AASL Standards-Based Learning

STEAM Activities in 30 Minutes

for Elementary Learners

Deborah Rinio

ALA Editions
CHICAGO | 2020

AASL American Association of School Librarians
TRANSFORMING LEARNING

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Deborah Rinio, PhD, is a former school librarian from Fairbanks, Alaska. She is currently an assistant teaching professor for the School Library Certification Program at Montana State University Bozeman and an adjunct instructor at the University of Alaska Fairbanks. She was a school librarian in elementary, middle, and high schools for the Fairbanks North Star Borough School District. She was on the AASL Standards and Guidelines Editorial Board that developed the *National School Library Standards.* She has served on various boards and committees including the ALA Policy Corps, Alaska Association of School Librarians, and Alaska Library Association. Her articles have been published in *VOYA, Knowledge Quest, School Library Connection,* and *School Libraries Worldwide.*

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ISBN: 978-0-8389-4680-0 (paper)

Library of Congress Control Number: 2019054059

Composition by Alejandra Diaz in the Utopia Std and Galano Classic typefaces.

℮ This paper meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).

Printed in the United States of America
24 23 22 21 20 5 4 3 2 1

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INTRODUCTION

Using a STEAM Approach in the Classroom and the School Library

STEAM education is a transdisciplinary approach to the curriculum that enables learners to make authentic connections with the knowledge, skills, and processes of an art form along with another subject area in science, technology, engineering, or mathematics. Both artists and scientists engage in an iterative process of exploration, creation, and analysis. They both engage in observation, discussion, and refinement as they practice their profession.

The STEAM approach is applicable to any elementary classroom. Classroom educators can collaborate with music educators to explore the science of sound or the mathematics of musical rhythms and patterns; educators can partner with another classroom educator to engage learners in creating science journals of local flora and fauna. Inherent in these practices and in a STEAM approach is a focus on inquiry, collaboration, and learner-driven exploration, three of the six Shared Foundations in the *National School Library Standards for Learners, School Librarians, and School Libraries*, making STEAM a perfect approach for the elementary school library. Although any elementary educator can use this book for ideas and inspiration on how to approach STEAM education in their classroom, school librarians are the primary audience. The school librarian can be found at the intersection of inquiry and exploration in the school, supporting all subject areas and grade levels.

Furthermore, a scaffolded approach is used in each activity. The average elementary school librarian sees every learner in the school, often in blocks of thirty to forty-five minutes. The school librarian must shift from one class to another, often with only a few minutes between classes. School librarians may find themselves working with a class of kindergartners, immediately followed by a group of fifth graders, with no break before a class of second-grade learners. To accommodate such a schedule, which makes planning for hands-on activities difficult, the activities in this book were written so that the same activity, with the same (or very similar) materials, can be used either throughout the day with all learners or with one specific group of learners.

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For example, in the activity "Coding with Cups: Designing a Structure Using Code," all learners use paper cups to build a structure and write a simple algorithm so that another group of learners can replicate the design using only the code. Kindergarten through second-grade learners write a simple arrow-based code, whereas third- and fourth-grade learners add the idea of replication in the design of their code, and fifth- and sixth-grade learners add the idea of loops to their code. Each set of learners engages in the same activity but at a greater level of complexity or cognition.

As learners engage in the inquiry and design processes, the path they follow may involve twists and turns. Inquiry is rarely linear, and true inquiry involves flexibility, allowing learners to determine the question or problem, the method for answering the question or solving the problem, and the ultimate conclusion or product. Given only thirty minutes, learners cannot engage in the full inquiry process, but they can be encouraged to engage in specific portions of the process, such as asking questions, using evidence to answer questions, sharing products, and reflecting on the process. Along the way, they will need to test and refine their ideas. In order to effectively engage in an iterative process, a growth mindset is needed.

Learners with a growth mindset will acknowledge "failures" as learning opportunities and necessary steps in the process, in contrast to learners with a fixed mindset who view failure as an identity. A person with a growth mindset might say, "The prototype failed," whereas a person with a fixed mindset might say, "I failed." This distinction becomes important because it has links to an individual's level of persistence, willingness to take risks, and likelihood of asking for help. For example, learners who have a fixed mindset might be afraid to ask for help because they perceive it as reinforcing their lack of intelligence or ability.

Fortunately, research shows that mindset can be shaped (Dweck, 2016; Good, Aronson, and Inzlicht, 2003; Smith, Brumskill, Johnson, and Zimmer, 2018). Chapter 2, "Applying a Growth Mindset," provides research and guidelines for fostering a growth mindset in our learners and ourselves. Additionally, growth mindset tips are provided within each activity. Encouraging learners to think of their skills and abilities as mutable not only is helpful in guiding them through the inquiry and design processes but also helps meet many of the Competencies in the Grow Domain within the *National School Library Standards*.

With the release of the *National School Library Standards for Learners, School Librarians, and School Libraries* (American Association of School Librarians [AASL] 2018), a need for lesson plans aligned to the new standards emerged. The six Shared Foundations of the *National School Library Standards*—Inquire, Include, Collaborate, Curate, Explore, and Engage—seem a natural fit for STEAM activities and lessons. True STEAM experiences involve the teaching of standards from at least two disciplines. In this book, the *National School Library Standards,* the Next Generation Science Standards, and the National Core Arts Standards are used as the

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basis for each activity. For educators seeking further STEAM or STEM collaboration opportunities, AASL also developed a *National School Library Standards* crosswalk with the Next Generation Science Standards, available through the AASL Standards web portal at standards.aasl.org.

HOW TO USE THIS BOOK

To set the stage for the activities, part I of the book focuses on the research and rationale behind a STEAM approach (chapter 1) and a discussion of how to apply a growth mindset (chapter 2).

Part II includes fourteen activities evenly divided into two sections: "Thinking Like a Scientist" (chapter 3) and "Designing Like an Engineer" (chapter 4). Each activity in this book is designed to be completed in a thirty-minute class period. The scientific principles addressed in these lessons are complex. In this short period, learners will not gain mastery in these concepts. Instead, view these activities as starting points or steps along the path toward understanding these topics; each activity is a starting point, not a destination.

Part III provides ideas and suggestions for educators who wish to write their own scaffolded lesson plans (chapter 5), collaborate with other educators in their school community (chapter 6), and assess learners' growth (chapter 7).

Activity Elements

The activities are divided into two categories: thinking like a scientist and designing like an engineer. The activities in the "thinking like a scientist" chapter rely primarily on the inquiry process. Learners are encouraged to ask questions, design and conduct experiments, and think critically about the world around them. The activities in the "designing like an engineer" chapter rely primarily on the exploration and design processes. Learners are encouraged to engage in iterative design and in trial and error testing and to think creatively.

Each activity includes the following components:

Essential Question. The essential question is a fundamental question used to guide the instruction across all grade levels. The question, like the standards, will not necessarily be answered fully over the course of the activity. However, it should be used as a guidepost for where the activity is going. If the activity is thought of as one piece of a larger unit, the essential question could be the goal for the unit as a whole.

Science Background for Educators. The "Science Background for Educators" section in each activity is intended to provide basic content for educators who are unfamiliar with the STEAM concepts in the activity. This content can also be shared with learners when developmentally appropriate and relevant to the curriculum.

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National Standards. Each activity includes standards that align to the *National School Library Standards,* using the *AASL Standards Framework for Learners* (AASL 2018), the Next Generation Science Standards (National Research Council 2013), and the National Core Arts Standards (State Education Agencies Directors of Arts Education [SEADAE] 2015). Remember that each standard or competency is complex. No single standard is intended to be taught and mastered in a thirty-minute period. Learners need repeated exposure and practice for mastery.

Materials. Materials are designed to be inexpensive or easy to obtain through donations (e.g., empty plastic bottles, rubber bands, etc.). Quantities of each material needed are indicated, along with potential alternative materials where appropriate.

Scaffolded Exploration. Activities are scaffolded into three grade-level bands: kindergarten through second grade, third and fourth grades, and fifth and sixth grades. This particular breakdown is based on learners' developmental ability to engage in different types of activities. However, educators know their learners best. It is up to each educator to decide how to implement the activity and with what grade-level learner. For example, steps for kindergarten through second grade might be more appropriate for a particular group of third-grade learners, or the third- and fourth-grade activity might be something that second graders can easily obtain. Feel free to utilize activities in this way. Educators should make the activities work for them and their learners.

Assessment. Formative assessment ideas are provided for each activity to help ensure learner growth. Additional formative assessment ideas are available in chapter 7, "Assessing Learners' Work."

Technology Integration. Access to technology in school libraries and classrooms is variable, and young learners often require additional time because they need more instruction in the use of a specific tool. Therefore, the lesson plans in this book do not require technology. However, it is recognized that effective use of technology can offer learners the opportunity to examine authentic problems, complete more complex STEAM projects, and gain a better understanding of STEAM concepts.

The technology integration sections are designed to use technology in meaningful ways that extend STEAM and inquiry-based learning, as opposed to a substitution for textbook-style instruction. To that end, the technology integration exploration in each lesson plan is designed to be used in conjunction with the activity as a means of engaging learners with technology-based skills and applications while still meeting the content and skill goals of the activity. Each exploration integrates with the activity at a different stage (before, during, or after) as described in the exploration itself.

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The technology integration exploration requires the use of Google Sheets, which is universally accessible and free to use. However, an educator could easily adapt the activities for use with Microsoft Excel or another spreadsheet software. Depending on computer availability and learner skill level, the technology integration exploration can be done as a whole-class, small-group, or independent activity. One technology integration idea is provided for each grade-level band within each activity. Educators should choose the one that works best for them and their learners or create their own.

An appendix toward the end of the book provides instructions for how to use each element of Google Sheets necessary to complete the technology integration explorations. At the end of the appendix is an Element Location Chart that indicates the activities in which each Google Sheet element is used.

Suggested Picture Books. The suggested picture books section in each activity can be used to provide context and background for the activity or as extensions to the activity. They are not intended to be read and discussed in the same thirty-minute period as the activity but should be done at a separate time. Of course, if time allows, they can certainly be used as a method of introducing learners to STEAM concepts before beginning the activity itself. The recommended age level is a starting point, but all books can be used with any group of learners. Conversation starters are included to help learners think critically and make connections between the concepts in the book and the activity.

References and Nonfiction Resources. References and nonfiction resources can be used to locate additional scientific background for educator and learner.

Remember that in addition to learning STEAM content knowledge, learners are developing skills in the six Shared Foundations of the *National School Library Standards* (AASL 2018). Giving learners the opportunity to practice Inquiry, Inclusion, Collaboration, Curation, Exploration, and Engagement in different content areas will help them improve their skills and see the value of these skills across content domains.

Whether you use every chapter of this book or just a few, the hope is that this book will inspire you to create opportunities to engage in STEAM practices, a growth mindset, and classroom educator and school librarian collaboration now and in the future.

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PART I

Understanding STEAM and Its Role in the Elementary School Library

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CHAPTER 1

Why STEAM?

STEM stands for Science, Technology, Engineering, and Mathematics and reflects a curriculum that puts special emphasis on inquiry-based learning. Learners engaging in a STEM curriculum are asked to solve problems and design solutions using STEM disciplines. In a STEAM approach to the curriculum, the arts are integrated into the STEM instruction. The arts are used to demonstrate understanding and construct meaning in the art form in question as well as a STEM subject area. Learners might use art to better understand STEM or use STEM to explore art.

With a STEAM approach, learning can take place through any artistic medium that uses creativity. Through this process, learners make authentic connections with the knowledge, skills, and processes of both the art form and another subject area. For example, in the activity "Making Dye: Examining Color," learners engage in the scientific method, learn about solutions, and practice the art form of dyeing fabric (in this case, thread). As a result of making the connections between the subject discipline and the art form, learners are able to make deeper connections to both sets of concepts.

Additionally, art provides a medium by which learners can visually and concretely process what might otherwise be abstract scientific knowledge. Young children (seven to eleven years of age) are still in the concrete operational stage of development (Inholder and Piaget 1958), which means that they depend on concrete mental operations and are unable to manipulate ideas mentally without the use of external tools such as illustrations, models, and manipulatives. For example, in the activity "Making a Tissue Box Guitar: Exploring Sound," learners use music to conceptualize pitch and wavelength by making a model in a way that makes an abstract concept more accessible for elementary-age learners.

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A variety of skills used by both scientists and artists are not often taught explicitly in K–12 science instruction. These skills include the ability to draw on curiosity, to observe and then accurately express one's observations, to construct meaning from one's observations, to work effectively with others, to think spatially, and to think kinesthetically (Sousa and Pilecki 2012). These skills are common to both art and science and, thus, are more likely to be explicitly addressed in a STEAM approach to the curriculum.

THE VALUE OF THE ARTS

The arts, regardless of their position in the curriculum, play a natural role in the lives of young people. Much of what children do when they play is a natural form of art—singing, drawing, and dancing all engage the senses. These acts help create neural networks needed for successful learning. Visual-spatial areas of the brain are developed as children draw and finger paint. Singing and rhyming impact auditory, visual, and cognitive functions. Dancing and movement help develop gross motor skills. Music and color play roles in memory retention, such as learning the alphabet song or using different colors to remember the various states in the United States. Overall, these experiences contribute to emotional and academic well-being because learners are led to realize the different ways people express emotions and ideas (Sousa and Pilecki 2012).

The arts, like each component of STEM, are often thought of as separate subjects (visual arts, dance, music, etc.). Each art form has a discrete set of skills and knowledge that make it its own discipline. However, just like science, technology, engineering, and mathematics, the arts share a common set of cognitive behaviors. When taught explicitly, the arts can enable learners to develop knowledge, skills, and dispositions that help prepare them for college, career, and life.

In his article "What the Arts Do for the Young," Elliot Eisner (2002) laid out three reasons that art education should be prevalent in our nation's schools: shaping human form, creating meaning, and developing thinking. At the heart of his argument is the idea that the arts enrich the human experience. Art education helps learners to both experience and frame the senses into aesthetic forms, which produce emotional satisfaction. Although this type of satisfaction can be found in other experiences, such as observing the aurora or scoring a goal during a sports game, arts education asks learners to take note of these ideas and examine them in a conscious way—to learn how to observe them and also to create them. Not all learners will be able to express their ideas through art effectively, but being able to "read" the images and ideas in art enables us to use art to give voice to our feelings, "and with this voice the arts make forms of meaning possible that would otherwise remain mute" (p. 16).

Visualization is also an important concept in scientific thinking (Graham and Brouillette 2016). Scientists utilize models, diagrams, graphs, and visual images in

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the process of making discoveries. Learners may develop their observation skills by sketching in science notebooks or exploring a model of the water cycle to understand how water changes states. With guidance, even the youngest learners can create simple bar graphs to collect and analyze data—for example, a graph of birthdays by month. When learners create these sorts of visualizations, educators can use the results for formative assessment and identification of learners' misconceptions.

Studies examining arts integration have shown relationships between academic achievement and arts education (Hetland and Winner 2004), improvement in science and writing test scores (Catterall, Dumais, and Hampden-Thompson 2012), and increases in learners' long-term retention of content (Rinne, Gregory, Yarmolinskaya, and Hardiman 2011). For example, most of us are familiar with how music can help young learners remember information, such as learning the alphabet through song.

Similarly, in a study of nine, hour-long art–physical science lessons, Graham and Brouillette (2016) tested three models of education: (1) an educator in an isolated classroom using a STEAM approach, (2) a classroom educator and an art educator working in collaboration, and (3) a traditional classroom. The researchers found that learners performed better on science benchmarks when educators used model 1 or 2—in other words, when a STEAM approach was used.

CREATIVITY AND CRITICAL THINKING

One of the components of art that we naturally think of is creativity. In reality, creativity is a complex idea that is often hard to quantify and is not relegated to the arts alone. One study compared the brains of professional jazz pianists as they played memorized music and improvised music. When the pianists were playing extemporaneously, the areas of the brain associated with individuality and self-expression were more active, and the areas of the brain associated with inhibition and self-regulation were less active. The more creative the musician, the less inhibited and focused that musician was (Limb and Braun 2008). In other words, by letting go of their inhibitions, the musicians were able to be more creative.

The arts promote this sort of creativity through the development of both subtle and complex forms of thinking by asking learners to make judgments in the absence of a rule, to evaluate and express opinions on an idea that has no right or wrong answer. This type of thinking is often undervalued in our schools, and yet life is filled with these sorts of situations, such as deciding which house to purchase or writing a review of a product. Both of these examples involve making decisions based not only on logic but also on personal opinion in the absence of a specific rule. You aren't wrong just because someone doesn't like your house or agree with your movie review. However, traditional schoolwork often focuses learners on right or wrong answers instead of answers that are multifaceted and complex.

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It's helpful to consider the two main types of thinking that people engage in when solving problems: convergent and divergent. Both types of thinking are present in STEAM fields. In convergent thinking, there is a piecing together of various bits of information to arrive at a single correct answer to a problem. Learners engage in convergent thinking when they are testing or calculating with defined outcomes. For example, a learner might be asked to find the wavelength of a particular frequency, test which of three different materials will produce the strongest bridge (with all other factors being the same), or calculate the density of an object after measuring its mass and volume.

In contrast, divergent thinking involves breaking a problem down into its component parts to investigate all possibilities and emerge with a solution. For example, in the activity "Building a Flashlight: Looking at Circuits," learners are asked to build a flashlight using common household items. Although there are multiple ways to approach the problem that will not produce light, there is no single, correct solution to this problem.

Both types of thinking are valid and necessary and will be engaged in during authentic inquiry. The engineer who uses convergent thinking to determine the strongest material for a bridge will use divergent thinking to produce several different designs that appeal to the aesthetic and usage demands of the community in which the bridge will be placed.

Jauk, Benedek, and Neubauer (2012) demonstrated greater brain wave activity associated with divergent thinking than with convergent thinking. This finding suggests that divergent tasks are more challenging, causing the brain to make new connections between neural networks, which increases creativity and improves one's ability to engage with complex and challenging problems (Takeuchi et al., 2010).

Schools, however, often focus primarily on convergent thinking. Standardized tests, for example, require a single, correct answer to a problem; yet, to foster critical thinking in learners, educators must provide experience with creativity and originality, which involves divergent thinking. In most U.S. schools, science curriculum is focused on carrying out experiments and solving problems for which the outcome is already known. Learners are not given opportunities to collect evidence, ask questions, or seek out possible answers (Sousa and Pilecki 2012).

Further, although activities that ask learners to engage in divergent, critical, or creative thinking are beneficial to the development of their skills, abilities, and dispositions, it is not uncommon for both learners and educators to be unfamiliar with this type of activity, or fail to recognize that it will require more time or effort than they are willing to expend. Yet studies show that learners demonstrate information-processing and creative-thinking skills at a much greater extent in inquiry-driven classrooms as opposed to traditional (textbook-centered) classrooms, as well as demonstrating a more positive attitude toward science classes and science educators (Yager 2007).

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SHARED COMPETENCIES

In addition to a basic understanding of how the arts and sciences can be melded in inquiry-driven instruction, it is useful to examine the standards of each component part of the lesson and to see how they are similar or different. The competencies of art education often parallel the Shared Foundations of the *National School Library Standards* (AASL 2018), as well as the practices and crosscutting concepts in *A Framework for K–12 Science Education* that formed the basis of the Next Generation Science Standards (National Research Council 2012). Seeing how the various goals and concepts of these distinct units overlap can be useful in designing, implementing, or justifying STEAM lessons in your school library or classroom.

Shared Foundations

Six Shared Foundations and their Key Commitments form the backbone of the *National School Library Standards:*

- **Inquire:** Build new knowledge by inquiring, thinking critically, identifying problems, and developing strategies for solving problems.
- **Include:** Demonstrate an understanding of and commitment to inclusiveness and respect for diversity in the learning community.
- **Collaborate:** Work effectively with others to broaden perspectives and work toward common goals.
- **Curate:** Make meaning for oneself and others by collecting, organizing, and sharing resources of personal relevance.
- **Explore:** Discover and innovate in a growth mindset developed through experience and reflection.
- **Engage:** Demonstrate safe, legal, and ethical creating and sharing of knowledge products independently while engaging in a community of practice and an interconnected world.

Science and Engineering Practices

A Framework for K–12 Science Education served as the blueprint for the Next Generation Science Standards (NGSS). The document identified eight practices of science and engineering that reflect the inquiry and discourse practices that learners must engage in alongside content knowledge in order to fully understand scientific and engineering ideas.

1. **Asking Questions (for Science) and Defining Problems (for Engineering):** Learners should be able to ask questions about their readings, observations, and conclusions. They should be able to define problems and seek out information necessary to determine constraints and parameters of working toward a solution.

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2. **Developing and Using Models:** Modeling includes the creation of diagrams, replicas, mathematical representations, and computer simulations. Models represent a system or parts of a system and thereby enable learners to ask questions, suggest explanations, make predictions, and communicate ideas.
3. **Planning and Carrying Out Investigations:** Investigations are used to describe a phenomenon, test a theory or model, or compare varying solutions to an engineering problem. Learners engaged in an explanation will identify the goal of the investigation, make predictions, collect data, and use data to support conclusions.
4. **Analyzing and Interpreting Data:** Once data are collected, learners must know how to present those data in a form that will reveal relationships and patterns, and effectively communicate results to others.
5. **Using Mathematics and Computational Thinking:** Mathematics is used to represent physical variables and their relationships. Learners might use computers or digital tools to observe, measure, record, and process data.
6. **Constructing Explanations (for Science) and Designing Solutions (for Engineering):** The goal of science is to construct explanations for various phenomena, while the goal of engineering is to solve problems. Learners will use models they have created or data they have collected to effectively make a claim or design a solution.
7. **Engaging in Argument from Evidence:** Argument is a necessary part of science and engineering, as it enables the best explanation for a phenomenon or the best design for a problem to emerge. Learners must use argumentation to compare and evaluate solutions.
8. **Obtaining, Evaluating, and Communicating Information:** Being able to read, interpret, and produce scientific and technical writing is fundamental to science. Learners must be critical of the information they read and communicate their own ideas effectively.

The Eight Competencies of Arts Education

In 2002, Elliot Eisner of Stanford University identified eight competencies of arts education. Sousa and Pilecki (2012) reenvisioned these eight competencies through the lens of a STEAM-focused curriculum. Further exploration reveals how the AASL Standards and the NGSS Science and Engineering Practices often parallel these competencies in practice (table 1.1).

1. **The perception of relationships.** When learners create a work of art in music, words, or another discipline, it helps them to see how pieces come together to form a whole. In the sciences, this skill enables a researcher to see how one part of an ecosystem affects other parts of the system (NGSS Practice: Analyzing and Interpreting Data). In information literacy, this competency often results in knowledge that forms the basis for new meaning and sparks curiosity (AASL Shared Foundation: Explore).

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2. **An attention to nuance.** A learner who wishes to excel in the arts will learn that small differences can make a large impact in the final product. For example, a learner creating a visual representation (painting, sculpture, etc.) must make decisions about form, color, and style that will impact the work. In writing, this competency applies to the use of language needed for metaphor, allusion, innuendo, and the like (NGSS Practice: Obtaining, Evaluating, and Communicating Information). An engineer designing a bridge, for example, may need to take these same ideas into consideration to ensure that the bridge not only is structurally sound but meets the aesthetic needs of the community (AASL Shared Foundations: Inquire and Explore).
3. **The perspective that problems can have multiple solutions and questions can have multiple answers.** Unfortunately, schools too often focus learning on finding a single right answer. In reality, almost anything can be approached in multiple ways. In science, and in life, difficult problems require the exploration of multiple options from varying perspectives. There is rarely one right answer to a given problem (NGSS Practice: Constructing Explanations and Designing Solutions). Instead, individuals must realize the positive and negative consequences of their actions. A food scientist, for example, may be exploring how to reduce pest impact on crops; each option from pesticide use to genetic modification of the crops has positive and negative consequences that must be considered. To explore multiple solutions and explanations, a learner must also interact with diverse opinions and contribute to discussions in which multiple viewpoints on a topic are expressed (AASL Shared Foundations: Inquire and Include).
4. **The ability to shift goals in process.** Schools often oversimplify the process of discovery, which is not always linear. Although learners should be able to design and carry out a plan of inquiry, the process itself is often murky and unknown because new knowledge and curiosity can shift learners' paths and guide them down new avenues of investigation (AASL Shared Foundations: Inquire and Explore). A scientist who begins an experiment, only to encounter surprising results, may end up shifting the investigation to new avenues (NGSS Practice: Planning and Carrying Out Investigations). For example, the microwave oven was invented by accident when Percy Spencer, while testing a new vacuum tube for a radar project, discovered that a chocolate bar in his pocket melted faster than he expected. His curiosity was piqued. He began to experiment with the vacuum tube, and, after extensive investigation, the microwave oven was born.
5. **The permission to make decisions in the absence of a rule.** Although there are times and places for specific rules and processes, there are often times when individuals must use their best judgment to determine if something has been done well, is complete, or meets the specified requirements. This sort of judgment occurs in science when scientists "defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers

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in searching for the best explanation for the phenomenon being investigated" (National Research Council 2012, 52; NGSS Practice: Engaging in Argument from Evidence). In the inquiry process, learners make judgment calls when they use reflection to guide informed decisions and iteratively respond to challenges (AASL Shared Foundations: Include and Collaborate).

6. **The use of imagination as the source of content.** In the arts, imagination is critical to the process because an artist will use imagination to visualize situations and then make the best decision for the task at hand. In inquiry and the sciences, this sort of imagination fuels the curiosity that results in questions that ultimately lead to sustained inquiry (NGSS Practice: Asking Questions and Defining Problems; AASL Shared Foundations: Inquire and Explore).
7. **The acceptance of operating within constraints.** Within the arts, an individual is often constrained by a specific medium, such as paint, clay, sound, or movement. Artists work to use the constraints of their medium to invent new ways of interacting with content. Similarly, scientists develop and use models to explore understandings. Within the models and simulations they create, scientists can explore a variety of concepts and test hypotheses (NGSS Practice: Developing and Using Models). Whether used in art or science, or another discipline altogether, the inquiry process requires that learners question and assess the validity and accuracy of information (AASL Shared Foundations: Explore and Engage). These operating constraints—in art, science, and inquiry—can be seen as hindrances but also as opportunities to engage in creativity and investigate the possibilities offered within the given constraint.
8. **The ability to see the world from an aesthetic perspective.** Experience in the arts can help learners to see the world in new ways, such as the poetic nature of music, or the design of a building. Although the sciences do not help people see the world from an aesthetic perspective, they do encourage the use of scientific thinking in the form of analyzing and interpreting data, which involves identifying the significant features and patterns of the data (NGSS Practice: Using Mathematics and Computational Thinking). Similarly, learners engaged in inquiry will "[adopt] a discerning stance toward points of view and opinions expressed" (AASL 2018, Learner II.A.2.), enabling them to look at the world in new ways (AASL Shared Foundation: Include).

In addition to the eight competencies of art education (Eisner 2002), connections can be drawn to the National Core Arts Anchor Standards (SEADAE 2015):

- **Creating:** Conceiving and developing new artistic ideas and work.
  - Anchor Standard 1. Generate and conceptualize artistic ideas and work.
  - Anchor Standard 2. Organize and develop artistic ideas and work.
  - Anchor Standard 3. Refine and complete artistic work.

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TABLE 1.1

Alignment of Eisner's competencies of art education, NGSS Science and Engineering Practices, and AASL Shared Foundations

Competencies of Art Education	NGSS Science and Engineering Practices	AASL Shared Foundations
The perception of relationships	Analyzing and Interpreting Data	Explore
An attention to nuance	Obtaining, Evaluating, and Communicating Information	Inquire, Explore
The perspective that problems can have multiple solutions and questions can have multiple answers	Constructing Explanations (for Science) and Designing Solutions (for Engineering)	Inquire, Include
The ability to shift goals in process	Planning and Carrying Out Investigations	Inquire, Explore
The permission to make decisions in the absence of a rule	Engaging in Argument from Evidence	Include, Collaborate
The use of imagination as the source of content	Asking Questions (for Science) and Defining Problems (for Engineering)	Inquire, Explore
The acceptance of operating within constraints	Developing and Using Models	Explore, Engage
The ability to see the world from an aesthetic perspective	Using Mathematics and Computational Thinking	Include

- **Performing, Presenting, Producing**
  Performing (dance, music, theatre): Realizing artistic ideas and work through interpretation and presentation.
  Presenting (visual arts): Interpreting and sharing artistic work.
  Producing (media arts): Realizing and presenting artistic ideas and work.
  - Anchor Standard 4. Select, analyze, and interpret artistic work for presentation.
  - Anchor Standard 5. Develop and refine artistic techniques and work for presentation.
  - Anchor Standard 6. Convey meaning through the presentation of artistic work.

- **Responding:** Understanding and evaluating how the arts convey meaning.
  - Anchor Standard 7. Perceive and analyze artistic work.
  - Anchor Standard 8. Interpret intent and meaning in artistic work.
  - Anchor Standard 9. Apply criteria to evaluate artistic work.

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- **Connecting:** Relating artistic ideas and work with personal meaning and external context.
  - Anchor Standard 10. Synthesize and relate knowledge and personal experiences to make art.
  - Anchor Standard 11. Relate artistic ideas and works with societal, cultural, and historical context to deepen understanding.

As learners engage in well-designed STEAM activities, they will create, perform, produce, present, respond, or connect to art through the exploration of science, mathematics, and technology. For example, learners who design a bridge in an engineering challenge activity have the opportunity to connect to the artistic nature of the design in several ways. They can *create* an artistic idea in the design of the bridge. They might also *present* their bridge and share it with others. They might *respond* to the design of bridges as they study the form and *connect* the artistic nature of the bridge to historical bridge designs.

No matter what form the integration of art and STEM takes, learners who engage in an inquiry-driven model of instruction employ divergent, critical, or creative thinking that is beneficial to the development of their skills, abilities, and dispositions and that fosters a more positive attitude toward science. Utilizing a STEAM approach enables learners to creatively and concretely express scientific concepts through an artistic medium in a way that addresses science, art, and school library standards. When STEAM is used in the school library, learners interact with each other and with science content to think, create, share, and grow every day.

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