# Problem-Based Inquiry Series in Mathematics

This series of problem-based inquiries is designed to supplement a primary mathematics curriculum. All inquiries emphasize interdisciplinary project/problem based learning and apply academic math content through the investigation of real world issues and questions. Each inquiry is conducted in 1-3, 50-minute sessions, privately with a student or in small groups by special arrangement. Inquires can be conducted as stand alone sessions or strung together to compose an entire unit. Each inquiry can be adapted for students in grades 6-12.

**Student learning** - This type of learning mimics the real life practices of mathematicians and scientists. Through this work students gain an enhanced sense of confidence, relevance, wonder, agency, and appreciation, not just for the study of mathematics, but for the overall process of learning. Additionally, the process strengthens students' depth of understanding of math concepts and facility with a wide range of mathematical skills.

**Inquiry process** - The concept of "authentic inquiry" refers to a natural, organic way of learning much akin to how humans learn as toddlers--asking questions and exploring for answers. In these inquiries the questions provide a launching point for investigations with the teacher acting as facilitator and guide. Each student's learning in a particular inquiry is unique, shaped by their personality and curiosity, and in all cases leading them to engage and learn new mathematics in response to their inquiry.

The workshop descriptions that follow contain only key questions without math content indicated. This is a central part of the pedagogical design, for students to determine the appropriate math tools themselves for each problem with the coaching of the teacher. To learn more about specific math content in any particular inquiry **contact Scott Beall: scott@scottbeall.com - 917.301.3530**

***Scott Beall***

*A central focus of Mr. Beall's work is innovation in mathematics education, education for sustainability, youth empowerment programs, and holistic interdisciplinary curricular design. Mr. Beall holds a masters degree in mathematics education from Stanford University and has been teaching in public schools and consulting for nearly 28 years. A published author of innovative mathematics education curricula (Functional Melodies, Key Curriculum Press), Mr. Beall is a regular speaker at conferences and has led teacher training workshops internationally as a consultant. For more information on Mr. Beall's work (Integral Vision Learning) visit the website: www.scottbeall.com*

# Inquiry Topics

## *Sustainability*

**1. The End of Oil:** When will all the oil reserves of planet earth be consumed? What is the value of math as a source of truth? What is the epistemology of math? How are projections made? What is the value of math as a source of truth?

**2. Ocean Fisheries:** What dynamics and parameters are in play for sustainable ocean fisheries? What economic decisions and geopolitical implications are inherent in managing ocean fisheries? What does civilization need to pay most attention to in order to preserve the future of ocean fisheries?

**3. Global Ecological Footprint:** What is an ecological footprint and when will humanity reach carrying capacity on Earth? What can be done to reduce per capita ecological footprints? What is the relationship between standard of living, population, land area, and a nation's ecological footprint?

**4. Thermal solar energy technology design (Concentrated solar energy):** What are the physical principles in play in solar thermal electricity generation and how can a collector be designed? (In this problem the student will create the mathematics to design a solar thermal collector).

**5. Energy Audit:** How can any facility, a home, business, school, etc. reduce its energy consumption, lower its footprint and reduce cost of operation? (This inquiry involves conducting an audit of a facility of the student's choosing).

## *Music*

**6. Music composition and theory:** Can music be composed using mathematical functions? Will such music sound "good?" What is the role of mathematics in aesthetics? Where is the boundary between art and mathematical thinking in the process of music? (This inquiry is project based, involving the student in creating their own original music composition using mathematical functions and the MuseScore software.)

**7. Physics of sound--scale temperament:** Is the musical scale a creation of technology, a man made tuning, or is it inherent in nature? How are guitars and pianos tuned and designed? What is the history of this development? What are the musical issues associated with this topic?

**8. The Mathematics of Polyrhythms:** What are polyrhythms? What is the mathematical basis of complexity in music from various cultures?

**9. Record Producer Algebra:** How do music programmers use Algebraic thinking to program music? How does the use of mathematics make life easier

## *Physics and Engineering*

**10. Make a Pendulum Wave Machine:** What factors determine the frequency of a pendulum swing? What is simple harmonic motion and how does it connect music, math and pendulums? What is a pendulum wave machine, what does it demonstrate and how can it be constructed?

**11. Golden Gate Bridge Suspension Cables:** How are the lengths of suspension cables on a suspension bridge calculated? How long are the cables of the Golden Gate Bridge in San Francisco, CA? (In this inquiry the actual plans of the Golden Gate Bridge are used as a resource to perform the calculations).

**12. Design a "Brise Soleil":** What is a Brise Soleil? What factors must be considered in its design? How and why does it work? Why is it important? (A Brise Soleil is an architectural retrofit of windows in a building to reduce heat retention and provide cooling, reducing energy consumption.)

**13. Time dilation:** What are some of the discoveries that made Albert Einstein famous? What is the theory of relativity? What is the relationship between time, mass and velocity for any object? Can that be measured and calculated? How do we know it is true?

## *General*

**14. Fibonacci numbers and the Golden Section Rectangle:** What is the Fibonacci number sequence, the golden section rectangle and how are they related? Where have they shown up in history and in art and music?

**15. Fractal Geometry-The Koch Snowflake:** What are fractals and why are they useful? How does one create a generalized formula from a pattern? How can an infinite series equal a finite number?

**16. Special Problems in Logic and Strategy:** This category emphasizes logic, creative problem solving, ingenuity, and perseverance in an assortment of often open ended problems that include Corey The Camel, Checkerboard Squares, Bobo and the Train, The Commuter Train, Its All Gone and more.

**17. Student designed problem project:** Original problem on research on existing classical math problem. This might include finding mathematical underpinnings of any area of interest, as well as career research.