Growing STEM Skills
Using Outdoor Maths

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Math is like ice cream, with more flavours than you can imagine- and if all your students ever do is textbook math, that's like feeding them broccoli-flavoured ice cream.

~Denise Gaskins

Teaching Math (*and STEM*) through sustainability

"Students often wonder about math--what is it good for? Why should I learn it? The world is facing a range of serious challenges on issues such as the environment, energy, and climate change and mathematics has an important role to play in understanding and addressing these sustainability issues. In addition to providing our students with the opportunity to see how math can be applied to important real world problems, lessons that address sustainability through math can provide students with the opportunity to make a positive contribution to addressing the challenges of sustainability in their schools, home and community."

Source- Mathematics Awareness Month, April 2013

http://www.mathaware.org/mam/2013/sustainability/#scmlessons

Outdoor Math- An Effective Instructional Strategy

Teaching sustainability and math concepts outside fosters learning that is:

- **Active** - students explore and experience sustainability and math concepts through hands on, concrete, kinesthetic activities
- **Meaningful** - students connect and extend math big ideas and concepts to real world situations and sustainability issues in their community
- **Engaging** - students see themselves as problem solvers as they construct or apply their understanding of concepts by solving relevant problems to make sense of their world

Sustainability: Big Ideas

In our every deliberation, we must consider the impact of our decisions on the next seven generations.

Great Law of the Iroquois Confederacy

Big Ideas of Sustainability http://sustainableschoolsproject.org/tools-resources/starter-kit	**Essential Questions**
Community *A group of living and non-living things sharing a common purpose or space*	Who lives in our human and natural communities? What is our responsibility to our community?
Systems *Parts that are connected through larger patterns*	What systems are you a part of? How do you affect and make changes in systems?
Diversity *All systems and places function because of variety*	Why is diversity important? In what ways is human diversity related to biodiversity?
Interdependence *All living things are connected. Every organism, system and place depends on others*	In what ways do you depend on natural systems? How are human and natural systems interrelated?
Equilibrium A state of balance	Why do animals or humans move from place to place?
Cycles *Every organism and every system goes through different stages*	What cycles can we find in our community? In what ways do we impact cycles?
Changes over time *All organisms, places and systems are constantly changing*	How has our community changed over time?
Limits *Every system has a carrying capacity*	What are limits in the natural world? What limits have you experienced? What can we learn from limits?
Fairness/Equity *Resources need to be shared to meet the needs of living things- across places and generations*	Is there a difference between wants and needs? Why is it important to think about the future?
Place *Natural and human communities together make up one's place*	How do humans and the natural world interact? How does where we live impact how we live?
Ability to make a difference *Everyone has the ability to change or impact a system, community and themselves*	What does it mean to be a citizen in our neighborhood? What is your responsibility to yourself, your community, and the world?
Long-term Effects *Actions will have effects beyond immediate reactions*	How do your actions impact the future of others?

Mathematics: Big Ideas

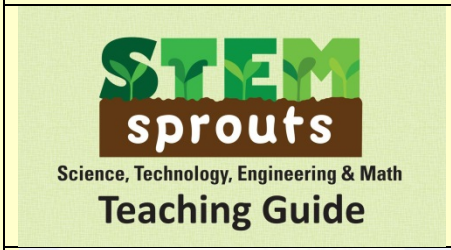
NUMBERS: The set of real numbers is infinite, and each real number can be associated with a unique point on the number line.	**ESTIMATION:** Numerical calculations can be approximated by replacing numbers with other numbers that are close and easy to compute with mentally. Measurements can be approximated using known referents as the unit in the measurement process.	**ORIENTATION & LOCATION:** Objects in space can be oriented in an infinite number of ways, and an object's location in space can be described quantitatively.
THE BASE TEN NUMERATION SYSTEM: The base ten numeration system is a scheme for recording numbers using digits 0-9, groups of ten, and place value.	**PATTERNS:** Relationships can be described and generalizations made for mathematical situations that have numbers or objects that repeat in predictable ways.	**TRANSFORMATIONS:** Objects in space can be transformed in an infinite number of ways, and those transformations can be described and analyzed mathematically.
EQUIVALENCE: Any number, measure, numerical expression, algebraic expression, or equation can be represented in an infinite number of ways that have the same value.	**VARIABLE:** Mathematical situations and structures can be translated and represented abstractly using variables, expressions, and equations.	**MEASUREMENT:** Some attributes of objects are measurable and can be quantified using unit amounts.
COMPARISON: Numbers, expressions, and measures can be compared by their relative values.	**PROPORTIONALITY:** If two quantities vary proportionally, that relationship can be represented as a linear function.	**DATA COLLECTION:** Some questions can be answered by collecting and analyzing data, and the question to be answered determines the data that needs to be collected and how best to collect it.
OPERATION MEANINGS & RELATIONSHIPS: The same number sentence (e.g. 12-4 = 8) can be associated with different concrete or real-world situations, AND different number sentences can be associated with the same concrete or real-world situation.	**RELATIONS & FUNCTIONS:** Mathematical rules (relations) can be used to assign members of one set to members of another set. A special rule (function) assigns each member of one set to a unique member of the other set.	**DATA REPRESENTATION:** Data can be represented visually using tables, charts, and graphs. The type of data determines the best choice of visual representation.
PROPERTIES: For a given set of numbers there are relationships that are always true, and these are the rules that govern arithmetic and algebra.	**EQUATIONS & INEQUALITIES:** Rules of arithmetic and algebra can be used together with notions of equivalence to transform equations and inequalities so solutions can be found.	**DATA DISTRIBUTION:** There are special numerical measures that describe the center and spread of numerical data sets.
BASIC FACTS & ALGORITHMS: Basic facts and algorithms for operations with rational numbers use notions of equivalence to transform calculations into simpler ones.	**SHAPES & SOLIDS:** Two- and three-dimensional objects with or without curved surfaces can be described, classified, and analyzed by their attributes.	**CHANCE:** The chance of an event occurring can be described numerically by a number between 0 and 1 inclusive and used to make predictions about other events.

Outdoor Math Activities

Activity	Description	Concepts	Source(s)
1. Energy Highs and Lows	**K-3** Students investigate local area to find extremes of light and wind energy. **4-6** Student learn about microclimates as they investigate the range of physical factors (light,wind,temperature, etc) in the area and compare findings to patterns of animal and plant distribution **7-8** Students investigate the urban heat islands. By measuring heat radiation of different surfaces, student look for patterns of how the natural and built environments influence physical environmental conditions of an area	• energy flows • human impact-built spaces • community • limits (wind/heat/light) • probability • data collecting • non standard measuring • standard measuring • patterning	OBIS: Outdoor Biology Instructional Strategies Sensory Hi-Lo Hunt http://www.outdoorbiology.com/files/resources/activities/SensoryHi-LoHunt.pdf OBIS: Terrestrial Hi-Lo Hunt http://www.outdoorbiology.com/TerrestrialHiLoHunt Exploring Microclimates https://ecologyexplorers.asu.edu/docs/explorers/lesson_plans/exploring_microclimates.pdf Urban Heat Island https://ecologyexplorers.asu.edu/overview/urban-heat-island/
2. Plant Hunt	**K-3** Students determine how many different plant species are growing in one or two areas **4-6** Students determine diversity of plants- among or within species using transects or random sampling **7-8** Students determine plant diversity and patterns of distribution	• biodiversity • sense of place • data collecting • sorting • classifying	OBIS: Outdoor Biology Instructional Strategies Plant Hunt http://www.outdoorbiology.com/PlantHunt Plant Patterns http://www.outdoorbiology.com/files/resources/activities/PlantPatterns.pdf
3. Losing Ground	**K-3** Students count numbers of invasive species in small study areas and compare different locations **4-6** Students look at populations of invasive species and ways to survey numbers/ percentages of different invasives **7-8** Students determine ratio of invasive plants to total plant diversity using a variety of survey methods- transects, random sampling, or percentage ground cover	• interdependence • biodiversity • cycles • collecting and counting • sorting • graphing	The Black Spot – Pirate Maths Outdoors http://creativestarlearning.co.uk/maths-outdoors/the-black-spot-pirate-maths-outdoors/ Invasive Plant Survey http://www.caryinstitute.org/educators/teaching-materials/changing-hudson-project/invasive-species/invasive-plant-survey Tracking Aliens http://www.projectnoah.org/reports/PN_Tracking_Aliens_Sample_Lesson.pdf

4. Where does the water go?	**K-3** Students determine if water is able to be absorbed by different ground surfaces **4-6** Students investigate if the living community of an area is adversly affected by soil compaction by comparing soil compaction and biodiversity in an area **7-8** Students investigate patterns of water movement through the school ground and compare it to surfaces, soil types, slope and drainage and connect it local issues related to storm sewers and flooding	• matter cycles • human impact – compaction • permeability • data collecting • timing • classifying	Impacts of Schoolyard traffic http://www.caryinstitute.org/educators/teaching-materials/syefest/lesson-plans/impacts-schoolyard-traffic Soil Permeability http://www.education.com/science-fair/article/soil-permeability/ Hold a Hill: slope and erosion http://www.outdoorbiology.com/files/resources/activities/HoldAHill.pdf Trail Impact Study http://www.outdoorbiology.com/files/resources/activities/TraillmpactStudy.pdf
5. The Giving Trees	**K-3** Students survey trees and count how animals are using each tree for a home (nests, holes). Alternatively, Students gather leaf samples and look for evidence that animals are eating the leaves. Students sort and tally the different ways. **4-6** Students survey and measure trees to compare trees potential to produce oxygen or paper **7-8** Students survey local tree populations and calculate the economic and ecological benefits of their trees based on species and diameter of each tree	• interdependence • human impact • data collecting • standard measuring • scaling • graphing	Search for animal homes http://www.nwf.org/kids/family-fun/outdoor-activities/animal-house-hike.aspx Mystery Marauders http://www.outdoorbiology.com/files/resources/activities/MysteryMarauders.pdf Calulate the economic and ecological benefits of trees http://www.treebenefits.com/calculator/

Resources

STEM Guides	Description and link
	**STEM SPROUTS** The goal of this guide is to assist educators in focusing and refining the naturally inquisitive behaviors of **three to five-year-olds** on science, technology, engineering, and math. It includes general information on how young children explore science topics as well as specific activity suggestions http://www.bostonchildrensmuseum.org/sites/default/files/pdfs/rttt/stem/english/STEM_Guide_English.pdf
	**Greening STEM Toolkit** Compiling activities and resources from five former toolkits on gardens, energy, geography, water and climate, this toolkit is your ultimate easy-to-use guide for lessons in greening STEM http://eeweek.org/sites/default/files/GreeningSTEMToolkit_FINAL.pdf
	**Using Technology to Connect Students & the Environment** EE Week partnered with Project Noah to develop a toolkit that includes activities and resources at all grade levels. Includes suggested apps for connecting to the natural world http://eeweek.org/sites/default/files/Video_Toolkit.pdf

Resources con't

Sustainability Big Ideas:

http://sustainableschoolsproject.org/education

http://sustainableschoolsproject.org/tools-resources/starter-kit

Math Big Ideas and Guides to Effective Instruction

Big Ideas and Understandings as the Foundation for Elementary and Middle School Mathematics
http://www.miedocdoc.com/file/big-ideas-and-understandings-as-the-foundation-for-.html

Data Management and Probability K-3
http://www.eworkshop.on.ca/edu/resources/guides/Data_Management_and_Probability_K-3.pdf

What Works? Research into Practice
http://www.edu.gov.on.ca/eng/literacynumeracy/inspire/research/whatworks.html

- ***August 2014:*** *Making Math Children Will Love: Building Positive Mathitudes to Improve Student Achievement in Mathematics*
- ***March 2007:*** *Learning Mathematics vs Following the Rules: The Value of Student Generated Methods*
- ***November 2009:*** *Problem-Based Learning in Mathematics*
- ***June 2011:*** *Word Problems*

Articles

iSTEM: Celebrating Earth Day with Sustainability, Amanda Sibley and Terri L. Kurz; Edited by Jorge Garcia, Teaching Children Mathematics, April 2014, Vol. 20, Issue 8

Problem Solvers: Solutions: Counting is for the birds www.nctm.org teaching children mathematics • February 2011 333 problem solvers

Bird Station Investigation, Julie Poth,
Teaching Children Mathematics, October 2006, Vol. 13, Issue 3

Collecting Data Outdoors: Making Connections to the Real World Carol G. Basile
http://www.billselak.com/educ448/docs/DataCollectingMathEnvironment.pdf

Trailblazers, Lyn D. English, Steve Humble and Victoria E. Barnes
http://uca.edu/steminstitute/files/2011/07/TrailblazersTCM2010-03-402a.pdf

Designing Math Trails for the Elementary School Kim Margaret Richardson
http://britton.disted.camosun.bc.ca/geometry/NCTM_Math_Trail.pdf

Outdoors maths
http://www.slideshare.net/KlausGroenholm/outdoor-math-outdoor-learning-and-play

Early Years Math Resources
Open Up to Outdoor Mathematics
http://outdoormatters.co.uk/open-up-to-outdoor-mathematics/

I'm a teacher, get me OUTSIDE here! Math Outdoors
http://creativestarlearning.co.uk/c/maths-outdoors/

The Outdoor Mathematician
http://www.slideshare.net/BenBeckers/the-outdoor-mathematician-early-years-outdoors-learning

Intermediate Math/Sustainability Resources

http://maths4sustainability.wordpress.com/

http://www.mathaware.org/mam/2013/sustainability/