Minnesota K–5 STEM/STEAM Guidance

Introduction

Science, Technology, Engineering, and Math (STEM) education has been a topic of conversation in K–5 education for almost 20 years. Integrated STEM experiences are a way of bringing real-world contexts into the classroom to provide greater connections to what happens in school. These experiences prepare students with important skills and strategies to solve some of the world's biggest challenges. MDE has deliberately chosen to focus on STEM + the Arts (STEAM) to benefit from the additional disciplinary skills and content that the arts bring to the table. Many of the ideas in this guide can also be applied to STEM programs and experiences.

MDE believes that there is no "one right way" of designing and implementing STEAM programming—it should reflect community values and the context or unique culture of the school. While no two STEAM programs will look the same, there are some fundamental aspects and components that quality K–5 STEAM programs share. This guide outlines what those are in Minnesota. It is important that STEAM experiences are accessible to all students and are created in an atmosphere that cultivates the cultural, social, and emotional well-being of all children. All programs should be student-centered, developmentally appropriate, rooted in culturally responsive/sustaining teaching practices, and guided by the Minnesota Academic Standards. Best practices in instruction should be used, including the Universal Design for Learning (UDL) framework to ensure all students have access to engaging STEAM experiences.

Purpose and Audience

This STEM/STEAM guidance document was created in response to needs expressed by teachers and administrators across Minnesota. Although STEM and STEAM schools, programs, and educational experiences have existed across the state for a long time, there hasn't been a comprehensive resource that districts, schools, and educators could reference. This guide provides a big-picture overview of STEAM, including the components that make up high-quality STEAM programs and experiences.

This guide includes two considerations when developing STEAM programs and experiences. The considerations are big ideas in STEAM education that help set the stage to address more specific features of STEAM programs and experiences. They will help educators think about resources and systems needed in a STEAM program.

STEAM can happen anywhere. This guide was created primarily for K–5 teachers who have been asked to teach a STEAM course or who are interested in incorporating STEAM experiences in their classrooms. It is also for K–5 instructional leaders, school principals, and/or district leaders who are new to leading a STEAM program or are starting a new STEAM program. This guide can be used to review a current program or plan new K–5 STEAM

experiences, classes, or schools, and the ideas can be applied or adapted to different contexts as well. This guide is designed to be used in conjunction with the following documents:

- Features of High-Quality STEAM Instruction (for Teachers and Instructional Leaders)
- Features of High-Quality STEAM Programs (for School and District Leaders)

STEM vs. STEAM

Integrated STEAM braids together five discrete content areas: science, technology (computer science), engineering, the arts, and mathematics. The following definitions summarize each of the STEAM content areas:

Science

Science is the process of exploring and explaining the processes, structures, designs, and systems that make up our natural and human-made world. In science, all students engage in practices including making observations, developing and revising models, and analyzing and interpreting data to answer scientific questions and design solutions to problems. Scientifically literate classroom communities make observations of the world around them, design investigations to answer questions, make connections between ideas across the science disciplines, and solve problems using technologies for an ever-changing world.

Technology (Computer Science)

MDE is deliberately including computer science as the technology component of STEAM. Computer science is the study of computers and algorithmic processes, including their principles, hardware and software designs, implementation, and impact on society. Computer science education should focus on teaching students how to think computationally and create new technologies, not simply on how to use technology.

Engineering

Engineering education at the elementary level is all about helping students learn how to solve problems by designing, building, testing, and improving solutions—just like real engineers do. It's hands-on, creative, and grounded in real-world challenges that matter to kids.

The Arts

In the arts, students build artistic literacy in an art form by applying foundational knowledge and skills while working in four processes fundamental to the arts: creating, responding, performing/presenting, and connecting. The Minnesota K–12 Academic Standards in the Arts include five arts areas: dance, media arts, music, theater, and visual arts.

Mathematics

Mathematics is the study of patterns and relationships. The goal of mathematics education is to prepare each and every student for effective participation in society, including in their career(s), post-secondary education, and daily decision-making about everything from finances and personal health to civic discourse and policymaking. It also develops a student's ability to comprehend and analyze data. All students should learn

mathematics "in order to expand professional opportunities, understand and critique the world, and experience the joy, wonder and beauty of mathematics" (National Council of Teachers of Mathematics [NCTM], 2018).

STEM and STEAM

STEM is an instructional approach that provides intentionally designed and integrated learning experiences for students to develop and apply understandings of science, technology, engineering, and mathematics practices and processes. STEAM builds on STEM by adding the arts into the picture. In integrated STEAM experiences, the arts—whether it's visual arts, music, dance, theater, or media arts—emphasize creativity, emotion, empathy, communication, critical thinking, and personal or cultural expression. The arts can help students connect more deeply to the content and to each other. Integrated STEAM education is intended to equip students with important skills and strategies to solve real-world problems. These skills and strategies, sometimes called "21st century skills" or "durable skills," include things like creativity, communication, leadership, collaboration, critical thinking, etc. Integrated STEAM experiences and programs should also leverage the Minnesota Academic Standards.

Integrated STEAM doesn't mean all of the subjects need to be included in every single experience or project. It's about finding natural connections between them and designing learning experiences that are purposeful, engaging, and authentic. Both STEM and STEAM use project-based and/or problem-based learning that focuses on the process and not the end product. The goal of these experiences is for students to see themselves as thinkers, creators, and problem-solvers and to gain skills and knowledge in identifying, analyzing, and solving complex problems. These big-picture outcomes should drive how and why STEAM subjects are integrated.

Consideration #1: Complexity and Frequency of Content Integration

STEAM is a way to provide students with real-world integrated experiences aligned to the Minnesota Academic Standards and should not be used as a replacement for learning in the arts or stand-alone science, math, and computer science courses/content.[1]

When integrating multiple content areas, it's important to consider how deeply students will engage in each content area. Looking at arts integration models can serve as a template for thinking about this. Figure 1: Arts Integration Continuum below shows how some models in arts integration compare in terms of complexity and how frequently they're typically done in schools. While this graphic focuses on the degree to which the arts are integrated in a learning experience, this relationship between frequency and complexity of integration holds true for all the content areas included in STEAM. A STEAM program should include a balanced mix of a range of interdisciplinary learning experiences, taking care to carve out time and resources for more complex and rigorous integration in addition to less complex experiences.

[1] Please see Current Arts Education Requirements: Standards, Credits and Courses for information about what arts education is required in Minnesota K–12 schools.

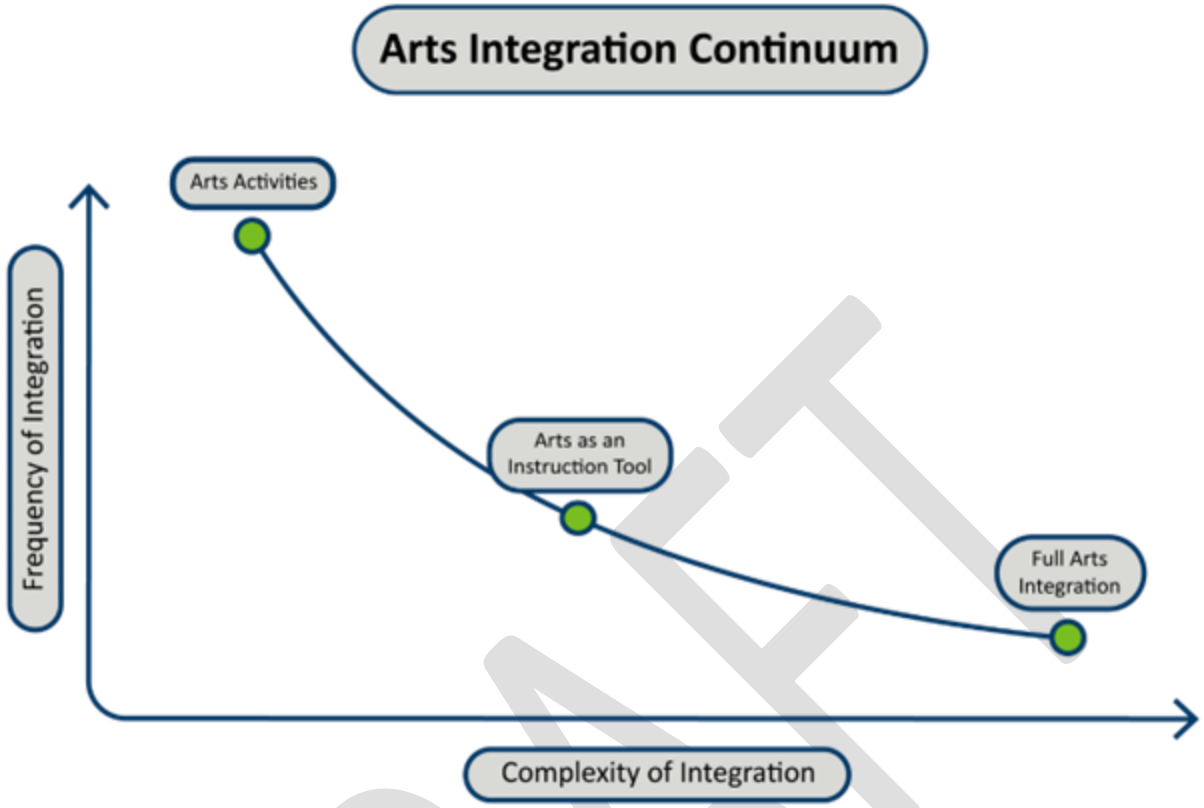

Figure 1: Arts Integration Continuum

Arts Activities – These types of activities can be done by any teacher and are a way to include arts in regular classroom work with a primary focus on increasing student engagement. Examples include illustrating a process as part of a math, science, or computer science lesson, drawing and labeling a model as part of a science or engineering lesson, singing a song to complete class routines, or taking a dance break to get the wiggles out.

Arts as an Instructional Tool – These types of activities include explicit instruction in the arts (and should be created with support from an arts specialist when available) to create products or use some of the arts processes as instructional strategies. The experience might even address some arts standards or benchmarks, although they are not typically assessed at this level.

Full Arts Integration – Often done in partnership between an arts specialist (when available) and an elementary generalist or in a co-teaching model, the experience addresses and assesses standards and benchmarks in all involved content areas, including the arts.

Consideration #2: Building Blocks of STEAM Programs

There are many ways that STEAM education can look and all approaches are valuable. The table below describes some of the building blocks of a STEAM program. When creating a STEAM program, it's important to select the

building blocks that address the needs of the school and community, considering school goals, teacher capacity, student access, and available resources.

Building Blocks	Description	Potential Benefits and Drawbacks
Individual Educators Doing STEAM Experiences	Every educator in the building is required to do a certain number of STEAM experiences during the year.	**Benefit:** Builds the capacity of all teachers in the school and can be deeper, project-based, standards-aligned experiences. **Potential pitfalls to avoid:** Students may not have consistent STEAM experiences across the school and requires teacher professional learning as well as time to build curriculum.
STEAM Specialist	A specialist visits every class on a rotation schedule.	**Benefit:** Every student is getting consistent STEAM experiences across the school. **Potential pitfalls to avoid:** Provides only a limited amount of time and doesn't automatically build the capacity of all teachers in the school (although this can be part of the role if planned for with intention).
Community Engagement	Individuals or community groups are invited to partner in developing, leading, and/or co-leading STEAM experiences.	**Benefit:** Creates community connections and buy-in and provides real-world connections for students. **Potential pitfalls to avoid:** Provides only a limited amount of time, doesn't build the capacity of teachers, and requires dedicated time and funds to plan experiences and build partnerships.

Afterschool STEAM Programming	STEAM experiences are scheduled during an afterschool program.	**Benefit:** Time and resources in afterschool programs can lead to richer STEAM experiences. **Potential pitfalls to avoid:** These programs are not accessible to all students, can be limited in the STEAM experiences they include, and likely are not aligned to state standards.

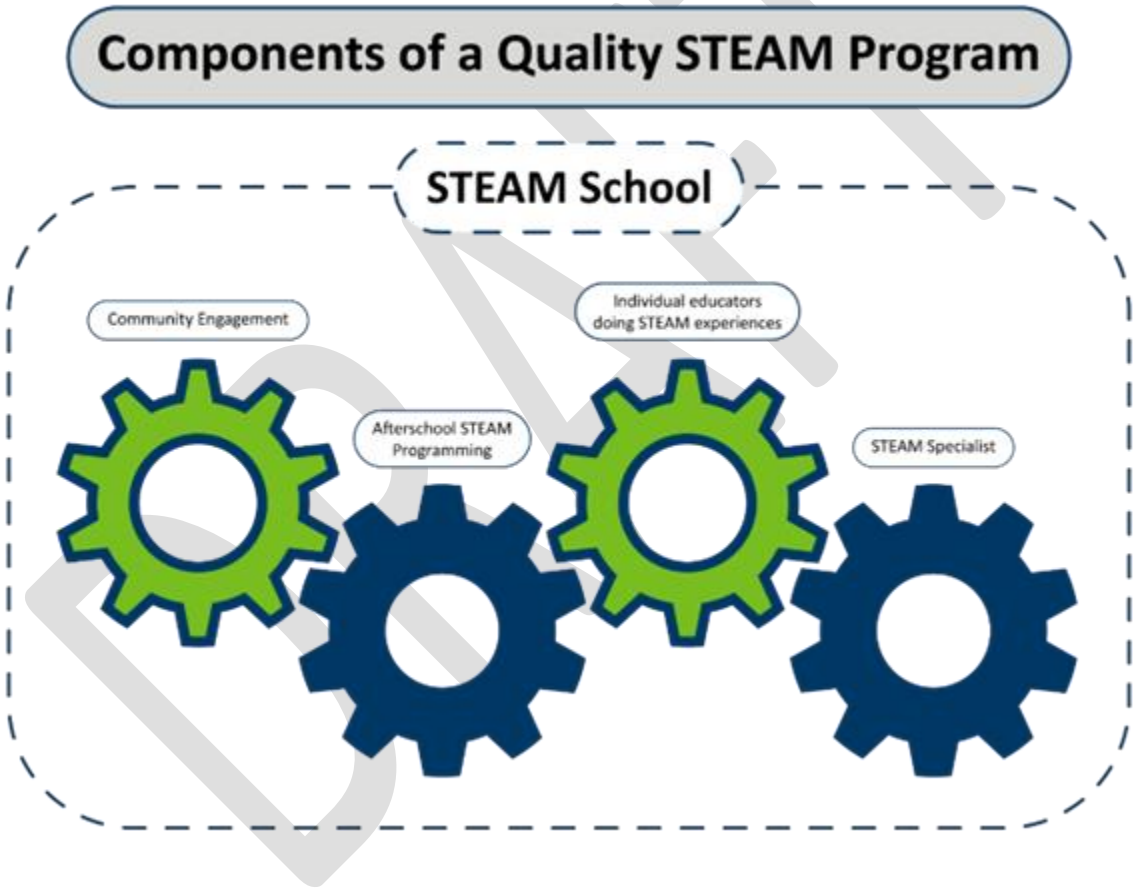

Figure 2: Building Blocks of a Quality STEAM Program

Additional Resources

- Features of High-Quality STEAM Instruction (for Teachers and Instructional Leaders)
- Features of High-Quality STEAM Programs (for School and District Leaders)
- STEM/STEAM Practices Sort Activity

- STEM/STEAM FAQ

References

"Arts Integration Continuum." Turnaround Arts, John F. Kennedy Center for the Performing Arts.

"Arts Integration." Perpich Center for Arts Education. https://perpich.mn.gov/professional-development/arts-education-resources/arts-integration/

Day, Kelly J. and Carol O'Donnell. "Teaching About Real-World, Transdisciplinary Problems and Phenomena through Convergence Education." Smithsonian Education. July 25, 2022. https://www.smithsonianmag.com/blogs/smithsonian-education/2022/07/25/teaching-about-real-world-transdisciplinary-problems-and-phenomena-through-convergence-education/

Hirsch, Amanda. "Transdisciplinary and interdisciplinary approaches." Center for Innovative Teaching and Learning. November 17, 2020. https://citl.news.niu.edu/2020/11/17/transdisciplinary-interdisciplinary/

"STEM Integration in K–12 Education." The National Academies of Sciences, Engineering, and Medicine. YouTube. March 6, 2014. Educational video. 3:30. https://youtu.be/AlPJ48simtE?si=ha9zgymTZeFaGkKJ

"What is STEAM Education?" Institute for Arts Integration and STEAM. https://artsintegration.com/what-is-steam-education-in-k-12-schools/

Inspiration provided by Georgia's Elementary STEM/STEAM Continuum, Nevada's STEM Framework, Ohio's Model for STEM and STEAM Schools, South Carolina's STEAM Implementation Continuum, Tennessee's STEM/STEAM Designation Guidebook, Wisconsin's STEM Reflection Tool, and the Minnesota Department of Education's Career and Technical Education STEM Framework.