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CHAPTER 1

A Model for Application of Arts–STEM in Early Childhood Education

> Man is unique because he does science, and he is unique not because he does art, but because science and art equally are expressions of his marvelous plasticity of the mind.
>
> —Jacob Bronowski

LEONARDO DA VINCI: THE ARTIST WHO BECAME A SCIENTIST

Once upon a time there was a little boy who was separated from his parents. Undoubtedly, he was very sad and unhappy, but he did go to live with his grandparents and later with his uncle. His uncle loved nature and helped the little boy observe the birds carefully and notice how their wings worked. The young boy recorded the flight of birds, the plants he saw, the insects and their parts, the water and how it flowed. He drew pictures of all that interested him, and he tried to figure out how everything worked. A very curious learner, he was known to be a harp player and dancer, too. This boy later became an artist, scientist, and engineer. His approach toward science was based on his detailed observations and a point of view with roots in the artistic rather than the experimental realm. His name was Leonardo da Vinci (1452–1519).

The arts were a catalyst for Leonardo da Vinci to pursue his understanding of engineering and the sciences such as aeronautics, botany, and anatomy. They helped him develop an insatiable curiosity for how things worked. The arts, in the early childhood field—including creative movement, drama, visual art, and music—are often put into action through play and are used to express creativity. The use of creative arts is a way for children to communicate their imaginative thinking to others. Through the magic of play, children can become anyone and go anywhere in any time frame; they do this through role-playing and improvisations. They

learn to see things from another point of view, and their knowledge is dramatically increased when they interact with others. Children generally express themselves spontaneously in the arts by using their imagination and creativity. Encouraging such creative expression in our schools will open endless realms of new knowledge and exploration for children of all ages. However, when this type of open-ended exploration begins in the earliest grades, with the youngest students, it can truly become second nature and continue through the rest of their lives.

Advocacy for the arts is especially critical today because many school systems are cutting arts programs to provide "more time" for teaching basic literacy. According to Ken Robinson (2009), an internationally recognized leader in creativity, elevating certain subjects (such as literacy) over other subjects and requiring a precise amount of time for specific subjects each day can prevent children from receiving the diversity of experiences that they need for developing their creativity.

THE ARTS: A CATALYST FOR 21ST CENTURY SKILLS, STEM, AND DEVELOPMENTALLY APPROPRIATE PRACTICE

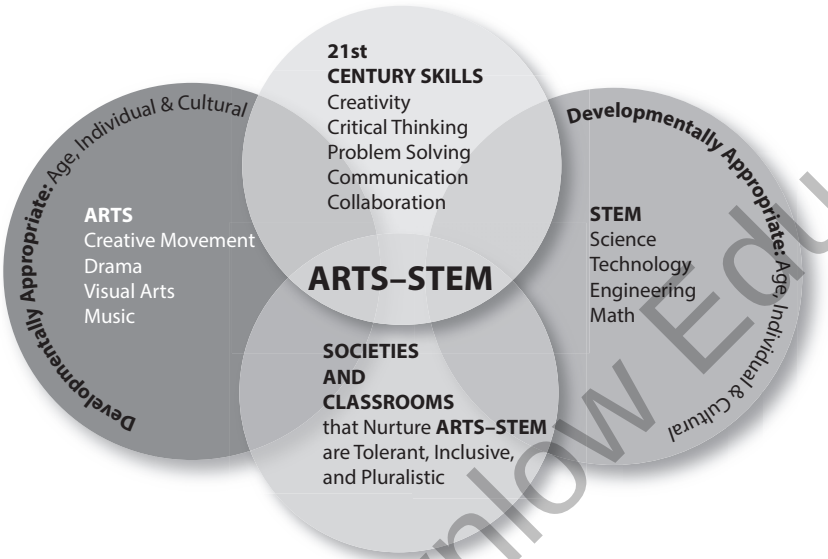
The arts are an effective way to communicate interests, feelings, and ideas to others, and they lay the foundations for creative thinking in math and science. Mathematics and science can be enhanced and expanded as children express their imaginative thinking. As children focus on their own interests, they often become intensely motivated to express themselves spontaneously through play by utilizing creative movement, drama, visual arts, and music.

The arts are connected to 21st century skills; to science, technology, engineering, and math (STEM); and to developmentally appropriate practice in unique ways that promote a synergetic effect for curriculum development in inclusive settings, as illustrated in Figure 1.1 and discussed below.

What Are 21st Century Skills?

Creativity is needed more than ever in our schools. Major reports on the skills that are needed for the future have been spurred by the Partnership for 21st Century Skills (2008, 2009), which is composed of large corporations, national professional organizations, and state offices of education. These organizations have expressed concern because they foresee a need that goes beyond what is presently emphasized in our schools. The reports emphasize the importance of creativity, critical thinking, and problem solving, as well as communication and collaboration, as skills needed for the 21st century. These skills are already nurtured in tolerant, inclusive, and pluralistic societies (Chua, 2007; Florida, 2007, 2012; Zhao, 2009) and are further discussed in Chapter 2. These skills are utilized in the arts as well as in the sciences, yet few sources have linked 21st century skills, the arts, and the sciences together. An examination of developmentally appropriate practice principles of child development and learning (Copple & Bredekamp, 2009)

Figure 1.1. A Model for Early Childhood Arts–STEM and Its Components Utilizing Developmentally Appropriate Practice



gives credence to a model that promotes an integrated approach based on cultural understanding. In this book my intention is to help the reader discover the Arts–STEM connection with 21st century skills and developmentally appropriate practice in an in-depth way so that the Arts–STEM movement can be practiced in early childhood at a more robust level.

Arts–STEM History and Emphasis

Innovation is the buzzword of the future because the world is moving into a creative conceptual age. According to Daniel Pink (2006), a conceptual age demands creativity, critical thinking, problem solving, collaboration, and communication with people of diverse backgrounds and thinking. The Arts–STEM connection has opened doors for artists and scientists to work together to produce innovative ideas and inventions for a global economy with diverse needs. This intersection has been called by various names, such as STEAM, STEM–Arts, ArtsSTEM, and TEAMS. It means an exchange between the arts (creative movement, drama, visual arts, and music) and STEM (science, technology, engineering, and math). These programs are scattered throughout the states. None are national programs, and very little has been done to promote them at the early childhood level in schools. However, it is in early childhood that interest in the STEAM fields starts to emerge, and the arts can be a catalyst for creativity in the fields of science, technology, engineering, and math. The arts are foundational to helping children express STEM concepts and dispositions (Piro, 2010; Sharapan, 2012).

The acronym STEM was first introduced by Judith Ramaley, assistant director of education and human resources at the National Science Foundation from 2001 to 2004. STEM has now become an important and integral part of education, due in large part to the America Competes Act (2007), which authorized federal funding for STEM initiatives. STEM has recently begun to appear in early childhood education literature (Counsell et al., 2016; Moomaw, 2013; Moomaw & Davis, 2010; Sharapan, 2012). The vision of STEM was that of recognizing real-world problems and giving students the tools to become the next generation of problem-solvers and innovators.

Because of the support for STEM in grants and the importance of innovation for our national economy, I believe that it is critical that an interdisciplinary connection to the arts be developed. This book is based on the thesis that the arts, particularly in early childhood, are an adjunct to and supporter of STEM. As such, it is incumbent upon teachers to recognize the connection to STEM as artistic endeavors take place. This book describes how such recognition unfolds. Throughout the text, the term Arts–STEM has been used rather than the commonly used STEAM in order to recognize the connections between the arts and each of the STEM disciplines.

In fact, there has been a movement from various sources to promote Arts–STEM in middle and high school, although the connection has not filtered down to early childhood in the same way. In one research project, students, ages 9 to 10, were trained to carefully observe pictures and reason about pictures in a museum setting. They were later asked to transfer to a similar task of looking at and reasoning about an image from the biological sciences. Their ability to complete the task presented clear evidence of the transfer of observational skills from art to science (Tishman, MacGillivray, & Palmer, 2002). The National Science Foundation is now funding science and art projects, such as the Learning Worlds Project (www.learningworldsinstitute.org), which emphasizes sciences and arts working together to promote scientific breakthroughs.

The STEM initiative is morphing into STEAM, according to Eger (2011). This idea was first expressed by Frans Johansson (2004) in the book *The Medici Effect*, and refers to the creativity enabled by the Medici family of Italy during the Renaissance. This was the time when Leonardo da Vinci grew up, and he would have been exposed to the arts and their importance in STEM. Johansson reports that during the Renaissance there was an intersection of different fields, cultures, and, ultimately, an explosion of new discoveries. These ideas have been reinforced by Weiner (2016). Many people think that the arts and sciences are mutually exclusive because the sciences are about knowledge and objectivity while the arts are about self-expression and nonobjectivity. In reality, there are many similarities between the two disciplines that draw on the creative processes. Collaboration of the arts and STEM in early childhood education may be the dawning of a new renaissance that provides a breakthrough of ideas, concepts, and cultures.

How Is Developmental Appropriateness Related to Arts–STEM and 21st Century Skills?

The National Association for the Education of Young Children (NAEYC) provides guidance on what constitutes research-based curriculum in several of its position statements, particularly on developmentally appropriate practice (DAP). It is important for directors, teachers, and principals to refer to DAP when choosing a curriculum. In thinking about the Arts–STEM approach, one should look at each of the DAP principles and contemplate how an Arts–STEM connection meets those principles. Especially noteworthy are the principles encompassing the following actions (Copple & Bredekamp, 2009):

- Exposing children to a wide range of teaching strategies and interactions in supporting all kinds of learning (Number 9, p. 14)
- Using play for developing self-regulation as well as promoting language, cognition, and social competence (Number 10, p. 14)
- Challenging children to achieve at a level just beyond their current mastery (Number 11, p. 15)
- Having children's experiences shape their motivation and approaches to learning such as the development of persistence, initiative, and flexibility—dispositions and behaviors that affect children's learning and development (Number 12, p. 15)

These principles along with the core decisions of age appropriateness, individual child appropriateness, and cultural relevance (Copple and Bredekamp, 2009) make an Arts–STEM connection important in helping create a developmentally appropriate curriculum that is intentional.

HOW ARE THE CREATIVE ARTS CONNECTED TO STEM?

There are many ways in which the creative arts can connect with STEM. This section focuses on the following specific areas of integration between arts and STEM: creative problem-solving commonalities; the similar personal characteristics of artists and scientists; similar philosophical approaches to arts and STEM; mutual pursuit of interests in artistic media, design, and nature; interdisciplinary concepts that enhance the Arts–STEM relationship; and cultural connections.

Creative Problem-Solving Commonalities in Arts–STEM

Inquiry. When art techniques are used with or encouraged in young children, they will help them develop curiosity, which is a skill needed to excel in STEM areas. A child who asks, "What if I mix these two colors together?" is actually producing

art, but this curiosity is leading to a major component of the sciences: cause and effect. In other words, when "what if" questions are asked while children are doing art, this stimulates their ideas in STEM courses and vice versa. Inquiry is an essential part of all educational endeavors, including the arts and STEM. (See Chapter 2 for a detailed discussion of curiosity and how it is important in scientific investigation.)

Problem Solving. Questions and problems, which are part of the artistic process, are also part of the acquisition of new ways of designing in the science and engineering fields. Artists ask: How can I use shapes to make this plane beautiful? Scientists ask: Why does this paper airplane go faster than the other? The scientist uses rigorous methods to discover and verify the answers within the scientific method. An engineer asks: How can I make this paper airplane go farther and safer? Engineers use a slightly different method to design, build, and test solutions. The arts, science, and engineering have propelled people to solve puzzling problems, develop useful inventions, and introduce innovation. (See Chapter 2 for a discussion of the stages of creative problem solving.)

Imagination. The arts with young children stimulate imagination, which is also necessary in STEM-based projects. *Imagination* is the ability to see things other than the way they are. It is the ability to visualize the future and foresee what might happen, plan to anticipate it, and represent it in some form. Artists and scientists perceive what is but imagine what could be. They use their awareness, knowledge, and technical skill to develop what could be. Michelangelo "saw" David in the stone before he carved it. Ben Franklin saw electricity in lightning, and he proved it was there by using a key. (See Chapter 2 for a further discussion of imagination.)

Learning from Mistakes. The arts in young children help with a positive approach to failure and a willingness to change. With art that young children make, it is generally easy to change, cover up, or redo. A mistake can usually be fixed, but most of all, an artist or a scientist must take advantage of the mistake and realize there are lessons to be learned—this is also referred to as "trial and error." Children show persistence in their creative arts, and this quality is needed in STEM. The arts and STEM require that one continually assess, recognize challenges in a process, and identify what further needs to be done. A mistake is not the beginning of learning; it is the continuation of learning and the impetus to learn something new. (See Chapter 3 to further understand the importance of allowing a child to make mistakes.)

Discovery. The environment of the creative arts is one of discovery, just as the laboratory of science is one of discovery. Children should have an environment where discovery can take place in the arts and sciences. The environmental conditions that promote creativity and discovery are discussed in Chapter 3. Children discover the science of sound by using string, wind, and percussion instruments in Chapter 7.