we include PreK examples of STEAM inquiries. We also include a robust collection of STEAM inquiry examples spanning grade bands and learning settings.

Aligning With the Latest Research: Opportunity and Access

Throughout the chapters, we also expand on the latest research and recommendations around equity in STEAM education. This edition aligns to the Integrated STEM Practices and the Equity-Oriented STEM Literacy Framework from our *Simplifying STEM* book series (Jackson et al., 2021; Jackson, Cook, et al., 2024; Jackson, Roberts, et al., 2024). We have revised Chapter 1 significantly to reexamine access, equity, and opportunity in STEAM education.

We also incorporate strategies grounded in Universal Design for Learning (UDL) to engage all types of learners. We incorporate UDL strategies throughout the examples and tips provided to educators. Since our first edition, some states have begun instituting integrated STEM standards to guide curriculum and implementation. In response, we include some of the newest STEM standards for integration across PreK–12 and reference them in STEAM inquiry planning.

Updated Resources

STEAM resources are constantly emerging and being refined. We significantly revised Chapter 9 to include the latest content and resources, books for educators, books for preK–5 learners, websites, tools, and more! In addition,

our companion website now offers additional templates for brainstorming sessions, action plans, and checklists to help educators put their ideas into practice.

Visit the companion website at
https://companion.corwin.com/courses/StepIntoSTEAM2e
for downloadable resources.

Generative Artificial Intelligence

The use of generative artificial intelligence (AI) has already had a profound effect on teaching and learning, and it is all but inevitable that it will continue to be more and more impactful in the years to come. New tools are being developed daily, and teachers are finding useful AI applications that reduce their workload by generating lesson ideas tailored to their learners, differentiating instruction, creating rubrics, formatively assessing learners' work, and so on. We've added a discussion to Chapter 9 to help readers navigate the rapidly evolving technology.

Positioning Youth at the Center of the Learning Experience

We have embedded actionable tips throughout each chapter to provide readers with information and ideas they can use immediately. Additionally, we provide a section of suggested readings to support ongoing learning and growth for educators and for learners. Note that we intentionally use the term "learners" instead of "students" to underscore that STEAM education can occur in a variety of settings beyond the traditional classroom. This framing positions youth at the center of the learning experience.

A LITTLE ABOUT OUR STEAM WORK

In our own work conducting research and facilitating professional development, we have partnered extensively with educators, instructional coaches, principals, school district leaders, state leaders, and consultants to build STEAM infrastructures, capacities, and sustainability. Through this work, we have witnessed transformational change in classrooms and schools and beyond, seen substantial growth in mathematics and science learning and teacher content and pedagogical content knowledge, and developed a model with strategies and practical applications for others who wish to launch STEAM education in their own settings.

A primary challenge we address in this book is a big one: how we create classrooms, schools, and districts as well as beyond the traditional setting STEAM experiences focused on preparing learners for jobs that don't yet exist, while still teaching key concepts in mathematics and science. Equally important, we are dedicated to working toward access to high-quality STEAM instruction for every learner. For us, this is nonnegotiable.

WHY THIS BOOK IS FOR YOU

This book is a guide for educators to use to build STEAM infrastructures, capacities, and sustainability that empowers educators to design and implement STEAM inquiries that are carefully aligned to key mathematics and science content and practices. Through this lens, educators, schools, and districts approach STEAM as an infrastructure put into place to deepen mathematics and science learning—as well as increase interest and belonging. We also speak to out-of-school STEAM learning settings.

Specifically, in this book we guide readers in conceptualizing STEAM through a standards-based planning, implementation, and intentional assessment approach. In addition, we share strategies for structuring the experience for STEAM relevant resources, and discuss and reflect on exemplar STEAM inquiries.

INSPIRATION TO GO

Are you reaching each of your learners every day? Do you wonder whether your learners can meaningfully apply the foundational mathematics and science content and practices? Do you want to increase your learners' interest, belonging, and achievement in mathematics and science and, more broadly, STEAM? Do you want to meaningfully connect your learners to real problems in your community and beyond? Do you want to transform the world? Let's embark on this STEAM journey together!

ACKNOWLEDGMENTS

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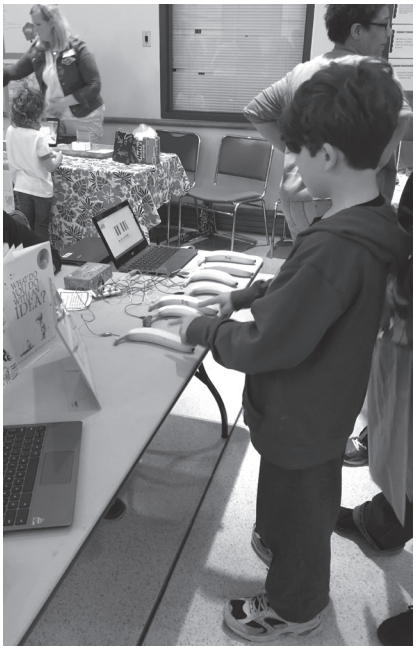
PART 1

THE STEAM LANDSCAPE



CHAPTER 1

WHAT IS STEAM AND WHY DOES IT MATTER?

Why does STEAM teaching and learning matter? How does it meet the needs of youth today and prepare them for the fast-changing world of tomorrow? In this chapter, we introduce the fundamentals of STEAM education and share how building STEAM inquiries around three guiding principles—the Es of **equity, empathy**, and **experience**—creates transformative and effective learning opportunities. This chapter addresses the following questions:

- ***Why should I care about STEAM? What does the research say?*** In a condensed and digestible way, we share the research around STEAM education, and more broadly STEM, to set the foundation for your journey.

- ***How does STEAM help provide equitable experiences for every learner?*** Learn the importance of embedding STEAM education in the regular school day and beyond, making it accessible to every learner.
- ***Why is empathy central to meaningful STEAM inquiries?*** Determine how you can create purpose-driven STEAM inquiries that anchor your mathematics and science instruction and also aim to improve life for others.
- ***What experiences are learners engaged in when learning STEAM?*** Consider the academic needs of your learners and how STEAM is uniquely positioned to meet those needs.

This chapter will also give you opportunities to pause and reflect on your own STEAM journey.

The career of an elementary educator is equal parts exciting and daunting. Let's acknowledge the tall order that comes with often being responsible for teaching many different subjects. We contend that with STEAM, we flip the script on the challenges of time, resources, and expertise that you face and instead channel your energy on integration to create amazing opportunities for learners.

INTRODUCTION

We imagine you might be interested in STEAM learning for many different reasons. Perhaps you keep hearing about STEAM in educational settings, a push from your district, among colleagues, on social media, in the latest exhibit at your local science center, or through your professional organization. Maybe you bought this book because you are interested in learning strategies for better connecting multiple subject areas to make the most out of your limited instructional time. Or you might be reading this because your school or district is embarking on STEAM to create transformative learning experiences that will prepare learners for future careers that, let's face it, don't even exist yet—and that we can't even imagine. Other important reasons might include wanting to deepen your learners' mathematics and science understanding or are looking for ways to engage every one of your learners in authentic problems. Or perhaps your state has recently adopted a new set of integrated STEM standards and you are seeking guidance. If any of these reasons make you think "That's me!," you've come to the right place!

Our work in STEAM education focuses on integrated learning. For an elementary educator, there are never enough hours in the day. By integrating subject areas in STEAM, we can address standards across the subject areas simultaneously. This book serves as a professional learning tool to guide your journey in using your state's content and practice standards in mathematics and science, and perhaps even integrated STEM, to drive your development of meaningful and authentic STEAM inquiries.

Defining STEAM: What Does the Field Say?

You might be wondering: Does integrated instruction work? Will integrating the subject areas be beneficial for my learners? Will my learners' understanding and academic achievement increase as a result? What is STEM literacy? How do I increase interest in and a sense of belonging in STEM? Experts have shared how the integration of the STEM subjects can improve a variety of learner outcomes in the STEM disciplines (as suggested by Bybee, 2013; Czerniak, 2007; Kennedy & Odell, 2014; Mohr-Schroeder et al., 2018; National Research Council, 2011, 2013; Park Rogers & Abell, 2007; Wang et al., 2011). Furthermore, the 2018 *Charting a Course for Success: America's Strategy for STEM Education* federal report from the National Science and Technology Council as part of the Executive Office of the President articulated a "vision for a future where all Americans will have lifelong access to high-quality STEM education and the United States will be the global leader in STEM literacy, innovation, and employment" (p. v).

Integrated STEM learning:

- Prepares learners to become innovators, solution seekers, and members of society who are STEM literate (see Bybee, 2010; Mohr-Schroeder et al., 2020; Zollman, 2012, for definition; National Academy of Engineering & National Research Council, 2014)
- Positions learners with successful skills for today's workforce, including solving problems that require the use of multiple subject areas as well as 21st century learning skills (Atkinson & Mayo, 2010)
- Increases opportunity and access to STEM for all learners and develops their positive identities, a strong sense of belonging, and interest in STEM (Jackson et al., 2021; Jackson, Cook, et al., 2024; Jackson, Roberts, et al., 2024)

Inquiry: Learner-centered instruction that encourages investigation, exploration, discussion, and collaboration.

Furthermore, integrated STEM learning is advocated for in standards such as the Next Generation Science Standards (NGSS; NGSS Lead States, 2013) as evidenced in the Science and Engineering Practices by intentionally focusing on engineering practices that learners should develop so that they deeply engage in rich scientific **inquiry** and direct connections to mathematics content and practice standards. Some states are even beginning to create or adopt integrated STEM standards (for example, Indiana released K–12 Integrated STEM Standards in 2023). Regardless of the standards your state uses, all states have process or practice standards (either the same as the Common Core State Standards Initiative, 2010 and NGSS Lead States, 2013, or a set specific to that state), which are skills and attributes we should work diligently to develop in our learners.

Evidence shows the positive effect of integrated STEM instruction on learner achievement not only in the practices but also in the content (Roehrig et al., 2012). For example, in a meta-analysis (statistical analysis that combines the results) of 28 studies that examined the effectiveness of integrated STEM instruction, Becker and Park (2011) found a positive effect on learner achievement. In another meta-analysis of 31 studies, Hurley (2001) found a positive effect on learner achievement in both mathematics and science when the subject areas were integrated.

Despite the promise that integrated STEM learning holds to be academically and humanistically beneficial and the support it has received broadly, it is still not implemented widely. Furthermore, even though the STEM workforce has gradually become more diverse, substantial occupation-level, educational degrees, and pay disparities persist for women, minoritized people, and people with disabilities (National Center for Science and Engineering Statistics, 2023). In short, because of the promise integrated STEM holds to increase learners' academic achievement in mathematics and science, and the critical need to disrupt the STEM status quo to increase opportunity, access and belonging in STEM, we suggest a focus specifically on STEAM.

Adding the "A" to STEM

The addition of the arts to STEM continues to gain traction in the field as a key ingredient for addressing the need for increased participation in STEM as well as meeting the needs of today's world. Just as with STEM, the central idea of STEAM is to move beyond traditional curricula with the disciplines purposefully and meaningfully crossing boundaries to solve complex and authentic problems (Bush & Cook, 2018). We consider authentic problems ones that are not only "real-world" but are also actual issues being faced in a community or beyond, in other words, they are not contrived. When considering reasons to add the *A*, the arts include an appreciation for beauty, creativity, aesthetics, and emotion in developing a solution (Bailey, 2016). In our own research (Cook & Bush, 2018), we have discussed the transformative role empathy plays in a STEAM learning environment to engage learners in developing solutions that make the world a better place—providing the essential affective connection. Through our work with classroom teachers, instructional coaches, building and district administrators, and their PreK–5 learners, as well as with educators in other educational settings, we have witnessed firsthand how the integration of the arts provides a vehicle through which to engage more learners, specifically learners who have not had positive experiences with mathematics or science (Ahn & Kwon, 2013; Bequette & Bequette, 2012; Wynn & Harris, 2012). Adding the arts expands the STEM conversation from developing the nation's next workforce to developing the nation's next creative thinkers.

When considering the most recent research findings related to the impact of STEAM education, a systemic review of literature by Irwanto and Ananda (2024) found overwhelming positive outcomes related to a STEAM approach, such as on learners' creative abilities, motivation to understand science, self-efficacy, leadership styles, and collaboration. STEAM has been shown to have a positive effect on both content and practice skills development in elementary children. Gyeong and Young (2013) investigated the effects of STEAM project-based learning on elementary learners' creative problem solving, scientific achievement, and class satisfaction in elementary science. Results showed a statistically significant difference in creative problem-solving ability and scientific achievement in the experimental group. In our own research, we analyzed Grades 3–5 learners' perceptions of their STEAM learning and found that high-quality STEAM learning experiences provide students with the opportunity to dive more deeply and really "make meaning out of their science and mathematics learning" (Bush et al., 2020, p. 712).

CONCEPTUALIZING STEAM EDUCATION THROUGH THE THREE Es: EQUITY, EMPATHY, EXPERIENCE

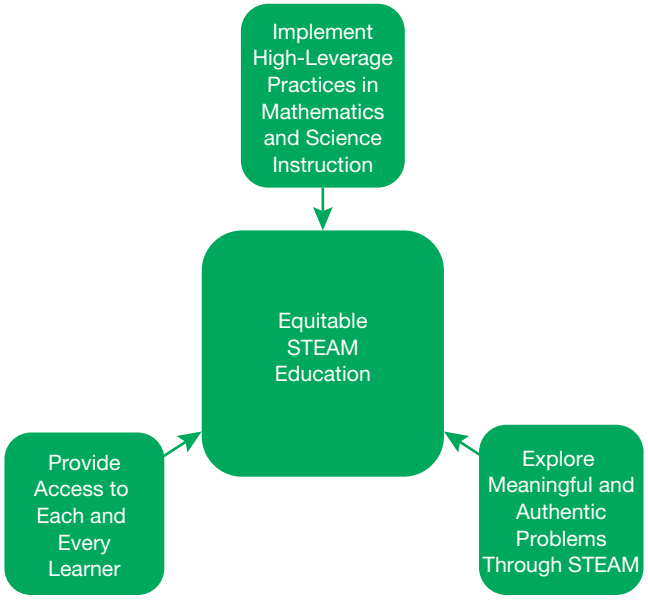
In this section, let's look closer at how we conceptualize STEAM education—that is through equity, empathy, and experience, the three Es! The order of the three Es is intentional. Equity is first and foremost because when STEAM learning opportunities are created it is imperative that every learner has opportunity and access. Empathy is the second E because empathy is the key to creating the most transformative STEAM learning experiences. The third *E*, experience, ties it all together, articulating the key characteristics and benefits of effective STEAM instruction. We'll look at each of the three Es in turn and discuss why they are so important in STEAM instruction.

Equity

Figure 1.1 illustrates the embodiment of the following three key ingredients to create equitable STEAM education infrastructures in classrooms, schools, districts, and beyond:

- implement high-leverage practices in mathematics and science instruction,
- provide access to each and every learner, and
- explore meaningful and authentic problems through STEAM.

FIGURE 1.1 Three Key Ingredients for an Equitable STEAM Education



We discuss the three Es in an interwoven way in this section as they cannot be separated. Equitable STEAM education can level the playing field for every learner. With equity, every learner should be able to consider STEM careers such as scientist, mathematician, computer programmer, and engineer as possible and understand the role the arts plays in these careers. And learners should understand that even if they don't ultimately pursue a STEM-focused career, a STEM mindset and STEM literacy will be very valuable to them in their personal lives and with any career path they choose. Out-of-school STEAM learning experiences can also be incredibly valuable and should be built on the foundation of inclusivity. We will continue to interweave the discussion of out-of-school STEAM learning experiences throughout the book (such as at museums, science centers, STEM/STEAM camps, science clubs, and at-home learning).

Implementing high-leverage practices in mathematics and science education, such as those described in *Principles to Actions: Ensuring Mathematical Success for All* (NCTM, 2014) and *A Framework for K–12 Science Education* (National Research Council, 2012), is a good place to start and provides research-informed guidance on how to best teach mathematics and science for deep understanding. We as educators can accomplish such practices through strategies such as facilitating meaningful discourse, posing purposeful questions, supporting productive struggle, and engaging learners in authentic scientific inquiry. Such teaching practices at their very core are designed to provide equitable access to high-quality mathematics and

science education—maximizing every learner's potential. Although these strategies and practices inherently represent "good teaching," an intentional focus on equitable instruction is also needed (see NCTM, 2020b, pp. 43–44).

Equitable instruction in STEAM education goes beyond every learner having access to high-quality STEAM learning experiences (although that is a critical first step). When we truly invite learners into equitable spaces, we develop meaningful relationships with each child and actively seek ways to build from each child's unique strengths (see Kobett & Karp, 2020). Geneva Gay's culturally responsive work describes using "the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them" (Gay, 2018, p. 36). Gholdy Muhammad in her 2023 book *Unearthing Joy* described the importance of teaching from cultural and historical realities and shared five pursuits to further this goal: identity, skills, intellect, criticality, and joy. Muhammad called for humanizing pedagogies, stating, "We can no longer have hidden figures. We must uncover them because we need their genius and their narratives to make us all better" (p. 21).

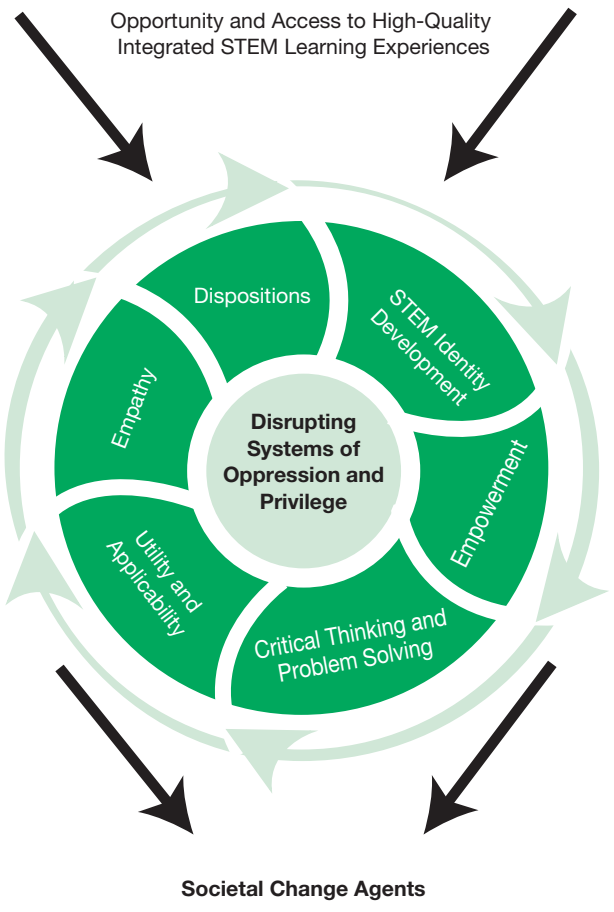
Aguirre et al. (2024) in their expanded edition of *The Impact of Identity in K–12 Mathematics: Rethinking Equity-Based Practices* shared five equity-based practices that include going deep with mathematics, leveraging multiple mathematical competences, affirming mathematics learners' identities, challenging spaces of marginality, and drawing on multiple resources of knowledge (p. 51). A meta-synthesis of science education literature (Brown, 2017) that explored equitable and inclusive practices within inquiry-based teaching indicated the practices of *Obtaining, Evaluating, and Communicating Information*; *Constructing Explanations and Designing Solutions*; and *Developing and Using Models* were used to advance culturally responsive instruction and assessment. The use and development of models allows learners to explore scientific concepts through families' funds of knowledge and explains content from Western science and Indigenous knowledge perspectives. In addition, the science education literature has often focused on the practice of *Analyzing and Interpreting Data* when interrogating science content in sociopolitical consciousness-raising experiences. However, specific inquiry-based practices have been underused when advancing culturally responsive science instruction. For example, *Using Mathematics and Computational Thinking* and *Engaging in Argument From Evidence* were infrequently encountered in the literature, although educators should prioritize these areas in their teaching and researchers need to prioritize it in their scholarship. The examples interwoven throughout this book emphasize these practices.

We lean heavily on guidance from these scholars who focus on the field of education broadly, as well as more specifically on mathematics education and science education when considering equitable instruction.

Our broader research team has worked to articulate specific aspects related to equitable instruction as it relates to integrated STEM and STEAM education. In our sister books, *Simplifying STEM: Four Equitable Practices to Inspire*

Meaningful Learning (for both Grades PreK–5 and 6–12; Jackson et al., 2024a, 2024b), we discussed the critical need to become "STEM System Disruptors" to "counteract the deeply rooted traditions in STEM education" that have excluded many from belonging and thriving in STEM (2024a, p. 6). Many have been marginalized during STEM learning opportunities and in STEM careers based on their gender, race, ethnicity, geography, ableness, socioeconomic background, language background, sexual orientation, and more. Thus, we have grounded our work in the "Equity-Oriented STEM Literacy Framework" (Figure 1.2; Jackson et al., 2021; Jackson, Cook, et al. (2024); Jackson, Roberts, et al. (2024)), which focuses on "illuminating the complexities of disrupting the status quo and rightfully transforming integrated STEM education in ways that provide equitable opportunities and access to all learners" (2021, p. 5). In this framework, we have focused on six connected components that include STEM Identity Development, Empowerment, Critical Thinking and Problem Solving, Utility and Applicability, Empathy, and Dispositions. Please see the *Simplifying STEM* series for a broader discussion on this (Jackson, Cook, et al. (2024); Jackson, Roberts, et al. (2024)).

FIGURE 1.2 Equity-Oriented STEM Literacy Framework



SOURCE: Jackson et al. (2021); Jackson, Cook, et al. (2024); Jackson, Roberts, et al. (2024).

Inherently good teaching and equitable practices *must* take place in the context of authentic integrated STEAM learning environments so that learners see the purpose and experience firsthand that mathematics and science are how we make sense of the world and be empowered to be part of making the world a better place.

Through our lens on equitable access, we have learned that integrated and authentic STEAM instruction:

- Provides a context for mathematics and science high-leverage teaching practices to be realized
- Engages learners in meaningful discourse and authentic scientific inquiry
- Positions mathematics as an essential component to seeking solutions to truly authentic problems
- Explores authentic and meaningful issues in learners' contexts and lives
- Encourages every learner to be interested and engaged in STEM

All learners need experiences in authentic integrated STEAM. All too often, authentic STEAM learning opportunities are presented as an enrichment class only for learners who are perceived as advanced or gifted, a voluntary after-school program for those learners already interested in STEM, or an optional summer camp. The script *must* be flipped. We argue that learners who often have the least amount of access to authentic STEAM learning experience could benefit from it the most! Part of providing access is scaffolding instruction in intentional ways. A STEAM learning experience naturally lends itself to scaffolded instruction because the following occurs:

1. Inquiries are low floor, high ceiling.
2. Learner strengths are showcased.
3. Learners have a reason to care!

STEAM inquiries are open-ended and have multiple solution paths. Therefore, every learner can enter and contribute to the inquiry (i.e., low floor), yet the inquiries are complex and learners have the opportunity to provide solutions at various levels of sophistication (i.e., high ceiling; similar to low-threshold, high-ceiling tasks in Huinker & Bill, 2017). A high-quality STEAM inquiry is also grounded in the underlying principles of Universal Design for Learning (UDL), which is a framework offering concrete suggestions to ensure all learners can participate and have access to meaningful learning opportunities and includes multiple means of engagement, multiple means of representation, and multiple means of action and expression (CAST, 2018a). In STEAM, this often comes through in choice and roles learners play during a STEAM inquiry, as well as in the options they are given to showcase their understanding.

Also, integrating multiple subject areas, including the arts, and incorporating the many "soft" skills learners use in working together toward a common goal allows each learner to showcase their strengths. "Soft" skills have traditionally been thought of as people skills, but Bersin (2019) argued that soft skills should be renamed "power" skills. He explained, "Hard Skills are soft (they change all the time, are constantly being obsolete, and are relatively easy to learn), and Soft Skills are hard (they are difficult to build, critical, and take extreme effort to obtain)" (para. 12). He argued that Power Skills are all behavioral and "highly complex, take years to learn, and are always changing in their scope" (para. 17). We argue that integrated STEAM learning is an ideal setting to begin to develop Power Skills in students, which can serve them well for a lifetime. This also fits seamlessly into learners engaged in seeking solutions to truly authentic problems.

Finally, when learners are engaged in solving authentic problems that interest them and in which there is a purpose, they care and are passionate about seeking a solution. This desire instantly leads to increased engagement and often fewer behavior challenges. We believe that every learner should have access to such high-quality STEAM learning experiences during the school day and that programs offered outside of the school day should be inclusive and designed to foster belonging and interest in STEM.

PAUSE AND REFLECT

1. What integrated STEAM opportunities are currently available at your school, district, or learning setting? Which learners have access to these opportunities?
2. How might integrated STEAM address the needs of your classroom, school, district, or learning setting?

TRY IT YOURSELF!

- Create a list of questions and wonderings you have about STEAM opportunities and access in your setting. Share out your list of questions and wonderings that you want to discuss with your colleagues and administrators.

Empathy

Not all STEAM inquiries are created equal! What do we mean by that? Let's walk through two examples that address another key ingredient in equitable STEAM education: the importance of empathy. First, consider an inquiry centered on designing a garden for a school: Let's call this a "Garden Inquiry." This well-known and common integrated inquiry tasks learners to design a green space for their school. In this inquiry, learners are engaged in each subject area of STEAM. Learners use the mathematics of measurement to find the area, perimeter, and volume of the spaces and use computation with decimals to create a detailed budget plan. They explore the biology of plants and their needs. Learners engage in the engineering practices (e.g., using mathematics and computational thinking and constructing explanations and designing solutions) as they design the blueprint. Technology might be used to conduct research online or to design a blueprint using learner-friendly design software. The arts are incorporated through the visual aesthetics. Through this work, learners have the opportunity to apply the different subject areas while learning about designing a green space.

Let's take a look at another example of a STEAM inquiry: "Let There Be Light"! In this scenario, learners begin with a real challenge that some children face often in rural areas of the United States as well as around the world. Through learner-led research, the class discovers that many households in a region close to them do not have consistent electricity. Learners consider what it must be like to grow up in a home with no electricity and imagine how their own day-to-day routines would change drastically as a result. Learners become passionate about helping other children their age and brainstorm ways to help—ultimately deciding to create and build battery and solar-powered light sources to mail to homes in this neighboring region. To create this solution, learners engage in the engineering practices (such as planning and carrying out investigations) as they try different solution paths and engage in testing and retesting their ideas. Science (i.e., energy and electricity) and mathematics (i.e., angle measurements and budget computation) are needed to build and explain their designs. At the end, learners decide that children their age would want visually aesthetically pleasing lights that reflected their history, and they decorate them to align with a variety of local traditions, incorporating the arts. You can read more detail about the Let There Be Light inquiry in Chapter 7.

Now, let's take a minute to compare the Garden Inquiry with this Let There Be Light inquiry.

PAUSE AND REFLECT

1. How are the Garden Inquiry and the Let There Be Light inquiry similar?
2. How are these two inquiries different?
3. Have you implemented any inquiries in your classroom that share the characteristics of either the Garden Inquiry or the Let There Be Light inquiry?

Consider your reflections from the Pause and Reflect as we return to the idea that not all STEAM inquiries are created equal. In fact, this idea was a key finding in our STEAM research. We found through analyzing 1,572 learner open responses to six prompts related to their perceptions that STEAM experiences were described by learners in such a way they could be organized into three categories: STEAM activities, Authentic Problems, and Empathic Problem Solving (Bush et al., 2020). Those categorized as Empathic Problem Solving were by far the most transformative STEAM learning experiences, and we have found in our work that the most effective integrated STEAM inquiries:

1. Are grounded in empathy
2. Have an undefined solution path
3. Create something for the greater good
4. Position mathematics as essential to make sense of the problem, not just as a tool that is grounded in deep learning of key ideas in science

First, let's look more at empathy. When we design inquiries by first taking our learners on a journey where they can feel what it is like to be in a certain situation or environment, the buy-in and passion learners develop for solving the problem become inspiring, and this enthusiasm will carry with them throughout the duration of the inquiry (see also Witt, 2019).

Second, because the most effective STEAM inquiries have undefined solution paths, this not only sets the stage for empathy but honors learner creativity and multiple entry points into the inquiry as well, as with the Let There Be Light inquiry.

Third, great STEAM inquiries often require learners to create or develop a solution for the greater good of their school, their community, or the world which aligns seamlessly with the focus on empathy.

Fourth, the best STEAM inquiries use mathematics and go deep into key science ideas. Chapter 7 provides more examples to show how a deep focus on mathematics and science content and practices can be accomplished.

PAUSE AND REFLECT

1. When have you used empathy in your curriculum? How did this affect learners' level of engagement?
2. Name two aspects of empathy that you want to learn more about.

TRY IT YOURSELF!

- Stop now, and take what you've learned in this section to jot down three ideas for incorporating empathy into your existing curriculum. Share and discuss with a colleague!

Experience

Let's turn to the third E: experience. What unique experiences does integrated STEAM education provide? STEAM offers the unique opportunity to:

1. Be in scenarios where perseverance is a necessity
2. Address the so-what question
3. Focus on key mathematics and science content and practices
4. Transcend the disciplines

In authentic STEAM inquiries, learners encounter a messy problem with an undefined solution path. Learners are engaged in solving a problem where they must create the solution. As a result, learners will reach failure points, and there will be many "course corrections" along the way, which help learners build their perseverance skills. In the following example, PreK learners experience a STEAM design inquiry linked to a children's storybook that presents a problem of a truck getting stuck in the mud. In this example, the storybook provides the so-what question for learners to explore.

EXAMPLE STEAM INQUIRY

▶ Preschoolers embarked on a design challenge to figure out how to build a road on which cars would not get stuck. To set the context, the preschool teacher read the book *The Little Blue Truck* (Schertle & McElmurry, 2008) in which a truck gets stuck in the mud and friends work together to get the truck unstuck. The teacher told the learners they would be acting as engineers, and engineers have to understand the core science idea of floating and sinking to design roads and highways so that cars and trucks do not get stuck on them.

To begin, the teacher asked the learners to do some investigating about materials that sink or float. After learners determined which objects sink or float (Figure 1.3), the teacher showed them a container with a matchbox car that got stuck on a road made of gelatin. She prompted the learners with the following: "Think about how you can solve this problem of the car sinking on the road." The preschoolers worked in teams to create a gelatin road that allowed the toy car to travel across without getting stuck. Learners could use any of the available materials to add to the gelatin (Figure 1.4). Learners investigated which ingredients would help make their road as strong as possible to protect their car from sinking in the "mud." They tested their prototype to see if the toy car would be able to drive across the gelatin without sinking.

FIGURE 1.3 Preschoolers Testing Different Materials to Determine Which Float or Sink

FIGURE 1.4 Selecting Materials to Create Prototypes

Learners discussed their design, data, and final results in front of the class. Learners made sense of the phenomenon of automobiles sinking in the mud by engaging in the science and engineering practices of asking questions and defining problems, using models, and designing solutions. The focus on mathematics included collecting and considering their data as they made decisions and persevere in getting the truck unstuck.

STEAM addresses the so-what question—that is, Why am I learning this?—in a powerful way. When will I ever use this in real life? I know this now, but so what? With the most effective STEAM inquiries, an educator will never hear these questions because learners will already know the answers. The *why* and *so what* are the reason learners are engaged in solution seeking in the first place. When learners clearly understand and see the purpose and value, amazing changes begin to happen.

Through innovative STEAM learning experiences, the following changes unfold:

1. Learners become more passionate about truly understanding the concepts.
2. Engagement increases.
3. Positive and strengths-focused classroom norms and behaviors flourish.
4. The door to reaching every learner is opened.

A FOCUS ON KEY MATHEMATICS AND SCIENCE CONTENT

Furthermore, a focus on key mathematics and science content and practices is also at the forefront of effective STEAM inquiries. In order for STEAM instruction to be most transformative, it is imperative to build foundational STEAM inquiries that start with alignment to key mathematics and science content and practice standards. When done intentionally, STEAM instruction can serve as a strategy for increasing learners' mathematics and science achievement and fostering learners' positive STEM identities as they seek solutions to complex problems in our world. Only through such experiences can learners begin to see how the different subject areas are connected to each other and used in tandem to generate thoughtful solutions. STEAM provides an avenue for learners to explore how mathematics and science are used in different careers and how the components of engineering, integration of current technologies, and the arts (including aesthetics and creativity) all play a critical role in finding solutions to the most pressing topics faced in their world.

Effective STEAM inquiries integrate subject areas—*and* they transcend them. While interdisciplinary learning occurs when content is the primary focus and a "synthesis of two or more disciplines" (Choi & Pak, 2006, p. 355) is at play, transdisciplinary learning in which the problem is the primary focus and the subject areas are explored more holistically requires "looking at the dynamics of the whole systems" (Choi & Pak, 2006, p. 355). In our work, we have seen firsthand the benefits of empathetic problem solving that is afforded by transdisciplinary learning. In fact, a 2022 federal report from The National Science and Technology Council as part of the Executive Office of the President furthered the conversation on integrated STEM learning with a focus on the critical need for transdisciplinary learning and described the notion of Convergence Education as "driven by compelling or complex socio-scientific problems or topics, where learners apply knowledge and skills using a blended approach across multiple disciplines (i.e. transdisciplinary) to create and innovate new solutions" (National Science and Technology Council, 2022, p. 13). The idea of Convergence Education aligns so well with the discussion on developing learners'

Power Skills, as well as to ensuring learners engage in truly authentic problems. We will continue to explore how STEAM inquiries can become transdisciplinary throughout this book.

PAUSE AND REFLECT

1. When was the last time you witnessed learners persevering as they sought a solution to a challenging issue?
2. How do you address the so-what question with your learners?
3. Name a time when you integrated mathematics into science instruction to make sense of a context (not just as a tool). Why?
4. In your own words, define *interdisciplinary learning* and *transdisciplinary learning*.

TRY IT YOURSELF!

- Stop now and consider strengths and barriers you face to creating high-quality STEAM experiences for learners. Share out with a STEAM partner!

NEXT STEPS

Continue this STEAM journey with us as we explore the following questions in Chapter 2: What should be the focus of my STEAM teaching? Who should I involve? We will investigate strategies for targeting key mathematics and science learning outcomes while building in relevant technology and the arts to complement the engineering process. We will also consider potential partners with whom you will collaborate to support learning in STEAM.