

# References for Teaching Artists Preparing Mathematics and the Arts Workshops

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**About this list:** I compiled this list for a workshop that Erik Stern and I taught at the Kennedy Center for the Performing Arts in Washington, DC, in September of 2007. This workshop was for a group of experienced teaching artists who teach interdisciplinary workshops for students and teachers around the country, and who also teach workshops at the Kennedy Center. It was offered because many of them are either already finding ways to link their art form with mathematics, or were interested in starting to do this. I hope this list will also be useful to other teaching artists who are also trying to make such connections in their educational work.

Recent years have seen an explosion of interest in ways of connecting mathematics with the arts. Even the entertainment world has jumped in, with major film releases such as *Good Will Hunting* and *A Beautiful Mind*, the TV series *NUMB3RS*, and the Broadway play *Proof* all having mathematician protagonists. At least two international conferences on math and the arts are held in most years, and a number of journals and conference proceedings are published every year as well. Much of the new material is in the visual arts, secondarily in music, and many new resources appear first at conferences and online before making appearances in published form.

**How to use this list.** If you feel uncomfortable with mathematics, but not with the arts, you might look at some of the writings by Martin Gardner (under Math and the Arts – General), who has a light and engaging style, and whose writings move effortlessly through literature, philosophy, and music, as well as the field known as “recreational mathematics.” You also might take a look at Sheila Tobias’s book on math anxiety, or the similar book by Kogelman and Warren (under Math Anxiety), since it might help shed new light at ideas you may have long held about mathematical ability. Look up the conferences mentioned, and see if one will be in your area in the near future. Most include presentations at all levels and on many subjects related to the arts and education, and some sessions are likely to be of interest. If you want a sense of what mathematicians are up to these days, take a look at Devlin’s book (under Math and the Arts – General).

Some of these references provide philosophical support for work linking the arts and mathematics, a few delve deeply into formal mathematics. This list does not aim to be all inclusive, but to help those searching for starting places find help in making links between the arts and mathematics.

The ethnomathematics sources might be particularly helpful, even if they are not specifically related to the arts. That newly developing field is devoted to finding and highlighting ways in which mathematical thinking is naturally embedded, though sometimes hidden, in aspects of human culture, and the arts often provide telling examples of this phenomenon.

If you find resources that have been particularly helpful to you, and are not included here, please send to Karl Schaffer at [karl\\_schaffer@yahoo.com](mailto:karl_schaffer@yahoo.com), and I’ll try to include in later versions of this list. I will also put future versions of this resource list online.

## CONFERENCES / ORGANIZATIONS

*Bridges: Mathematical Connections in Art, Music, and Science* (Accessed 8/26/07).

<http://www.bridgesmathart.org/>. Summer (usually late July or early August) conferences on mathematics and the arts. The visual arts are more strongly represented than other art forms, and many presentations go deeply into the mathematics, but the presentations are extremely diverse. Each year since 1998 they have published Proceedings, available through their site.

*ISAMA, The International Society for the Arts, Mathematics, and Architecture*, maintained by John M. Sullivan, International Society of Arts, Mathematics, and Architecture:

<http://www.isama.org/> The organization publishes a monthly webzine, *Hyperseeing*, of articles, reviews, news, and announcements about art and mathematics. They also hold a yearly conference, usually in late spring or summer.

*ISGEM, the International Study Group on Ethnomathematics*. Web site:

<http://www.rpi.edu/~eglash/isgem.htm>, maintained by Ron Eglash, links to their online Journal of Mathematics and Culture. Hundreds of links to online sites dealing with ethnomathematics are maintained at <http://www.rpi.edu/~eglash/isgem.dir/links.htm>. Next international conference is tentatively scheduled for 2010 in Baltimore. Do not hold yearly conferences, but usually sponsors a “thread” at the National Council of Teachers national conference.

*ISIS-SYMMETRY, International Society for the Interdisciplinary Study of Symmetry*. Web site:

<http://www.mi.sanu.ac.yu/vismath/isis.htm>. Publishes two quarterly journals, *Symmetry: Art and Science*, and *Visual Mathematics*. “Brings together artists and scientists, educators and students devoted to, or interested in, the research and understanding of the concept and application of symmetry,” holds symposia, and publishes journals on this subject.

*National Council of Teachers of Mathematics*. Web site: <http://www.nctm.org>. This organization holds yearly national and regional conferences, and all include a fair number of sessions devoted to arts integration, at varying levels of sophistication. The visual arts are the most popular art form for integration with mathematics at these events, but there are also usually sessions on fiber arts, music, and sometimes dance or movement.

*OSME, Origami in Science, Math, and Education*. See

<http://www.langorigami.com/science/4osme/4osme.php4>, the site for the 4<sup>th</sup> International Conference of this organization. Conferences were held in 1989, 1994, 2001, and 2006, and each conference has generated a Proceedings volume. Origami is the Japanese art of paper folding, and recent developments in origami have expanded its reach into the folding of all kinds of objects!

## MATH AND THE ARTS – GENERAL

*ArtsEdge*, at <http://artsedge.kennedy-center.org/>. Maintained by the John F. Kennedy Center for the Performing Arts and the Marco Polo Education Foundation. Clicking on “Lessons” under “Teach” brings up 43 lesson plans (as of 9/02/07) linking math with the arts, the majority dealing with the visual arts. Other links help educators “...teach in, through, and about the arts by providing the tools to develop interdisciplinary curricula that fully integrate the arts with other academic subjects.”

Beveridge, W.I.B. (1950). *The Art of Scientific Investigation*. Vintage Books. Beveridge sees

scientific investigation seen as a creative art, and helps bridge the gap between “the two cultures.”

Cornett, Claudia E. (3rd Edition, 2006). *Creating Meaning Through Literature and the Arts: An Integrated Resource for Classroom Teachers*. Prentice-Hall. Though she does not include a large number of activities relating to math, Cornett’s book is a limitless resource of arts integration ideas and strategies.

Emmer, Michele (2000-2005). *Mathematics and Culture, volumes I – V*. Springer. Five volumes of articles on all aspects of culture and mathematics. Expensive, but maybe your library has them!

Eppstein, David (Accessed 8/26/07). *The Geometry Junkyard* by: <http://www.ics.uci.edu/~eppstein/junkyard/> A web site with clippings, articles, problems, “and other stuff related to discrete and computational geometry,” some serious, some entertaining.

Devlin, Keith. (1994). *Mathematics, the Science of Patterns: The Search for Order in Life, Mind, and the Universe*. New York: Scientific American Library. An illustrated look at contemporary mathematics, which Devlin defines as the “science of patterns.”

Fife, Earl, and Larry Husch (Accessed 8/26/07). <http://archives.math.utk.edu/topics/artMusic.html> A site with links on mathematics and the arts and music, part of the Math Archives site.

Gardner, Martin (2001). *The Colossal Book of Mathematics: Classic Puzzles, Paradoxes, and Problems*. W.W. Norton and Company. Frequently people tell me that because they always wanted to know more about mathematics, they have gotten out their old college algebra text and are planning to work their way through it. “No!” I shout, “Throw it away, read anything by Martin Gardner instead!” Gardner is the most important popularizer of mathematics in the last 100 years, and this volume collects 50 of his best mathematics essays. Or get the CD of his collected Mathematical Games columns.

Gardner, Martin (2005). *Martin Gardner’s Mathematical Games*. Mathematical Association of America. 4500 pages of Martin Gardner’s extraordinary writings on all kinds of subjects, but mostly the mathematical. He is a beautiful writer, and he writes fluidly on topics as diverse as literature, the arts, and philosophy, as well as mathematics.

Gould, Stephen Jay (2000). *Crossing Over Where Art and Science Meet*. Three Rivers Press. Short, erudite and enjoyable essays on the visual art of science.

*Journal of Mathematics and the Arts*. (2007). Published online by Taylor & Francis, at <http://www.tandf.co.uk/journals/titles/17513472.asp>. A peer reviewed journal on connections between mathematics and the arts, that began publishing in 2007. Early issues had articles on paintings, beading, sand drawings, sculpture, and poetry.

Kapraff, Jay (1990). *Connections, The Geometric Bridge between Art and Science*. McGraw-Hill. A free-ranging exploration of mathematics, the arts, from the point of view of design science.

Kemp, Martin (2001). *Visualizations: The Nature Book of Art and Science*. Univ. of Calif. Press. Illustrated and philosophical essays on science and the arts.

King, Jerry P. (1993). *The Art of Mathematics*. Ballantine Books, republished by Dover

Publications, Inc. in 2006. A dissertation on the connections between the aesthetics of mathematics and the aesthetics of the arts.

Peterson, Ivars (2001). *Fragments of Infinity: A Kaleidoscope of Math and Art*. Wiley. Focuses mostly on recent mathematically inspired sculpture.

Sinclair, Nathalie, David Pimm, and William Higginson (editors, 2006). *Mathematics and the Aesthetic: New Approaches to an Ancient Affinity*. Springer. Essays of a philosophical, psychological, and historical nature on the connections between mathematical and artistic processes.

White, Alvin M. (1993). *Essays in Humanistic Mathematics*. The Mathematical Association of America. Mathematics, like the arts, uses metaphor, has ambiguity, and is as much a part of the humanities as the sciences. Essays dealing with philosophy, culture, and the arts.

## **MATH ANXIETY**

Kogelman, Stanley, and Joseph Warren (1979). *Mind Over Math: Put Yourself on the Road to Success by Freeing Yourself from Math Anxiety*. McGraw-Hill. Accessible description and counterbalance to myths about mathematics.

*Platonic Realms MiniTexts*, "Coping with Math Anxiety". Accessed 8/28/07 at <http://www.mathacademy.com/pr/miniText/anxiety/>. Web site devoted to exploring and exploding myths about mathematics.

Tobias, Sheila (1978). *Overcoming Math Anxiety*. W W Norton & Co Ltd. The classic study of math anxiety, still quite relevant. The first half of the book goes over some of the most common myths about mathematics ability in a very readable and supportive manner.

## **ARCHITECTURE**

O'Connor, J. J. and E. F. Robertson (2002). *Mathematics and Architecture*. Accessed 8/28/07 at <http://www-history.mcs.st-and.ac.uk/HistTopics/Architecture.html>. A short essay on mathematics and architecture, with many references.

*Nexus*. <http://www.nexusjournal.com/>. Birkhauser. An online and print journal on mathematics and architecture.

## **DANCE**

Blowers, J.V. 2001. Matrices, contra dancing and quilts. (Aug. 12). Accessed 8/24/07 at <http://jimvb.home.mindspring.com/Matcontra.htm>. What do mattress flipping, contra dance, and quilts have in common? The symmetries are very similar, and this article goes into the details.

Gilbert, Anne Green (1977). *Teaching the Three R's Through Movement Experiences, A Handbook for Teachers*, see section on Mathematics, pp 83-146. First published by Burgess Publishing Company in 1977, republished by Prentice-Hall, Inc. Available from

www.creativedance.org. Many, many ideas for movement activities, somewhat oriented toward primary grades, but adaptable to others.

Gilbert, Anne Green. *Creative Dance for All Ages: A Conceptual Approach*. American Alliance for Health, Physical Recreation, and Dance. Hundreds of dance activities, organized according to the “elements of dance: time, space, force, body, and movement;” many could be expanded to highlight their mathematical elements as well.

Peterson, Ivars. “Contra Dancing, Matrices, and Groups,” in Science News Online, Mathland, accessed 8/24/07 at <http://www.sciencenews.org/articles/20030308/mathtrek.asp>, March 8, 2003; Vol. 163, No. 10. An online article about mathematics of contra dance.

Schaffer, Karl, Stern, Erik, & Kim, Scott. (2001). *Math Dance with Dr. Schaffer and Mr. Stern* (Prelim. Ed.). Santa Cruz, CA: MovespeakSpin, available through <http://www.mathdance.org>. A book of classroom activities dedicated to simultaneous classroom explorations of math and the art form of dance.

Schaffer, Karl. <http://www.mathdance.org/MathDance-Bibliography.pdf>. A web page with an annotated bibliography on mathematics and dance, maintained by Karl Schaffer, published originally as Chapter 14 of Schaffer, Stern and Kim’s Math Dance.

Watson, Anne (Accessed 8/26/07 at <http://www.icme-organisers.dk/tsg14/TSG14-11.pdf>). *Dance and mathematics: power of novelty in the teaching of Mathematics*. An academic paper on the power of dance to engage students in the math classroom; not many examples of lessons, but lots of ideas about the possibilities and intellectual background for this kind of work.

## **ETHNOMATHEMATICS AND MULTICULTURALISM**

Ascher, Marcia. (1991). *Ethnomathematics: A Multicultural View of Mathematical Ideas*. Pacific Grove, CA: Brooks/Cole Publishing Company. In depth look at mathematical thinking, drawn from a variety of cultures.

Ascher, Marcia. (2002). *Mathematics Elsewhere: An Exploration of Ideas Across Cultures*. Princeton Univ. Press. Further in-depth essays by Ascher on the ethnomathematics of a number of cultures.

Bazin, Maurice, Modesto Tamez, of the Exploratorium Teacher Institute (2002). *Math and Science Across Cultures: Activities and Investigations from the Exploratorium*. Innovative classroom activities that connect math, science, and cultures from around the world, developed at the Exploratorium in San Francisco.

Braxton, Beverly, Philip Gonsalves, Linda Lipner, and Jacqueline Barber (1996). *Math Around the World: Teacher's Guide : Grades 5-8*. Univ. of California Press. Mathematics lessons connected to world cultures.

Closs, Michael P. (editor, 1996). *Native American Mathematics*. Univ. of Texas Press. Articles on the wide range of mathematics developed by Native Americans.

Culin, Stewart (1992). *Games of the North American Indians, Vol. 1: Games of Chance*. Univ. of Nebraska Press. This book collects and describes many North American Indian games of chance, in which strategizing involved knowledge of probability,

Eglash, Ron (1999). *African Fractals: Modern Computing and Indigenous Design*. Rutgers Univ. Press. Eglash traces the occurrence of fractal design in indigenous African art and culture.

Gerdes, Paulus. (1999). *Geometry from Africa: Mathematical and Educational Explorations*. Washington, DC: Mathematical Association of America. Gerdes is one of the primary expositors of mathematics from Africa, and this work is aimed at showing educationally useful connections, especially between geometry and the arts.

Gerdes, Paulus (1998). *Women, Art and Geometry in Southern Africa*. Africa World Press. Women and the geometric arts of Africa.

Joseph, George Gheverghese (new edition, 2000, originally published by Penguin in 1992). *The Crest of the Peacock: Non-European Roots of Mathematics*. Princeton Univ. Press. Detailed historical account of mathematical developments outside Europe.

Nelson, David, Joseph, George Gheverghese, and Williams, Julian (1993). *Multicultural Mathematics*. Oxford University Press.

Powell, Arthur B. and Frankenstein, Marilyn (1997). *Ethnomathematics: Challenging Eurocentrism in Mathematics Education*. Albany: State University of New York Press. A collection of articles on ethnomathematics, many of which see ethnomathematics as a means of combatting Eurocentrism in mathematics education.

Schaffer, Karl. [http://nebula.deanza.fhda.edu/math/karl/Multicult\\_biblio\\_V4\\_5\\_01.htm](http://nebula.deanza.fhda.edu/math/karl/Multicult_biblio_V4_5_01.htm). An annotated bibliography on mathematics and multiculturalism.

Selin, Helaine (editor, 2000). *Mathematics Across Cultures: the History of Non-Western Mathematics*. Kluwer Academic Publishers. The second volume in a history of non-western science, with 21 articles on mathematics in cultures outside the United States and Europe.

Zaslavsky, Claudia. (1973). *Africa Counts: Number and Pattern in African Culture*. Boston, MA: Prindle, Weber & Schmidt, Inc. The history and development of mathematics in Africa.

Zaslavsky, Claudia (1993). *Multicultural Mathematics: Interdisciplinary Cooperative-Learning Activities*. J. Weston Walch.

## **FIBER ARTS**

belcastro, sarah-marie (Accessed 8/26/07). <http://www.toroidalsnark.net/mathknit.html>. sarah-marie's math and knitting site.

Beyer, Jinny (1991). *Designing Tessellations : The Secrets of Interlocking Patterns*. McGraw-Hill. Creating tessellation designs for use in quilting.

Chaky, Rebecca (Accessed 8/26/07). <http://members.aol.com/mathquilt/> A web page with links to sites devoted to mathematics and quilting.

Harris, Mary. (1997). *Common Threads: Women, Mathematics and Work*. Staffordshire, England: Trentham Books. A book about the way in which mathematical thinking has been “woven” throughout the sewing and cloth work of women throughout history.

Venters, Diana and Krajenke Ellison, Elaine (1999). *Mathematical Quilts: No Sewing Required!* Key Curriculum.

Venters, Diana and Krajenke Ellison, Elaine (2003). *More Mathematical Quilts: No Sewing Required!* Key Curriculum.

## LITERATURE AND READING

Anno, Mitsumasa (1997). *Anno's Math Games 3*. Putnam Juvenile. Anno's books often deal with mathematical puzzles and content; this one has a geometric flavor.

Doty, Jane K., Gregory N. Cameron, and Mary Lee Barton (2002). *Teaching Reading in Mathematics*. McRel. How to integrate mathematics and reading lessons.

Fadiman, Clifford (1958). *Fantasia Mathematica*. Fireside. A collection of short mathematical fiction.

Fadiman, Clifford (1962). *The Mathematical Magpie*. Simon and Schuster. A second collection of mathematical literature, humorous and serious, including poems, cartoons and more, edited by Fadiman. Republished in 1997 by Springer.

Frucht, William (editor, 2000). *Imaginary Numbers: An Anthology of Marvelous Mathematical Stories, Diversions, Poems, and Musings*. Wiley. An anthology of imaginative writings about mathematics.

Kasman, Alex (2005). *Reality Conditions: Short Mathematical Fiction*. The Mathematical Association of America. Humorous and dramatic short stories with a mathematical bent.

Shannon, George (1991). *Stories to Solve: Folktales from Around the World*. Harper Trophy. Stories and folk tales involving logical puzzles. See also Shannon's sequels published by Greenwillow, in 1991 and 1994.

Thiessen, Diane, Margaret Matthias, Jacquelin Smith (1998). *The Wonderful World of Mathematics: A Critically Annotated List of Children's Books in Mathematics*. National Council of Teachers of Mathematics. An annotated list of over 550 children's books having mathematical content.

Welchman-Tischler, Rosamond (1992). *How to Use Children's Literature to Teach Mathematics*. National Council of Teachers of Mathematics. Ways teachers can use children's literature and mathematics together.

Wilde, Sandra, and David J. Whitin (1992). *Read Any Good Math Lately?: Children's Books for Mathematical Learning, K-6*. Heinemann. Resources for linking reading and mathematics teaching.

Wilde, Sandra, and David J. Whitin (1995). *It's the Story that Counts: More Children's Books for Mathematical Learning, K-6*. Heinemann. More resources for linking reading and mathematics teaching.

## **MUSIC**

Benson, Dave (2006). *Music: A Mathematical Offering*. Cambridge Univ. Press. A serious and technical look at the mathematics of music.

Fauvel, J., R. Flood, and R. Wilson (editors, 2003). *Music and Mathematics: from Pythagoras to Fractals*. Oxford Univ. Press. A collection of essays on aspects of mathematics and music.

Garlan, Trudi Hammel, and Charity Vaughan Kahn (1995). *Math and Music: Harmonious Connections*. Dale Seymour Publications. An accessible look at math and music.

Harkleroad, Leon (2006). *The Math Behind the Music*. Cambridge Univ. Press. An accessible introduction to several linkages between mathematics and music. Especially useful is the final chapter, "How *Not* to Mix Mathematics and Music."

Rothstein, Edward (1995). *Emblems of Mind: The Inner Life of Music and Mathematics*. Crown. A philosophical and historical look at mathematics and music.

## **THEATER**

Kirsten Shepherd-Barr (2006). *Science on Stage: From "Doctor Faustus" to "Copenhagen"*. Princeton Univ. Press. An analysis of theatrical works dealing with scientific content, including some mathematically oriented works.

## **VISUAL ARTS**

Britton Jill (1999). *Investigating Patterns: Symmetry, and Tessellations*. Classroom activities on symmetry and tessellations.

Day, Lewis F. (1999). *Pattern Design*. Dover Publications. A compendium of mathematical patterns from various cultures.

Emmer, Michael (editor, 1993). *The Visual Mind: Art and Mathematics*. The MIT Press. Learned essays on mathematics and the visual arts.

Emmer, Michael (editor, 2005). *The Visual Mind II*. The MIT Press. Further essays on mathematics and the arts, but this volume delves also into computer graphics, the philosophy of aesthetics, and cinema.

Hull, Thomas (2006). *Project Origami: Activities for Exploring Mathematics*. A. K. Peters, Ltd. Classroom activities connecting mathematical topics with origami.

Hargittai, Istvan, and Magdolna Hargittai (1994). *Symmetry: A Unifying Concept*. Shelter Publications, Inc. A visually rich picturebook about symmetry.

Kim, Scott (1996). *Inversions*. Key Curriculum Press. Scott Kim's play with letterforms and symmetry, including a chapter on how to create your own.

Schattschneider, Doris (2004). *M.C. Escher: Visions of Symmetry*. Harry N. Abrams. A detailed history and analysis of Escher's mathematical work.

Schattschneider, Doris, and Michele Emmer (editors, 2003). *M.C. Escher's Legacy: A Centennial Celebration*. Springer. Lavishly illustrated essays from the centennial conference honoring Escher's birth.

Seymour, Dale, and Jill Britton (1986). *Introduction to Tessellations*. Dale Seymour Publications. Step-by-step directions for making tessellations, plus discussions of mathematics of symmetry.

Slocum, Jerry, Jacob Botermans, et al (2003). *The Tangram Book*. Sterling. Tangrams are a beautiful puzzle form that lend themselves to many kinds of math and arts lessons; this book goes into the history and development of tangrams.

Washbourn, Dorothy K. and Donald W. Crowe (1991). *Symmetries of Culture*. Univ. of Washington Press. Mathematical analyses of symmetrical patterns from a variety of cultures.

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