

Case studies: Music improves math skills

- Dr. Frances Rauscher of the University of Wisconsin Oshkosh has been heavily involved in research on music and cognitive performance. She gives far more credit to the active playing of instruments than simply passive listening. In her 2006 article published in the *Educational Psychologist*, she explains that **“young children provided with instrumental instruction score significantly higher on tasks measuring spatial-temporal cognition, hand-eye coordination and arithmetic.”** Part of this is due to the amount of overlap between music skills and math skills. For example, Rauscher says the part-whole concept that is necessary for understanding fractions, decimals and per cents is highly relevant in understanding rhythm.
- **“Our research consistently shows that young children provided with instrumental instruction score significantly higher on tasks measuring spatial-temporal cognition, hand-eye coordination, and arithmetic.”** – *“The Mozart Effect: Music Listening is Not Music Instruction,”* Frances H. Rauscher Department of Psychology University of Wisconsin Oshkosh Sean C. Hinton Department of Neurology Medical College of Wisconsin
- A study published in 2007 by Christopher Johnson, professor of music education and music therapy at the University of Kansas, revealed that **students in elementary schools with superior music education programs scored around 22 percent higher in English and 20 percent higher in math scores on standardized tests, compared to schools with low-quality music programs, regardless of socioeconomic disparities among the schools or school districts.** Johnson compares the concentration that music training requires to the focus needed to perform well on a standardized test.
- In another study, published by Martin Gardiner (currently at Brown University's Center for the Study of Human Development) in the May 1996 issue of the journal *Nature*, **groups of first graders were given music instruction** that emphasized sequential skill development and musical games involving rhythm and pitch. **After six months, the students scored significantly better in math than students in groups that received traditional music instruction.**
- In an analysis of U.S. Department of Education data on more than 25,000 secondary school students (NELS:88, National Education Longitudinal Survey), **researchers found that students who report consistent high levels of involvement in instrumental music over the middle and high school years show "significantly higher levels of mathematics proficiency by grade 12."** This observation holds regardless of students' socio-economic status, and differences in those who are involved with instrumental music vs. those who are not is more significant over time.

RESEARCH AND WEBSITES:

First bullet reference:

MUSIC INSTRUCTION

A second area of investigation, however, deserves further consideration by educators: the effects of music instruction on children's cognitive abilities. To avoid confusion, and because they have nothing at all to do with Mozart, we prefer that the instruction studies not be referred to as the Mozart effect, although others have unfortunately generalized the term to refer to any effect of music on behavior (e.g., Campbell, 1997).

The instruction studies, unlike the listening studies, have profound implications for educational practice. **Our research consistently shows that young children provided with instrumental instruction score significantly higher on tasks measuring spatial-temporal cognition, hand-eye coordination, and arithmetic** (Rauscher, 2001, 2002; Rauscher, LeMieux, & Hinton, 2005; Rauscher et al., 1997; Rauscher & Zupan, 2000).

Other researchers have found similar effects (see Hetland, 2000b, for review). More recently, a study by Schellenberg (2004) showed small but significant increases in generalized IQ for children randomly assigned to receive music instruction compared to control groups of children who received drama instruction or no special training. Effects of music instruction have been found to persist for at least 2 years after the instruction was terminated (Rauscher, LeMieux, & Hinton, 2005).

Although the age of the participants, the methods used, and the outcomes achieved are distinctly different from those of the listening studies, Waterhouse (2006) also refers to this phenomenon as the Mozart effect. She asserts that "the research findings from 1993 [referring to the original listening study] onward led to the conclusion that experience of music, and especially of Mozart's music, whether for a brief time or over a longer period, whether listened to or played, significantly improved spatial cognitive skills."

We know of no studies, anecdotal evidence, or popular press accounts suggesting that performing Mozart's music affects spatial cognition or any other domain of intelligence. Waterhouse further confuses the two sets of findings when she states that "Rauscher (2002) suggested that the Mozart effect might work either through transfer of learning from the music domain to the visual-spatial domain, or through changing the physical structure of the brain." Rauscher's reasoning concerned the effects of music instruction, not the effects of listening to a Mozart sonata—the so-called Mozart effect. We do not suggest that listening to Mozart's music transfers to spatial task performance or that it changes the physical structure of the brain. In fact, the article Waterhouse cited to support her conclusion (i.e., Rauscher, 2002) included nothing about possible mechanisms for the

effects of listening to Mozart. The article reported a study on the effects of music instruction and possible mechanisms for instruction's effects on cognition. We believe that Waterhouse's conflating the listening studies with the music instruction studies will lead to greater misinterpretation of the research by educators, politicians, and laypeople. Care must be taken to distinguish these independent research findings so as not to compound the misunderstandings that already exist.

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<http://alliance.la.asu.edu/temporary/students/katie/MultipleIntelligenceMozart.pdf>

Second bullet reference:

Improved Test Scores

A study published in 2007 by Christopher Johnson, professor of music education and music therapy at the University of Kansas, revealed that **students in elementary schools with superior music education programs scored around 22 percent higher in English and 20 percent higher in math scores on standardized tests, compared to schools with low-quality music programs, regardless of socioeconomic disparities among the schools or school districts.** Johnson compares the concentration that music training requires to the focus needed to perform well on a standardized test.

Aside from test score results, Johnson's study highlights the positive effects that a quality music education can have on a young child's success. Luehrisen explains this psychological phenomenon in two sentences: "Schools that have rigorous programs and high-quality music and arts teachers probably have high-quality teachers in other areas. If you have an environment where there are a lot of people doing creative, smart, great things, joyful things, even people who aren't doing that have a tendency to go up and do better."

And it doesn't end there: along with better performance results on concentration-based tasks, music training can help with basic memory recall. "Formal training in music is also associated with other cognitive strengths such as verbal recall proficiency," Pruetz says. "People who have had formal musical training tend to be pretty good at remembering verbal information stored in memory."

<http://www.pbs.org/parents/education/music-arts/the-benefits-of-music-education/>

Third bullet reference:

In another study, published by Martin Gardiner (currently at Brown University's Center for the Study of Human Development) in the May 1996 issue of the journal *Nature*, **groups of first graders were given music instruction** that emphasized sequential skill development and musical games involving rhythm and pitch. **After six months, the students scored significantly better in math than students in groups that received traditional music instruction.** (Reading scores for the two groups didn't show marked differences.) Follow-up studies with different groups of students showed similar results.

http://www.educationworld.com/a_curr/curr123.shtml

Fourth bullet reference:

In the field of cognitive research, the mind-body connections between music and mathematics have fueled continuing debate surrounding the so-called “Mozart Effect,” which was first popularized in the early 1990s. In some studies, test subjects performed better on spatial-temporal tasks — such as visualizing a boat in one’s mind and then building it with Lego pieces — immediately following exposure to a Mozart sonata.

This might be explained by the fact that the same parts of the brain are active when listening to Mozart as when engaged in spatial-temporal reasoning.

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In her 2006 article published in the *Educational Psychologist*, she explains that **“young children provided with instrumental instruction score significantly higher on tasks measuring spatial-temporal cognition, hand-eye coordination and arithmetic.”** Part of this is due to the amount of overlap between music skills and math skills. For example, Rauscher says the part-whole concept that is necessary for understanding fractions, decimals and per cents is highly relevant in understanding rhythm. “A literate musician is required to continually mentally subdivide beat to arrive at the correct interpretation of rhythmic notation,” she writes. “The context has changed, but the structure of the problem is essentially the same as any part-whole problem posed mathematically.”

The visual and spatial skills that a child exercises every time he practises an instrument and plays music strengthen his mental-physical connection.

The link between the physical practice of music and strong mathematical abilities are demonstrated in studies that show that kids who play a musical instrument can perform

more complex arithmetical operations than those who do not play an instrument. The slow work of practice, the attention to detail and the discipline it takes to learn an instrument are also excellent preparation for the practice involved in building strong math skills.

The math-music connection shines in the field of education as well. Research shows that children who learn their academics through music and dance retain the information better than children who learn the same concepts by verbal instruction.

<http://www.vancouversun.com/Entertainment/interesting+connection+between+math+music/1473881/story.html>

Fifth bullet reference:

U.S. Department of Education data on more than 25,000 secondary school students found that **students who report consistent high levels of involvement in instrumental music over the middle and high school years show “significantly higher levels of mathematics proficiency by grade 12.”** - *U.S. Department of Education NELL88 Database*

Benefits of Music Education

(Facts compiled by the National Association for Music Education in Spring 2002.)

The basic statement is unlikely to be challenged by anyone involved in education. In the sometimes harsh reality of limited time and funding for instruction, however, the inclusion of the arts in every student's education can sometimes be relegated to a distant wish rather than an exciting reality.

It doesn't have to be that way! All that's needed is a clear message sent to all those who must make the hard choices involved in running a school or school system. The basic message is that music programs in the schools help our kids and communities in real and substantial ways. You can use the following facts about the benefits of music education, based on a growing body of convincing research, to move decision-makers to make the right choices.

The benefits conveyed by music education can be grouped in four categories:

- Success in society
- Success in school
- Success in developing intelligence
- Success in life

When presented with the many and manifest benefits of music education, officials at all levels should universally support a full, balanced, sequential course of music instruction taught by qualified teachers. And every student will have an education in the arts.

Benefit One: Success in Society

Perhaps the basic reason that every child must have an education in music is that music is a part of the fabric of our society. The intrinsic value of music for each individual is widely recognized in the many cultures that make up American life -- indeed, every human culture uses music to carry forward its ideas and ideals. The importance of music to our economy is without doubt. And the value of music in shaping individual abilities and character are attested in a number of places:

- Secondary students who participated in band or orchestra reported the lowest lifetime and current use of all substances (alcohol, tobacco, illicit drugs). *Texas Commission on Drug and Alcohol Abuse Report. Reported in Houston Chronicle, January 1998*
- "Music is a magical gift we must nourish and cultivate in our children, especially now as scientific evidence proves that an education in the arts makes better math and science students, enhances spatial intelligence in newborns, and let's not forget that

the arts are a compelling solution to teen violence, certainly not the cause of it!" *Michael Greene, Recording Academy President and CEO at the 42nd Annual Grammy Awards, February 2000.*

- The U.S. Department of Education lists the arts as subjects that college-bound middle and junior high school students should take, stating "Many colleges view participation in the arts and music as a valuable experience that broadens students' understanding and appreciation of the world around them. It is also well known and widely recognized that the arts contribute significantly to children's intellectual development." In addition, one year of Visual and Performing Arts is recommended for college-bound high school students. *Getting Ready for College Early: A Handbook for Parents of Students in the Middle and Junior High School Years, U.S. Department of Education, 1997*
- The College Board identifies the arts as one of the six basic academic subject areas students should study in order to succeed in college. *Academic Preparation for College: What Students Need to Know and Be Able to Do, 1983 [still in use], The College Board, New York*
- The arts create jobs, increase the local tax base, boost tourism, spur growth in related businesses (hotels, restaurants, printing, etc.) and improve the overall quality of life for our cities and towns. On a national level, nonprofit arts institutions and organizations generate an estimated \$37 billion in economic activity and return \$3.4 billion in federal income taxes to the U.S. Treasury each year. American Arts Alliance Fact Sheet, October 1996
- The very best engineers and technical designers in the Silicon Valley industry are, nearly without exception, practicing musicians. *Grant Venerable, "The Paradox of the Silicon Savior," as reported in "The Case for Sequential Music Education in the Core Curriculum of the Public Schools," The Center for the Arts in the Basic Curriculum, New York, 1989*

Benefit Two: Success in School

Success in society, of course, is predicated on success in school. Any music teacher or parent of a music student can call to mind anecdotes about effectiveness of music study in helping children become better students. Skills learned through the discipline of music, these stories commonly point out, transfer to study skills, communication skills, and cognitive skills useful in every part of the curriculum.

Another common variety of story emphasizes the way that the discipline of music study; particularly through participation in ensemble; helps students learn to work effectively in the school environment without resorting to violent or inappropriate behavior. And there are a number of hard facts that we can report about the ways that music study is correlated with success in school:

- "The term 'core academic subjects' means English, reading or language arts, mathematics, science, foreign languages, civics and government, economics, arts, history, and geography." *No Child Left Behind Act of 2002, Title IX, Part A, Sec. 9101 (11)*
- **A study of 237 second grade children used piano keyboard training and newly designed math software to demonstrate improvement in math skills. The group scored 27% higher on proportional math and fractions tests than children that used only the math software. *Graziano, Amy, Matthew Peterson, and Gordon Shaw, "Enhanced learning of proportional math through music training and spatial-temporal training." *Neurological Research* 21 (March 1999).***
- **In an analysis of U.S. Department of Education data on more than 25,000 secondary school students (NELS:88, National Education Longitudinal Survey), researchers found that students who report consistent high levels of involvement in instrumental music over the middle and high school years show "significantly higher levels of mathematics proficiency by grade 12." This observation holds regardless of students' socio-economic status, and differences in those who are involved with instrumental music vs. those who are not is more significant over time. *Catterall, James S., Richard Chapleau, and John Iwanaga. "Involvement in the Arts and Human Development: General Involvement and Intensive Involvement in Music and Theater Arts." Los Angeles, CA: The Imagination Project at UCLA Graduate School of Education and Information Studies, 1999.***
- **Students with coursework/experience in music performance and music appreciation scored higher on the SAT: students in music performance scored 57 points higher on the verbal and 41 points higher on the math, and students in music appreciation scored 63 points higher on verbal and 44 points higher on the math, than did students with no arts participation. *College-Bound Seniors National Report: Profile of SAT Program Test Takers. Princeton, NJ: The College Entrance Examination Board, 2001.***
- According to statistics compiled by the National Data Resource Center, students who can be classified as "disruptive" (based on factors such as frequent skipping of classes, times in trouble, in-school suspensions, disciplinary reasons given, arrests, and drop-outs) total 12.14 percent of the total school population. In contrast, only 8.08 percent of students involved in music classes meet the same criteria as "disruptive." *Based on data from the NELS:88 (National Education Longitudinal Study), second follow-up, 1992.*
- Data from the National Education Longitudinal Study of 1988 showed that music participants received more academic honors and awards than non-music students, and that the percentage of music participants receiving As, As/Bs, and Bs was higher than the percentage of non- participants receiving those grades. *NELS:88 First Follow-up, 1990, National Center for Education Statistics, Washington DC*

- Physician and biologist Lewis Thomas studied the undergraduate majors of medical school applicants. He found that 66% of music majors who applied to medical school were admitted, the highest percentage of any group. 44% of biochemistry majors were admitted. As reported in *"The Case for Music in the Schools," Phi Delta Kappan, February 1994*
- A study of 811 high school students indicated that the proportion of minority students with a music teacher role-model was significantly larger than for any other discipline. 36% of these students identified music teachers as their role models, as opposed to 28% English teachers, 11% elementary teachers, 7% physical education/sports teachers, 1% principals. *D.L. Hamann and L.M. Walker, "Music teachers as role models for African-American students," Journal of Research in Music Education, 41, 1993*
- Students who participated in arts programs in selected elementary and middle schools in New York City showed significant increases in self-esteem and thinking skills. *National Arts Education Research Center, New York University, 1990*

Benefit three: Success in Developing Intelligence

Success in school and in society depends on an array of abilities. Without joining the intense ongoing debate about the nature of intelligence as a basic ability, we can demonstrate that some measures of a child's intelligence are indeed increased with music instruction. Once again, this burgeoning range of data supports a long-established base of anecdotal knowledge to the effect that music education makes kids smarter. What is new and especially compelling, however, is a combination of tightly-controlled behavioral studies and groundbreaking neurological research that show how music study can actively contribute to brain development:

- In a study conducted by Dr. Timo Krings, pianists and non-musicians of the same age and sex were required to perform complex sequences of finger movements. Their brains were scanned using a technique called "functional magnetic resource imaging" (fMRI) which detects the activity levels of brain cells. The non-musicians were able to make the movements as correctly as the pianists, but less activity was detected in the pianists' brains. Thus, compared to non-musicians, the brains of pianists are more efficient at making skilled movements. These findings show that musical training can enhance brain function. *Weinberger, Norm. "The Impact of Arts on Learning." MuSICa Research Notes 7, no. 2 (Spring 2000). Reporting on Krings, Timo et al. "Cortical Activation Patterns during Complex Motor Tasks in Piano Players and Control Subjects. A Functional Magnetic Resonance Imaging Study." Neuroscience Letters 278, no. 3 (2000): 189-93.*
- "The musician is constantly adjusting decisions on tempo, tone, style, rhythm, phrasing, and feeling--training the brain to become incredibly good at organizing and conducting numerous activities at once. Dedicated practice of this orchestration can have a great payoff for lifelong attentional skills, intelligence, and an ability for self-

knowledge and expression." *Ratey John J., MD. A User's Guide to the Brain. New York: Pantheon Books, 2001.*

- A research team exploring the link between music and intelligence reported that music training is far superior to computer instruction in dramatically enhancing children's abstract reasoning skills, the skills necessary for learning math and science. *Shaw, Rauscher, Levine, Wright, Dennis and Newcomb, "Music training causes long-term enhancement of preschool children's spatial-temporal reasoning," Neurological Research, Vol. 19, February 1997*
- Students in two Rhode Island elementary schools who were given an enriched, sequential, skill-building music program showed marked improvement in reading and math skills. Students in the enriched program who had started out behind the control group caught up to statistical equality in reading, and pulled ahead in math. *Gardiner, Fox, Jeffrey and Knowles, as reported in Nature, May 23, 1996*
- Researchers at the University of Montreal used various brain imaging techniques to investigate brain activity during musical tasks and found that sight-reading musical scores and playing music both activate regions in all four of the cortex's lobes; and that parts of the cerebellum are also activated during those tasks. *Sergent, J., Zuck, E., Tenial, S., and MacDonall, B. (1992). Distributed neural network underlying musical sight reading and keyboard performance. Science, 257, 106-109.*
- Researchers in Leipzig found that brain scans of musicians showed larger planum temporale (a brain region related to some reading skills) than those of non-musicians. They also found that the musicians had a thicker corpus callosum (the bundle of nerve fibers that connects the two halves of the brain) than those of non-musicians, especially for those who had begun their training before the age of seven. *Schlaug, G., Jancke, L., Huang, Y., and Steinmetz, H. (1994). In vivo morphometry of interhemispheric asymmetry and connectivity in musicians. In I. Deliège (Ed.), Proceedings of the 3d international conference for music perception and cognition (pp. 417-418). Liege, Belgium.*
- A University of California (Irvine) study showed that after eight months of keyboard lessons, preschoolers showed a 46% boost in their spatial reasoning IQ. *Rauscher, Shaw, Levine, Ky and Wright, "Music and Spatial Task Performance: A Causal Relationship," University of California, Irvine, 1994*
- Researchers found that children given piano lessons significantly improved in their spatial-temporal IQ scores (important for some types of mathematical reasoning) compared to children who received computer lessons, casual singing, or no lessons. *Rauscher, F.H., Shaw, G.L., Levine, L.J., Wright, E.L., Dennis, W.R., and Newcomb, R. (1997) Music training causes long-term enhancement of preschool children's spatial temporal reasoning. Neurological Research, 19, 1-8.*
- A McGill University study found that pattern recognition and mental representation scores improved significantly for students given piano instruction over a three-year period. They also found that self-esteem and musical skills measures improved for the students given piano instruction. *Costa-Giomi, E. (1998, April). The McGill Piano*

Project: Effects of three years of piano instruction on children's cognitive abilities, academic achievement, and self-esteem. Paper presented at the meeting of the Music Educators National Conference, Phoenix, AZ.

- Researchers found that lessons on songbells (a standard classroom instrument) led to significant improvement of spatial-temporal scores for three- and four-year-olds. *Gromko, J.E., and Poorman, A.S. (1998) The effect of music training on preschooler's spatial-temporal task performance. Journal of Research in Music Education, 46, 173-181.*
- In the Kindergarten classes of the school district of Kettle Moraine, Wisconsin, children who were given music instruction scored 48 percent higher on spatial-temporal skill tests than those who did not receive music training. *Rauscher, F.H., and Zupan, M.A. (1999). Classroom keyboard instruction improves kindergarten children's spatial-temporal performance: A field study. Manuscript in press, Early Childhood Research Quarterly.*
- An Auburn University study found significant increases in overall self-concept of at-risk children participating in an arts program that included music, movement, dramatics and art, as measured by the Piers-Harris Children's Self-Concept Scale. *N.H. Barry, Project ARISE: Meeting the needs of disadvantaged students through the arts, Auburn University, 1992*

Benefit four: Success in Life

Each of us wants our children; and the children of all those around us to achieve success in school, success in employment, and success in the social structures through which we move. But we also want our children to experience "success" on a broader scale.

Participation in music, often as not based on a grounding in music education during the formative school years, brings countless benefits to each individual throughout life. The benefits may be psychological or spiritual, and they may be physical as well:

- **"Studying music encourages self-discipline and diligence, traits that carry over into intellectual pursuits and that lead to effective study and work habits. An association of music and math has, in fact, long been noted.** Creating and performing music promotes self-expression and provides self-gratification while giving pleasure to others. In medicine, increasing published reports demonstrate that music has a healing effect on patients. For all these reasons, it deserves strong support in our educational system, along with the other arts, the sciences, and athletics." *Michael E. DeBakey, M.D., Leading Heart Surgeon, Baylor College of Music.*
- "Music has a great power for bringing people together. With so many forces in this world acting to drive wedges between people, it's important to preserve those things that help us experience our common humanity." *Ted Turner, Turner Broadcasting System.*

- "Music is one way for young people to connect with themselves, but it is also a bridge for connecting with others. Through music, we can introduce children to the richness and diversity of the human family and to the myriad rhythms of life." *Daniel A. Carp, Eastman Kodak Company Chairman and CEO.*
- "Casals says music fills him with the wonder of life and the 'incredible marvel' of being a human. Ives says it expands his mind and challenges him to be a true individual. Bernstein says it is enriching and ennobling. To me, that sounds like a good cause for making music and the arts an integral part of every child's education. Studying music and the arts elevates children's education, expands students' horizons, and teaches them to appreciate the wonder of life." *U.S. Secretary of Education Richard W. Riley, July 1999.*
- "The nation's top business executives agree that arts education programs can help repair weaknesses in American education and better prepare workers for the 21st century." "*The Changing Workplace is Changing Our View of Education.*" *Business Week, October 1996.*
- "Music making makes the elderly healthier.... There were significant decreases in anxiety, depression, and loneliness following keyboard lessons. These are factors that are critical in coping with stress, stimulating the immune system, and in improved health. Results also show significant increases in human growth hormones following the same group keyboard lessons. (*Human growth hormone is implicated in aches and pains.*)" Dr. Frederick Tims, reported in *AMC Music News, June 2, 1999*
- "Music education opens doors that help children pass from school into the world around them a world of work, culture, intellectual activity, and human involvement. The future of our nation depends on providing our children with a complete education that includes music." - *Gerald Ford, former President, United States of America*
- "During the Gulf War, the few opportunities I had for relaxation I always listened to music, and it brought to me great peace of mind. I have shared my love of music with people throughout this world, while listening to the drums and special instruments of the Far East, Middle East, Africa, the Caribbean, and the Far North and all of this started with the music appreciation course that I was taught in a third-grade elementary class in Princeton, New Jersey. What a tragedy it would be if we lived in a world where music was not taught to children." *H. Norman Schwarzkopf, General, U.S. Army, retired*

(Facts compiled by the National Association for Music Education staff, Spring 2002. When using factual quotes from this brochure, please be sure to cite individual research source which follows each quote/fact. Other text copy in the brochure was authored by the National Association for Music Education staff. When citing from these sections, please reference as: "Source: MENC: The National Association for Music Education "Benefits of Music Education" Brochure, Spring 2002".)