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March, 2006 *Dr. Diane Y. Watanabe, Editor*

Announcement No. 11 The Joy of Learning Math Through Music

The fields of neuroscience and cognitive psychology are now able to contribute to data-driven decisions by practical, score-driven educators who are seeking to raise math achievement levels. Key research findings, as well as specific programs based on those findings, are being successfully applied in classrooms. In 1985, Dr. Diane Watanabe and Richard Sjolseth co-founded the Institute of Learning, Teaching, and the Human Brain (ILTHB) at the Los Angeles County Office of Education (LACOE) to bring together research on how students learn best.

The ILTHB, a professional development provider and think tank, shares LACOE's goal for improving student achievement. This Institute deliberately includes factors of the whole child—social, emotional, physical, and intellectual—as well as accelerated learning strategies and higher level thinking skills.

JOY IN LEARNING-Since emotion, interest, and motivation promote learning and memory, the Institute investigates programs which instill joy in learning. Brain research shows that the brain produces at least three pleasure chemicals when joy is present: endorphins, dopamine, and serotonin. Watanabe and Sjolseth attest that when students are eager and motivated, when there is joy, learning is maximized.

20,000 Students Currently Served, K-5-A remarkable example of neuroscience findings moving quickly from the research labs into classrooms is the collaboration between the ILTHB and neuroscientists of the MIND Institute, a non-profit spun out of the University of California at Irvine in 1998. The results of this partnership are now serving over 90 schools and 20,000 students. ILTHB has increased the visibility of the success of this program, and over half of the participating schools are in Los Angeles County. *Music Increases Nueronal Development.

In 1998, Watanabe and Sjolseth had called up physicist and principal investigator Dr. Gordon Shaw, then at UC Irvine. He was conducting a pilot study at 95th Street Elementary in LAUSD using a program combining music training with unique computer math software. His previous decades of research had shown that music training increases spatial-temporal abilities, and the pilot study combined music training with spatial-temporal computer math games to assist students to learn mathematics.

MATH + MUSIC- A working relationship was established among the ILTHB and Dr. Shaw, Dr. Mark Bodner, neuroscientist from UCLA, and Dr. Matthew Peterson, neuroscientist from UC Berkeley. We will explore in this article how scientific principles, combined with innovation and a dedication to benefiting students, were turned into an education program with extraordinary results.

THINKING IN PICTURES AND PATTERNS- Dr. Bodner explains the key finding from computational models of the structured cortex dating back to 1974. The human brain is hard-wired to do spatial-temporal reasoning: to maintain visual images in working memory, and manipulate or evolve them over multiple steps in time. In simpler terms, this is thinking in pictures and patterns. Examples of where this ability is used are in chess, reading/playing music, and in mathematical problem solving.

The Joy of Learning Math Through Music continued...

The genesis of the connection between brain research and music is intriguing and often misunderstood. It came about by discovering a strong connection between certain musical patterns and neural activity patterns in the brain. It was then hypothesized that music might resonate with certain neural networks, and could potentially enhance the ability to perform certain cognitive operations. A seminal experiment showed, specifically, that training in piano keyboard improves children's spatial-temporal ability. These findings were further supported by fMRI brain imaging and are the subject of continued rigorous study.

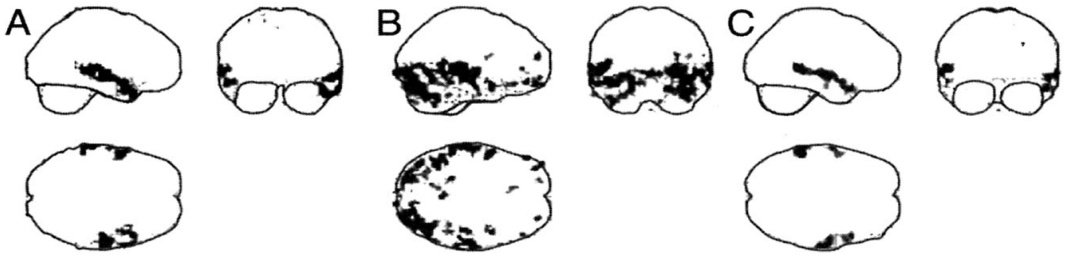
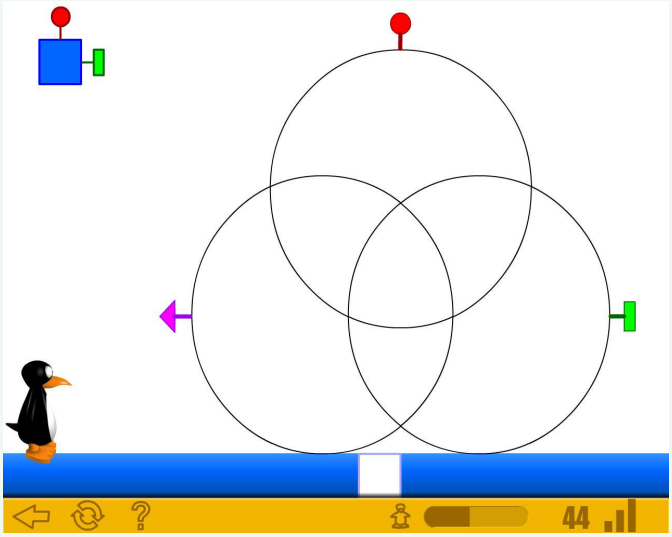


FIGURE 24.3 fMRI brain imaging activation in subject listening to three pieces of piano music, each shown in three projections (see Fig. 6.7). (A) 1930s "popular" music activates the auditory areas of the cortex (see Fig. 6.6). (B) Mozart Sonata (K.448) activates the auditory areas, visual areas, and planning areas. (C) Beethoven's Fur Elise activates auditory areas similar to those of A. From Bodner *et al.* (2001).

IDEAL FOR ENGLISH LEARNERS- Dr. Peterson describes the next step in this application of neuroscience to the classroom: the teaching of mathematics through spatial-temporal reasoning. Dr. Peterson invented his Spatial-Temporal Math (ST Math) software which combines video game metaphors with virtual manipulatives to engage students as they progressed through a grade level of curriculum aligned to the California math standards. In ST Math, students are first trained to visualize the underlying mathematical concepts, and then they learn to apply these visualization skills to solve math problems. This approach, which is in tune with how the brain works, truly instills in children the joy of learning mathematics. Furthermore, because the software doesn't rely on language skills, the language barrier to math proficiency is eliminated, which is especially valuable for English learners.



The Joy of Learning Math Through Music continued...

The neuroscience, the music connection, and the unique ST Math software were combined into the ST Math + Music program. The music component was designed to develop spatial-temporal reasoning ability, and to tie into the patterns and symmetries important to mathematics, such as fractions and algebraic thinking.

MATH ACHIEVEMENT SCORES SOAR- The 1998 pilot study involved eighteen second grade students, who outperformed their peers by 26 percentile points on the 1999 SAT-9 math test. By 2003, the curriculum had been extended to second through fourth grades, and the number of students served to over 8,000. The yardstick for success remained the California standardized math assessment, whether SAT-9 or CATG-6 or CST. Year after year, this program has realized a dramatic average increase for implementing students in the range of 15-20 percentile points as compared to non-participants in the same grades and schools.

The increases in CST performance highlight a remarkable aspect of this neuroscience-based program: it is benefiting every proficiency level. There are far fewer participants in the "Far Below Basic" category and those who are already "Proficient" are being moved up into the""Advanced" category. This same program has success at very low-performing and very high-performing schools. This extraordinary applicability of the program derives from the brain-based design. The unique visual approach to presenting math concepts develops general problem-solving skills beneficial to every student.

To see how this program has benefited our most recent school, observe the results for Bryant Elementary in Long Beach USD. The chart below shows the large increase in CST scores after one year for participating grades (2nd, 3rd, and 4th grades), versus the stagnant scores for grades not in ST Math+Music program (5th grade).

Bryant Elementary School

Year by Year Comparison by Grade Level

2nd Grade	2004	2005	% Δ
% Advanced	4%	24%	20%
% Proficient	22%	22%	0%
% Basic	34%	38%	4%
% Below Basic	35%	15%	-20%
% Far Below Basic	4%	2%	-2%
3rd Grade	**2004**	**2005**	**% Δ**
% Advanced	19%	29%	10%
% Proficient	35%	28%	-7%
% Basic	24%	28%	4%
% Below Basic	22%	15%	-7%
% Far Below Basic	0%	0%	0%
4th Grade	**2004**	**2005**	**% Δ**
% Advanced	3%	31%	28%
% Proficient	23%	28%	5%
% Basic	42%	31%	-11%
% Below Basic	32%	7%	-25%
% Far Below Basic	0%	2%	2%

5th Grade - No M+M	2004	2005	% Δ
% Advanced	9%	8%	-1%
% Proficient	26%	27%	1%
% Basic	35%	30%	-5%
% Below Basic	22%	30%	8%
% Far Below Basic	7%	5%	-2%

The Joy of Learning Math Through Music continued...

THE FUTURE OF MATH CURRICULUM IS BRAIN-BASED-Coming from one of the first programs with a neuroscience-based design, perhaps these results are not so much stunning as they are predictive of a far more productive future in teaching and learning math for all students.

Resources/Contacts:

Keeping Mozart in Mind, second edition, (2004), Elsevier Academic Press

fMRI Study to Investigate Spatial Correlates of Music Listening and Spatial-temporal Reasoning, (2004), Muftuler T., Bodner M., Shaw G. L., Nalcioglu O., 12th Annual Meeting of the International Society of Magnetic Resonance in Medicine.

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