Introduction to the Mathematics Correlation

Correlation between National Common Core Standards for Mathematics and the North American Association for Environmental Education Guidelines for Excellence in Environmental Education

Mathematics is a critical subject in problem solving. It is a one of the major tools in the identification and assessing of our environment. It empowers a person to use a means of studying and recording all aspects of our ecosystem using quantitative and qualitative methods.

It is essential to the process of learning about our environment that "each person" has garnered a complete package of skills and concepts to make informed decisions. Hungerford and Volk (1990) recommend that skills for problem solving are essential for identifying and solving environmental problems.[i] In *A Problem Solving Approach to Environmental Problem Solving*, Quetal (1985) states it is crucial to have appropriate skills for problem solving to permit investigations that have merit and value.[ii] Good problem solving requires substantive mathematical skills. These must be in the repertoire of any person who is seeking to make an informed decision about our earth and our environment.

The National Council of Teachers of Mathematics and the National Research Council are unequivocal in their standards and principles that mathematics must be used in the context of problem solving. Connections to in-field study are critical to understanding relationships between mathematics and problem solving. It is especially poignant that mathematics connections and problem solving be used to make sense of phenomena such as the interactive systems of our earth and environment.

The *Common Core State Standards for Mathematics* are connected to National Council for Teachers of Mathematics Standards [iii] and the National Research Council's document, *Adding Up*.[iv] Kentucky's Common Core aligns with all of these organizations and their standards. It is necessary for the Kentucky Environmental Education Council, its Environmental Literacy Standards, and those of the North American Association for Environmental Education be aligned because mathematics and studying the environment are co-dependent in the process of making informed decisions.

Additionally the Standards of Mathematical Practice articulated in the *Common Core Standards* that include eight points, such as "making sense of problems, reasoning quantitatively, modeling, using appropriate tools," are indeed the essentials for studying mathematics and for studying our environment.

The lens of environmental education offers a number of connections to the *Common Core Standards for Mathematics*. The intent of this (crosswalk – correlation) is to help teachers understand how the *Common Core Standards for Mathematics* compares with expectations found in the *North American Association for Environmental Education Standards for Excellence in Learning (K-12).*

[i] Hungerford, H. and T. Volk. "Changing learner behavior through environmental education." Journal of Environmental Education. Spring 1990, p 8-21.

[ii] Quetel, R., et al. *A problem taking approach to environmental education*. UNESCO-UNEP – International Environmental Education Programme, Division of Science, Technology and Environmental Education. 1985, page 47.

[iii] *Principles and Standards*. National Council of Teachers of Mathematics, Reston, VA, 2008.

[iv] Kilpatrick, J., et al (eds.) *Adding It Up. Center for Education: Division of Behavioral and Social Sciences and Education*. National Research Council, 2001.

Introduction to the North American Guidelines for Excellence in Environmental Education

The North American Association for Environmental Education (NAAEE) first published *Excellence in Environmental Education: Guidelines for Learning (K-12)* in 1999. It is now in its fourth edition (2010). This set of guidelines is part of a series of documents that includes guidelines for excellence for environmental education programs, materials, early childhood environmental education programs, and the preparation and professional development of environmental educators. The guidelines were produced as part of the National Project for Excellence in Environmental Education, and were prepared and reviewed by thousands of individuals and organizations representing all aspects of environmental education. The National Project on Environmental Education has been funded by the US Environmental Protection Agency through the Environmental Education and Training Partnership, under agreement with NAAEE.

The entire series of Guidelines for Excellence in Environmental Education is available free of charge through the NAAEE Website, at http://eelinked.naaee.net/n/guidelines/topics/National-Project-for-Excellence-in-EE. Printed copies may be ordered from NAAEE at (202) 419-0412.

4th Grade Correlations

Common Core Standards for Mathematics	*NAAEE: Guidelines for Learning (4th Grade)*	*Examples/Ideas for Implementation*
Operations & Algebraic Thinking		
1. Use the four operations with whole numbers to solve problems.	–	
2. Gain familiarity with factors and multiples.	–	
3. Generate and analyze patterns.	1E. Organizing information – Learners are able to describe data and organize information to search for relationships and patterns concerning the environment and environmental topics. 1F. Working with models and simulations – Learners understand that relationships, patterns, and processes can be represented by models.	Observe and record seasonal patterns within plant and animal populations. i.e. migration, first flower, fall colors
Numbers & Operations in Base Ten		
4. Generalize place value understanding for multi-digit whole numbers.	–	
5. Use place value understanding and		

properties of operations to perform multi-digit arithmetic.	–	
Numbers & Operations – Fractions		
6. Extend understanding of fraction equivalence and ordering.	–	
7. Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.	–	
8. Understand decimal notation for fractions, and compare decimal fractions.	–	
Measurement & Data		
9. Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.	1A. Questioning – Learners are able to develop questions that help them learn about the environment and do simple investigations. 1B. Designing investigations – Learners are able to design simple investigations. 1C. Collecting information – Learners are able to locate and collect information about the environment and environmental topics.	Collect weather data and convert measurement to other units. For example, convert rain fall data from inches to feet.

10. Represent and interpret data.	1C. Collecting information – Learners are able to locate and collect information about the environment and environmental topics. 1E. Organizing information – Learners are able to describe data and organize information to search for relationships and patterns concerning the environment and environmental topics. 1G. Drawing conclusions and developing explanations – Learners can develop simple explanations that address their questions about the environment.	Collect data on energy sources used in local community and have student graph and interpret information. Collect data on solid waste and recycling. Present data in graphs and interpret results.
11. Geometric measurement: understand concepts of angle and measure angles.	–	
Geometry		
12. Draw and identify lines and angles, and classify shapes by properties of their lines and angles.	–	

8th Grade Correlations

Common Core Standards for Mathematics	*NAAEE: Guidelines for Learning (8th Grade)*	*Examples/Ideas for Implementation*
The Number System		
1. Know that there are numbers that are not rational, and approximate them by rational numbers.	–	
Expressions & Equations		
2. Work with radicals and integer exponents.	–	
3. Understand the connections between proportional relationships, lines, and linear equations.	–	

4. Analyze and solve linear equations and pairs of simultaneous linear equations.	–	
Functions		
5. Define, evaluate, and compare functions.	–	
6. Use functions to model relationships between quantities.	1F. Working with models and simulations – Learners understand many of the uses and limitations of models. (define math "function")	Food web/chain relationships. Effect of limiting factors on population and representing in graphical form.
Geometry		
7. Understand congruence and similarity using physical models, transparencies, or geometry software.	1F. Working with models and simulations – Learners understand many of the uses and limitations of models.	Search online environmental simulations. Have students interpret data and make conclusions about the limitations to the model.

8. Understand and apply the Pythagorean Theorem.	–	
9. Solve real-world and mathematical problems involving volume of cylinders, cones, and spheres.	1C. Collecting information – Learners are able to locate and collect reliable information about the environment or environmental topics using a variety of methods and sources.	Determining the volume of water collected in a rain barrel.
Statistics & Probability		
10. Investigate patterns of association in bivariate data.	1C. Collecting information – Learners are able to locate and collect reliable information about the environment or environmental topics using a variety of methods and sources. 1E. Organizing information – Learners are able to classify and order data, and to organize and display information in ways that help analysis and interpretation. 1F. Working with models and simulations – Learners understand many of the uses and limitations of models.	Collect soil data (oxygen, CO2 levels) and analyze different locations around campus. Have individual students collect data on the number of organisms in a certain area and then combine results from class by determining mean of populations. Have students reflect on the average per person trash output and how it adds up over time. (PBS lesson) Population & Simulation Activity (PBS Activity)

12th Grade Correlations

Common Core Standards for Mathematics – *Number and Quantity*	***NAAEE: Guidelines for Learning (12th Grade)***	***Examples/Ideas for Implementation***
The Real Number System		
1. Extend the properties of exponents to rational exponents	–	
2. Use properties of rational and irrational numbers.	–	
Quantities		
3. Reason quantitatively and use units to solve problems	1E. Organizing information – Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. 1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena.	Create outdoor garden and have students measure soil contents and determine types, amounts, etc. of soil additives to enhance growing conditions. Compare different levels of phosphates and nitrates in different growing areas.
The Complex Number System		
4. Perform arithmetic operations with complex numbers	–	

5. Represent complex numbers and their operations on the complex plane	–	
6. Use complex numbers in polynomial identities and equations	–	
Vector and Matrix Quantities		
7. Represent and model with vector quantities.	1E. Organizing information – Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. 1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena.	Measure wind speeds and directions with classroom built anemometers, weather vanes, etc. Classroom game of kick ball with lessons on best place to kick the ball. (I.e. speed and direction.)
8. Perform operations on vectors.	–	
9. Perform operations on matrices and use matrices in applications.	–	

Common Core Standards for Mathematics – *Algebra*	***NAAEE: Guidelines for Learning (12th Grade)***	***Examples/Ideas for Implementation***
Seeing Structure in Expressions		
1. Interpret the structure of expressions	–	
2. Write expressions in equivalent forms to solve problems	–	
Arithmetic with Polynomials and Rational Expressions		
3. Perform arithmetic operations on polynomials	–	
4. Understand the relationship between zeros and factors of polynomials	–	
5. Use polynomial identities to solve problems	–	
6. Rewrite rational expressions	–	
Creating Equations		
7. Create equations that describe numbers or relationships	1E. Organizing information – Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. 1G. Drawing conclusions and developing explanations – Learners are able to use evidence and logic in developing proposed explanations that address their	Research historical weather data for your area (online) and have students compare seasonal difference in weather conditions as they relate to time of year.

	initial questions and hypotheses.	
Reasoning with Equations and Inequalities		
8. Understand solving equations as a process of reasoning and explain the reasoning	1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena.	
9. Solve equations and inequalities in one variable	-1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena.	
10. Solve systems of equations	–	
11. Represent and solve equations and inequalities graphically	1E. Organizing information – Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. 1G. Drawing conclusions and developing explanations – Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.	

Common Core Standards for Mathematics – **Functions**	***NAAEE: Guidelines for Learning (12th Grade)***	***Examples/Ideas for Implementation***
Interpreting Functions		
1. Understand the concept of a function and use function notation	–	
2. Interpret functions that arise in applications in terms of the context	–	
3. Analyze functions using different representations	–	
Building Functions		
4. Build a function that models a relationship between two quantities	1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena.	Calculate the amount of seeds and plants needed by a nursery to ensure they meet the demand next season.
5. Build new functions from existing functions	–	
Linear, Quadratic, and Exponential Models		
6. Construct and compare linear, quadratic, and exponential models and solve problems	1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena.	
7. Interpret expressions for functions in terms of the situation they model	1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena.	

Trigonometric Functions		
8. Extend the domain of trigonometric functions using the unit circle	–	
9. Model periodic phenomena with trigonometric functions	–	
10. Prove and apply trigonometric identities	–	

Note: No correlations were made for the High School: Modeling section.

Common Core Standards for Mathematics – **Geometry**	***NAAEE: Guidelines for Learning (12th Grade)***	***Examples/Ideas for Implementation***
Congruence		
1. Experiment with transformations in the plane	–	
2. Understand congruence in terms of rigid motions	–	
3. Prove geometric theorems	–	
4. Make geometric constructions	1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena.	
Similarity, Right Triangles, and Trigonometry		
5. Understand similarity in terms of similarity transformations	–	
6. Prove theorems involving similarity	–	
7. Define trigonometric ratios and solve problems involving right triangles	–	
8. Apply trigonometry to general triangles	–	
Circles		

9. Understand and apply theorems about circles	–	
10. Find arc lengths and areas of sectors of circles	–	
Expressing Geometric Properties with Equations		
11. Translate between the geometric description and the equation for a conic section	–	
12. Use coordinates to prove simple geometric theorems algebraically	–	
Geometric Measurement and Dimension		
13. Explain volume formulas and use them to solve problems	–	
14. Visualize relationships between two-dimensional and three-dimensional objects	1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena.	
Modeling with Geometry		
15. Apply geometric concepts in modeling situations	1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena.	

Common Core Standards for Mathematics – **Statistics & Probability**	***NAAEE: Guidelines for Learning (12th Grade)***	***Examples/Ideas for Implementation***
Interpreting Categorical and Quantitative Data		
1. Summarize, represent, and interpret data on a single count or measurement variable	1E. Organizing Information – Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. 1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena. 1G. Drawing conclusions and developing Explanations – Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.	
2. Summarize, represent, and interpret data on two categorical and quantitative variables	1E. Organizing Information – Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. 1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena. 1G. Drawing conclusions and developing Explanations – Learners are able to use evidence and logic in	

	developing proposed explanations that address their initial questions and hypotheses.	
3. Interpret linear models	1E. Organizing Information – Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. 1F. Working with models and simulations - Learners are able to create, use, and evaluate models to understand environmental phenomena. 1G. Drawing conclusions and developing Explanations – Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.	
Making Inferences and Justifying Conclusions		
4. Understand and evaluate random processes underlying statistical experiments	1C. Collecting information - Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data. 1E. Organizing Information – Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. 1F. Working with models and simulations - Learners are able to create, use, and evaluate models to understand environmental phenomena.	

	1G. Drawing conclusions and developing Explanations – Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.	
5. Make inferences and justify conclusions from sample surveys, experiments and observational studies	1C. Collecting information - Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data. 1E. Organizing Information – Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. 1F. Working with models and simulations - Learners are able to create, use, and evaluate models to understand environmental phenomena. 1G. Drawing conclusions and developing Explanations – Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.	
Conditional Probability and the Rules of Probability		
6. Understand independence and conditional probability and use them to interpret data	1E. Organizing Information – Learners are able to organize and display information in ways appropriate to different types	

	of environmental investigations and purposes.	
7. Use the rules of probability to compute probabilities of compound events in a uniform probability model	1E. Organizing Information – Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. 1F. Working with models and simulations - Learners are able to create, use, and evaluate models to understand environmental phenomena. 1G. Drawing conclusions and developing Explanations – Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.	
Using Probability to Make Decisions		
8. Calculate expected values and use them to solve problems	–	
9. Use probability to evaluate outcomes of decisions	1D. Evaluating accuracy and reliability - Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources. 1E. Organizing information – Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. 1F. Working with models and simulations – Learners are able to create, use, and evaluate models to understand environmental phenomena.	

	1G. Drawing conclusions and developing Explanations – Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses. 3.1A. Identifying and investigating issues – Learners apply their research and analytical skills to investigate environmental issues ranging from local issues to those that are regional or global in scope. 3.1B. Sorting out the consequences of issues – Learners are able to evaluate the consequences of specific environmental changes, conditions, and issues for human and ecological systems. 3.1C. Identifying and evaluating alternative solutions and courses of action – Learners are able to identify and propose action strategies that are likely to be effective in particular situations and for particular purposes.	

[i] Hungerford, H. and T. Volk. "Changing learner behavior through environmental education." Journal of Environmental Education. Spring 1990, p 8-21.
[ii] Quetel, R., et al. *A problem taking approach to environmental education*. UNESCO-UNEP – International Environmental Education Programme, Division of Science, Technology and Environmental Education. 1985, page 47.
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