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How the Arts Develop the Young Brain

Neuroscience research is revealing the impressive impact of arts instruction on students' cognitive, social and emotional development

By David A. Sousa

Every culture on this planet has art forms. Why is that? Neuroscientists continue to find clues as to how the mental and physical activities required for the arts are so fundamental to brain function.

Certain brain areas respond only to music while others are devoted to initiating and coordinating movement from intense running to the delicate sway of the arms. Drama provokes specialized networks that focus on spoken language and stimulate emotions. Visual arts excite the internal visual processing system to recall reality or create fantasy with the same ease.

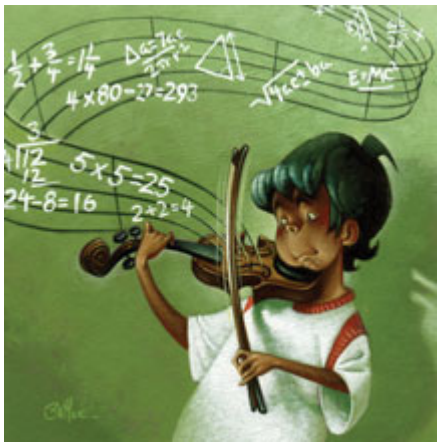

Illustration © by Ralph Butler

These cerebral talents are the result of many centuries of interaction between humans and their environment, and the continued existence of these talents must indicate they contribute in some way to our survival. In those cultures without reading and writing, the arts are the media through which that culture's history, mores and values are transmitted to the younger generations and perpetuated. They also transmit more basic information necessary for the culture's survival, such as how and what to hunt for food and how to defend the village from predators. Here, art becomes an important force behind group survival.

In modern cultures, the arts are rarely thought of as survival skills, but rather as frills — the esthetic product of a wealthy society with lots of time to spare. People pay high ticket prices to see the arts performed professionally, leading to the belief that the arts are highly valued. This cultural support often is seen in high schools, which have their choruses, bands, drama classes and an occasional dance troupe.

Yet seldom do public elementary schools enjoy this continuous support. When school budgets get tight, elementary-level art and music programs are among the first to be reduced or eliminated. Now, pressure from the No Child Left Behind Act to improve reading and mathematics achievement is prompting elementary schools to trade off instruction in the arts for more classroom preparation for the mandatory high-stakes tests. Ironically, this is happening just when neuroscience research is revealing the impressive impact that the arts have on the young brain's cognitive, social and emotional development.

Cognitive Growth

During the brain's early years, neural connections are being made at a rapid rate. Much of what young children do as play — singing, drawing, dancing — are natural forms of art. These activities engage all the senses and wire the brain for successful learning.

When children enter school, these art activities need to be continued and enhanced. Brain areas are developed as the child learns songs and rhymes and creates drawings and finger paintings. The dancing and movements during play develop gross motor skills, and the sum of these activities enhances emotional well-being. And sharing their artwork enhances social skills.

The arts are not just expressive and affective, they are deeply cognitive. They develop essential thinking tools — pattern recognition and development; mental representations of what is observed or imagined; symbolic, allegorical and metaphorical representations; careful observation of the world; and abstraction from complexity.

The arts also contribute to the education of young children by helping them realize the breadth of human experience, see the different ways humans express sentiments and convey meaning, and develop subtle and complex forms of thinking. Although the arts are often thought of as separate subjects, like chemistry or algebra, they really are a collection of skills and thought processes that transcend all areas of human engagement.

Music Listening

Many researchers believe the ability to perceive and enjoy music is an inborn human trait. This biological aspect is supported by the discovery that the brain has specialized areas that respond only to music and that these areas provoke emotional responses. Brain scans show the neural areas stimulated depend on the type of music — melodic tunes stimulate areas that evoke pleasant feelings while dissonant sounds activate other areas that produce unpleasant emotions.

Research studies show that before infants reach their first birthday, they are able to use music as a retrieval cue, differentiate between two adjacent musical tones, recognize a melody when it is played in a different key and categorize rhythmic and melodic patterns on the basis of underlying tempo. Research on the effects of music on the brain and body are divided into the effects of listening to music and the effects of creating or producing music on an instrument.

The notion that music affects cognitive performance catapulted from the research laboratory to the television talk shows in 1993 when a study found that spatial-temporal reasoning — the ability to form mental images from physical objects or to see patterns in time and space — improved in college students after listening to a Mozart sonata for 10 minutes. However, the media failed to report that the students' improved abilities faded within an hour. The results of this study, promptly dubbed "The Mozart Effect," were widely publicized and misinterpreted to imply that listening to a Mozart sonata would enhance intelligence by raising IQ.

Subsequent studies have confirmed that listening to Mozart does enhance various types of spatial and temporal reasoning tasks, especially problems requiring a sequence of mental images to correctly reassemble objects. The data suggest that the effect is real, yet it occurs with other kinds of music beside Mozart. Researchers, however, do not yet know conclusively why the effect occurs. Nonetheless, the effect is important to educators because it shows that passive listening to music stimulates spatial thinking and that neural networks normally associated with one kind of mental activity readily share the cognitive processes involved in a different activity. In other words, learning or thinking in one discipline may not be completely independent of another.

Other studies have shown that listening to certain music stimulates the parts of the brain responsible for memory recall and visual imagery. Researchers have also found that listening to background music enhances the efficiency of those working with their hands. This explains why background music in the classroom helps many students stay focused while completing specific learning tasks. Overly stimulating music, however, serves more as a distraction and interferes with cognitive performance.

Creating Music

Although passive listening to music has short-term educational benefits, creating instrumental music provides many more cerebral advantages. Learning to play a musical instrument challenges the brain in new ways. In addition to being able to discern different tone patterns and groupings, new motor skills must be learned and coordinated in order to play the instrument correctly. These new learnings cause profound and seemingly permanent changes in the brain, and certain cerebral structures are larger in musicians than in non-musicians.

This raises an intriguing question: Are the brains of musicians different because of their training in music, or did these differences exist before they learned music? The answer came when researchers trained non-musicians to listen for small changes in pitch and similar musical components. In just three weeks, their brains showed increased activation in the auditory processing regions. This suggests the brain differences in highly skilled musicians are more likely the result of training and not inherited. No doubt some genetic traits enhance music learning, but it seems most musicians are made, not born.

David Sousa during a presentation to educators in Centerville, Ohio

The beneficial effects of learning to play an instrument begin at an early age. One major study involved 78 children from three California preschools, including one school serving mostly poor, inner-city families. The children were divided into four groups. One group took individual, 12- to 15-minute piano lessons twice a week. Another group took 30-minute singing lessons five days a week, and a third group trained on computers. The fourth group served as the control and received no special instruction. All students took tests before the lessons began to measure different types of spatial-reasoning skills.

After six months, the children who received piano keyboard training had improved their scores by 34 percent on tests measuring spatial-temporal reasoning. On other tasks, there was no difference in scores. Furthermore, the enhancement lasted for days, indicating a substantial change in spatial-temporal function. The other three groups, in comparison, had only slight improvement on all tasks. Subsequent studies continue to show a strong relationship between creating music with keyboards and the enhancement of spatial reasoning in young children.

In addition, numerous studies have shown that musical training improves verbal memory. Researchers in one study administered memory tests to 90 boys between the ages of 6 and 15. Half belonged to their school s strings program for one to five years, while the other half had no musical training. The musically trained students had better verbal memory. Furthermore, the memory benefits of musical training were long-lasting. Students who dropped out of the music training group were tested a year later and found to retain the verbal memory advantage they had gained earlier.

Better Numeracy

Of all academic subjects, mathematics is most closely connected to music. Counting is fundamental to music because one must count beats, count rests and count how long to hold notes. Music students use geometry to remember the correct finger positions for notes or chords on instruments. Reading music requires an understanding of ratios and proportions so that whole notes are held longer than half notes.

Music and mathematics also are related through sequences called intervals: A mathematical interval is the difference between two numbers and a musical interval is the ratio of their frequencies. And arithmetic progressions in music correspond to geometric progressions in mathematics.

Several imaging studies have shown that musical training activated the same areas of the brain that were also activated during mathematical proc-essing. It appears that early musical training begins to build the same neural networks that later will be used to complete numerical and mathematical tasks.

To further study this idea, researchers sought to determine whether learning to play a piano keyboard would help young students learn specific mathematics skills. They focused on proportional mathematics, which is particularly difficult for many elementary students and which is usually taught with ratios, fractions and comparative ratios. One group of 2nd-grade students from a low socioeconomic Los Angeles neighborhood was given four months of piano keyboard training along with computer training on software designed to teach proportional mathematics. This group scored 166 percent higher on proportional mathematics and fractions subtests than the matched group that received neither music nor specific computer lessons, but did play with the computer software. These findings are significant because proportional mathematics is not usually introduced until 5th or 6th grade and because a grasp of proportional mathematics is essential to understanding science and mathematics at higher grade levels.

Another study found that low socio-economic students in California who took music lessons from 8th through 12th grade increased their test scores in mathematics and scored significantly higher than those low socioeconomic students who were not involved in music. Mathematics scores more than doubled, and history and geography scores increased by 40 percent.

A subsequent review of studies involving more that 300,000 secondary school students confirmed the strong association between music instruction and achievement in mathematics. Of particular significance is an analysis of six experimental studies that revealed a causal relationship between music and mathematics performance and that the relationship had grown stronger in recent years.

Educators might want to consider this relationship in planning the core curriculum. If numeracy is so important, perhaps every student should learn to play a musical instrument.

Reading Connections
Several studies confirm a strong association between music instruction and stand-ardized tests of reading ability. Studies conducted with 4- and 5-year-old children revealed that the more music skills children had, the greater their degree of phonological awareness and reading development.

Apparently, music perception taps and enhances auditory areas that are related to reading. Although we cannot say that taking music instruction caused the improvement in reading ability, this consistent finding in a large group of studies builds confidence that there is a strong relationship. Researchers suggest this relationship results because both music and written language involve similar decoding and comprehension reading processes and require a sensitivity to phonological and tonal distinctions.

In the area of the visual arts, the human brain has the incredible ability to form images and representations of the real world or sheer fantasy within its mind's eye. Solving the mystery of DNA's structure, for example, required James Watson and Francis Crick in the early 1950s to imagine numerous three-dimensional models until they hit on the only image that explained the molecule's peculiar behavior — the spiral helix. This was an incredible marriage of visual art and biology that changed the scientific world forever.

Exactly how the brain performs the functions of imagination and meditation may be uncertain, but no one doubts the importance of these valuable talents, which have allowed human beings to develop advanced and sophisticated cultures.

Image Producers
Although teachers spend much time talking about the learning objective, little time is given to developing visual cues. This process, called imagery, is the mental visualization of objects, events and arrays related to the new learning and represents a major method for storing information in the brain.

Photo by Karen Heid/University of South Carolina

Imagery takes place in two ways: *imaging* is the visualization in the mind's eye of something that the person has actually experienced; *imagining* depicts something the person has not yet experienced and, therefore, has no limits. The research evidence is clear: Individuals can be taught to search their minds for images and be guided through the process to select appropriate images that enhance learning and increase retention.

As students today engage with electronic media that produce external images, they are not getting adequate practice in generating their own internal imaging and imagining, skills that not only affect survival but also increase retention and, through creativity, improve the quality of life.

Imagery can be used in many classroom activities, including visualized notetaking, cooperative learning groups and alternative assessment options. Mindmapping is a specialized form of imagery that combines language with images to show relationships between and among concepts and how they connect to a key idea.

Coaches have known for a long time that athletes who use imagery to mentally rehearse what they intend to do perform better than if they do not use imagery. Studies reveal that the more time and intensity devoted to imagery, the better the athletic performance.

Apart from sports, data from nine studies involving nearly 1,500 students were analyzed and showed a statistically significant association between imagery and creativity. Not surprisingly, students who used more imagery during learning displayed more creativity in their discussions, modeling and assessments.

Physical Activity

Even short, moderate physical exercise improves brain performance. Studies indicate that regular physical activity increases the number of capillaries in the brain, thus facilitating blood transport. It also increases the amount of oxygen in the blood, which significantly enhances cognitive performance. Despite the realization that physical activity enhances brain function and learning, secondary students spend most of their classroom time sitting. Although enrollment in high school daily physical education classes has risen slightly in recent years, it represents only about 25 percent of the student body.

Teachers need to encourage more movement in all classrooms at all grade levels. At some point in every lesson, students should be moving about, talking about their new learning. Not only does the movement increase cognitive function, but it uses up some kinesthetic energy so students can settle down and concentrate better later. Mild exercise before a test also makes sense. So does teaching dance to all students in K-8 classrooms. Dance techniques help students become more aware of their physical presence, spatial relationships, breathing, and of timing and rhythm in movement.

Movement activities are also effective because they involve more sensory input, hold the students' attention for longer periods of time, help them make connections between new and past learnings and improve long-term recall. We can easily recall the time we participated in the school play or other public performance because this experience activated our kinesthetic sensory system. Moreover, many students are involved with interesting kinesthetic activities after school. Doing these types of activities in school awakens and maintains that interest.

Arts Integration

Research studies have examined both stand-alone arts programs as well as those that integrate concepts and skills from the arts into other curriculum areas. One intriguing revelation of these studies is that the most powerful effects are found in programs that integrate the arts with subjects in the core curriculum. Researchers suggest that arts integration causes both students and teachers to rethink how they view the arts and generates conditions that are ideal for learning.

Studies consistently show the following in schools where arts are integrated into the core curriculum: Students have a greater emotional investment in their classes; students work more diligently and learn from each other; cooperative learning groups turn classrooms into learning communities; parents become more involved; teachers collaborate more; art and music teachers become the center of multi-class projects; learning in all subjects becomes attainable through the arts; curriculum becomes more authentic, hands-on and project-based; assessment is more thoughtful and varied; and teachers' expectations for their students rise.

The arts play an important role in human development, enhancing the growth of cognitive, emotional, and psychomotor pathways. Schools have an obligation to expose children to the arts at the earliest possible time and to consider the arts as fundamental (not optional) curriculum

areas. Finally, learning the arts provides a higher quality of human experience throughout a person's lifetime.

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