Green Infrastructure Toolkit For Schools

Engagement and Resources for Integrating Green Infrastructure into the Classroom

OMAHA STORMWATER PROGRAM

UNIVERSITY OF Nebraska Lincoln

Nebraska Science and Mathematics Curriculum Standard Overview

The Nebraska science and mathematics curriculum standards are designed to test student performance on a variety of topics. Each school district in Nebraska is responsible for students to become science and math literate by creating a K-12 science curriculum that meets the state standards. The standards are laid out by grade level, Kindergarten through Grade 12. Both Science and Mathematics standards are categorized into four science inquiries. There is the Nature of Science and Technology, Physical Science, Life Science, and Earth and Space Science for the Science standards, and Number, Algebra, Geometry, and Data for the Mathematics standards.

The Nebraska State Board of Education adopted the current version of the Nebraska Science Standards on October 6th, 2010. The standards are to be reviewed and updated every seven years and are currently going through the revision process. These standards set the stage for what is taught in classrooms across the state.

Green infrastructure is an excellent way to teach many specific science and math topics inside and outside of the classroom. In addition to science, green infrastructure applies to other subject areas including technology, engineering, arts, and math. These subjects together are often known as STEM or STEAM. This packet of information is the start of creating a better awareness with those in the education system of what is possible with green infrastructure and using it as a means to become more aware of our community's environment.

The standards that have been selected and listed in this package are taken from the 2011 Nebraska Science Standards and 2015 Nebraska Mathematics Standards from the Nebraska Department of Education and can be met through the use of green infrastructure principles and practices. Green infrastructure can be used to explore many areas of science including the water cycle, botany, horticulture, insects and animals, soil science, weather, climate change, environmental pollution, chemistry, and more. It can also involve many areas of math such as calculation, measuring, and chart reading. Utilization of green infrastructure principles and practices provides a dynamic opportunity for students to meet and exceed these science standards. For example, the Science standard 2.4.2.b for K2 states, “Recognize ways in which individuals and families can conserve Earth's resources by reducing, reusing, and recycling.” Runoff from a school roof can be directed into a rain garden where plants will use the water rather than letting it go down the storm drain, carrying pollution with it. The Math standard MA 2.3.3.d for second graders states, “Measure the length of an object using two different length units and describe how the measurements relate to the size of the specific unit.” A rain garden can provide students a hands-on opportunity to measure its length and width, while also learning about unit conversion.

Standards selected and listed here can be taught using green infrastructure principles and practices. Depending on a teacher’s lesson plan, there may be other standards that could be applied to incorporate green infrastructure; so view this document not as a definitive list but as a resource to build upon. One final note: this package is only good if it is used, so we want feedback on how to improve it into the future. Please send questions, comments, or inquiries to omahastormwater@ci.omaha.ne.us, thank you!

Nebraska 9-12 Science Curriculum 2011 - Summary for Green Infrastructure

Inquiry - the Nature of Science, and Technology

Inquiry – Students will design and conduct investigations that lead to the use of logic and evidence in the formulation of scientific explanations and models. 12.1.1

1. Scientific Questioning: Formulate a testable hypothesis supported by prior knowledge to guide an investigation 12.1.1.a
2. Scientific Investigations: Design and conduct logical and sequential scientific investigations with repeated trials and apply findings to new investigations 12.1.1.b
3. Scientific Controls and Variables: Identify and manage variables and constraints 12.1.1.c
4. Scientific Tools: Select and use lab equipment, and technology, appropriately and accurately 12.1.1.d
5. Scientific Observations: Use tools and technology to make detailed qualitative and quantitative observations 12.1.1.e
6. Scientific Data Collection: Represent and review collected data in a systematic, accurate, and objective manner 12.1.1.f
7. Scientific Interpretations, Reflections, and Applications: Analyze and interpret data, synthesize ideas, formulate and evaluate models, and clarify concepts and explanations 12.1.1.g
8. Scientific Interpretations, Reflections, and Applications: Use results to verify or refute a hypothesis 12.1.1.h
9. Scientific Interpretations, Reflections, and Applications: Propose and/or evaluate possible revisions and alternate explanations 12.1.1.i
10. Scientific Communication: Share information, procedures, results, conclusions, and defend findings to a scientific community (peers, science fair audience, policy makers) 12.1.1.j
11. Scientific Communication: Evaluate scientific investigations and offer revisions and new ideas as appropriate 12.1.1.k
12. Mathematics: Use appropriate mathematics in all aspects of scientific inquiry 12.1.1.l

Nature of Science – Students will apply the nature of scientific knowledge to their own investigations and in the evaluation of scientific explanations. 12.1.2

1. Scientific Knowledge: Recognize that scientific explanations must be open to questions, possible modification, and must be based upon historical and current scientific knowledge 12.1.2.a
2. Science and Society: Describe how society influences the work of scientists and how science, technology, and current scientific discoveries influence and change society 12.1.2.b
3. Science as a Human Endeavor: Recognize that the work of science results in incremental advances, almost always building on prior knowledge, in our understanding of the world 12.1.2.c
4. Science as a Human Endeavor: Research and describe the difficulties experienced by scientific innovations who had to overcome commonly held beliefs of their times to reach conclusions that we now take for granted12.1.2.d

Technology – Students will solve a complex design problem. 12.1.3

1. Abilities to do Technical Design: Propose designs and choose between alternative solutions of a problem 12.1.3.a
2. Abilities to do Technical Design: Assess the limits of a technical design 12.1.3.b
3. Abilities to do Technical Design: Implement the selected solution 12.1.3.c

Physical Science

Matter – Students will investigate and describe matter in terms of its structure, composition and conservation. 12.2.1

1. States of Matter: Compare and contrast the three normal states of matter (solid, liquid, gas) in terms of energy, particle arrangement, particle motion, and strength of force of attraction between particles 12.2.1.c
2. Physical and Chemical Changes: Recognize a large number of chemical reactions involve the transfer of either electrons (oxidation/reduction) or hydrogen ions (acid/base) between reacting ions, molecules, or atoms 12.2.1.d
3. Physical and Chemical Changes: Identify factors affecting rates of chemical reactions (temperature, particle size, surface area) 12.2.1.e

Force and Motion – Students will investigate and describe the nature of field forces and their interactions with matter. 12.2.2

1. Motion: Describe motion with respect to displacement, velocity, and acceleration 12.2.2.a

Energy – Students will describe and investigate energy systems relating to the conservation and interaction of energy and matter. 12.2.3

1. Sound/Mechanical Waves: Recognize that the energy in waves can be changed into other forms of energy 12.2.3.b
2. Heat: Distinguish between temperature (a measure of the average kinetic energy of atomic or molecular motion) and heat (the quantity of thermal energy that transfers due to a change in temperature) 12.2.3.d
3. Heat: Compare and contrast methods of heat transfer and the interaction of heat with matter via conduction, convection, and radiation 12.2.3.e
4. Electricity/Magnetism: Compare and contrast segments of the electromagnetic spectrum (radio, micro, infrared, visible, ultraviolet, x-rays, gamma) based on frequency and wavelength 12.2.3.g

Life Science

Structure and Function of Living Systems – Students will investigate and describe the chemical basis of the growth, development, and maintenance of cells. 12.3.1

1. Characteristics of Life: Identify the complex molecules (carbohydrates, fats, lipids, proteins, and nucleic acids) that make up living organisms 12.3.1.a
2. Cellular Composition of Organisms: Identify the form and function of sub-cellular structures that regulate cellular activities 12.3.1.b
3. Cellular Composition of Organisms: Describe the cellular functions of photosynthesis, respiration, cell division, protein synthesis, transport of materials, and energy capture/release 12.3.1.c

Heredity – Students will describe the molecular basis of reproduction and heredity. 12.3.2
1. Reproduction: Describe that sexual reproduction results in a largely, predictable, variety of possible gene combinations in the offspring of any two parents 12.3.2.d
Flow of Matter and Energy in Ecosystems – Students will describe, on a molecular level, the cycling of matter and the flow of energy between organisms and their environment. 12.3.3
1. Flow of Energy: Explain how the stability of an ecosystem is increased by biological diversity 12.3.3.a
2. Ecosystems: Explain how distribution and abundance of different organisms in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials 12.3.3.c
3. Impact on Ecosystems: Analyze factors, which may influence environmental quality 12.3.3.d
Biodiversity – Students will describe the theory of biological evolution. 12.3.4
1. Biological Adaptations: Identify different types of adaptations necessary for survival (morphological, physiological, behavioral) 12.3.4.a
2. Ecosystems: Explain how distribution and abundance of different organisms in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials 12.3.3.c
Earth and Space Science
Earth Structures and Process – Students will investigate the relationships among Earth's structure, systems, and processes. 12.4.2
1. Properties of Earth Materials: Recognize how Earth materials move through geochemical cycles (carbon, nitrogen, oxygen) resulting in chemical and physical changes in matter 12.4.2.a
2. Use of Earth Materials: Evaluate the impact of human activity and natural causes on Earth's resources (groundwater, rivers, land, fossil fuels) 12.4.2.c
Energy in Earth's Systems – Students will investigate and describe the relationships among the sources of energy and their effects on Earth's systems. 12.4.3
1. Recognize how Earth materials move through geochemical cycles resulting in chemical and physical changes in matter SC12.4.2.a

Reference:
SAMPLE K-12 SCIENCE CURRICULUM 2011 [PDF].(n.d.). Lincoln: Nebraska Department of Education.
NEBRASKA SCIENCE STANDARD GRADE K12 2010 [PDF].(n.d.). Lincoln: Nebraska Department of Education.

Nebraska 9-11 Mathematics Curriculum 2011 - Summary for Green Infrastructure

NUMBER

Numeric Relationships: Students will demonstrate, represent, and show relationships among the subsets of real numbers and the complex number system. 11.1.1

1. Use drawings, words, and symbols to explain the effects of operations such as multiplication and division on the magnitude of quantities in the real number system, including powers and roots (e.g., if you take the square root of a number, will the result always be smaller than the original number?). 11.1.1.c

Operations: Students will compute with real and complex numbers. 11.1.2

1. Select, apply, and explain the method of computation when problem solving using real numbers (e.g., models, mental computation, paper-pencil, or technology). 11.1.2.c
2. Use estimation methods to check the reasonableness of real number computations and decide if the problem calls for an approximation (including appropriate rounding) or an exact number. 11.1.2.d

ALGEBRA

Algebraic Relationships: Students will demonstrate, represent, and show relationships with functions. 11.2.1

1. Define a function and use function notation. 11.2.1.a
2. Analyze a relation to determine if it is a function given graphs, tables, or algebraic notation. 11.2.1.b
3. Classify a function given graphs, tables, or algebraic notation, as linear, quadratic, or neither. 11.2.1.c
4. Identify domain & range of functions represented in either algebraic or graphical form. 11.2.1.d
5. Analyze and graph linear functions and inequalities (point-slope form, slope-intercept form, standard form, intercepts, rate of change, parallel and perpendicular lines, vertical and horizontal lines, and inequalities). 11.2.1.e
6. Analyze and graph absolute value functions (finding the vertex, symmetry, transformations, determine intercepts, and minimums or maximums using the piecewise definition). 11.2.1.f
7. Represent, interpret, and analyze inverses of functions algebraically and graphically. 11.2.1.h

Algebraic Processes: Students will apply the operational properties when evaluating rational expressions, and solving linear and quadratic equations, and inequalities. 11.2.2

1. Convert equivalent rates (e.g., miles per hour to feet per second). 11.2.2.a
2. Identify and explain the properties used in solving equations and inequalities. 11.2.2.b
3. Perform operations on rational expressions (add, subtract, multiply, divide, and simplify). 11.2.2.d
4. Solve an equation involving several variables for one variable in terms of the others. 11.2.2.f

Applications: Students will solve real-world problems involving linear equations and inequalities, systems of linear equations, quadratic, exponential, square root, and absolute value functions. 1.2.3

1. Analyze, model, and solve real-world problems using various representations (graphs, tables, linear equations and inequalities, systems of linear equations, quadratic, exponential, square root, and absolute value functions). 11.2.3.a

GEOMETRY

Characteristics: Students will identify and describe geometric characteristics and create two- and three-dimensional shapes. 11.3.1

1. Know and use precise definitions of ray, line segment, angle, perpendicular lines, parallel lines, and congruence based on the undefined terms of geometry: point, line and plane. 11.3.1.a
2. Prove geometric theorems about angles, triangles, congruent triangles, similar triangles, parallel lines with transversals, and quadrilaterals using deductive reasoning. 11.3.1.b
3. Apply geometric properties to solve problems involving similar triangles, congruent triangles, quadrilaterals, and other polygons. 11.3.1.c
4. Know and use precise definitions and terminology of circles, including central angle, inscribed angle, arc, intercepted arc, chord, secant, and tangent. 11.3.1.f
5. Sketch, draw, and construct appropriate representations of geometric objects using a variety of tools and methods which may include ruler/straight edge, protractor, compass, reflective devices, paper folding, or dynamic geometric software. 11.3.1.h

Coordinate Geometry: Students will determine location, orientation, and relationships on the coordinate plane. 11.3.2

1. Use coordinate geometry to analyze linear relationships to determine if lines are parallel or perpendicular. 11.3.2.b
2. Given a line, write the equation of a line that is parallel or perpendicular to it. 11.3.2.c
3. Derive and apply the distance formula. 11.3.2.d
4. Use coordinate geometry to prove triangles are right, acute, obtuse, isosceles, equilateral, or scalene. 11.3.2.e
5. Use coordinate geometry to prove quadrilaterals are trapezoids, isosceles trapezoids, parallelograms, rectangles, rhombi, kites, or squares. 11.3.2.f
6. Perform and describe positions and orientation of shapes under a single translation using algebraic notation on a coordinate plane. 11.3.2.g
7. Derive the equation of a circle given the radius and the center. 11.3.2.k

Measurement: Students will perform and compare measurements and apply formulas. 11.3.3

1. Convert between various units of length, area, and volume (e.g., such as square feet to square yards). 11.3.3.a
2. Convert between metric and standard units of measurement. 11.3.3.b
3. Apply the effect of a scale factor to determine the length, area, and volume of similar two- and three-dimensional shapes and solids. 11.3.3.c
4. Find arc length and area of sectors of a circle. 11.3.3.d
5. Determine surface area and volume of spheres, cones, pyramids, and prisms using formulas and appropriate units. 11.3.3.e

DATA
Analysis & Applications: Students will analyze data to address the situation. 11.4.2
1. Identify and compute measures of central tendency (mean, median, mode) when provided data both with and without technology. 11.4.2.a
2. Explain how transformations of data, including outliers, affect measures of central tendency. 11.4.2.b
3. Compare data sets and formulate conclusions. 11.4.2.c
4. Support conclusions with valid arguments. 11.4.2.d
5. Develop linear equations for linear models to predict unobserved outcomes using the regression line and correlation coefficient with technology. 11.4.2.e
6. Describe the shape, identify any outliers, and determine the spread of a data set. 11.4.2.f
7. Explain the impact of sampling methods, bias, and the phrasing of questions asked during data collection, and the conclusions that can rightfully be made. 11.4.2.g
8. Explain the differences between a randomized experiment and observational studies. 11.4.2.h
9. Using scatter plots, analyze patterns and describe relationships in paired data. 11.4.2.i
10. Recognize when arguments based on data confuse correlation with causation. 11.4.2.j
11. Interpret data represented by the normal distribution, formulate conclusions, and recognize that some data sets are not normally distributed. 11.4.2.k
Probability: Students will interpret and apply concepts of probability. 11.4.3
1. Use appropriate counting techniques to determine the probability of an event. 11.4.3.b

Reference:
NEBRASKA MATHEMATICS STANDARDS (Rep.). (n.d.). Retrieved https://www.education.ne.gov/math/Math_Standards/Adopted_2015_Math_Standards/2015_Nebraska_College_and_Career_Standards_for_Mathematics_Vertical.pdf

Nebraska 12 Advanced Topics (AT) Mathematics Curriculum 2011 - Summary for Green Infrastructure

ALGEBRA

Algebraic Relationships: Students will demonstrate, represent, and show relationships with non-linear and trigonometric functions. 12.2.1

1. Analyze and graph non-linear functions (e.g., quadratic, trigonometric, square root, logarithmic, rational, higher-order polynomials, exponential, absolute value, piecewise, and sinusoidal). 12.2.1.a
2. Evaluate sine, cosine, and tangent functions at positive and negative multiples of 30, and 45 degrees. 12.2.1.c
3. Understand that the radian measure of an angle is the length of the arc on the unit circle subtended by that angle. 12.2.1.f
4. Convert between radian and degree measures of an angle. 12.2.1.g

Applications: Students will solve real-world problems involving trigonometric functions. 12.2.3

1. Model periodic events with specified amplitude, frequency, and shifts. 12.2.3.a
2. Solve real-world problems using trigonometric and inverse trigonometric functions. 12.2.3.b

GEOMETRY

Characteristics: Students will identify and describe geometric characteristics and create two- and three-dimensional shapes. 12.3.1

1. Apply the Law of Sines and the Law of Cosines to find unknown measures in triangles. 12.3.1.a

Coordinate Geometry: Students will determine location, orientation, and relationships on the coordinate plane. 12.3.2

1. Identify features of a function (e.g., local and global maxima and minima, concavity, approximate locations of points of inflection and vertical and horizontal asymptotes) from its graph. 12.3.2.a
2. Identify symmetry properties of a function (e.g., axis of symmetry of a parabola) and know the connection between its symmetry properties and specific transformations. 12.3.2.b
3. Recognize that vector quantities have both magnitude and direction and can be represented by directed line segments. 12.3.2.c
4. Add and subtract vectors graphically and algebraically. 12.3.2.d
5. Perform scalar multiplication of a vector and show it graphically. 12.3.2.e
6. Derive the equations of parabolas, ellipses, and hyperbolas from a graph or given parameters. 12.3.2.f
7. Determine the shape of a two-dimensional cross-section of a three-dimensional object. 12.3.2.h

Measurement: Students will perform and compare measurements and apply formulas. 12.3.3

1. Use Cavalieri's Principle to determine the volume of a sphere and other solid figures. 12.3.3.a
2. Determine the tolerance interval and percent of error in measurement. 12.3.3.b

DATA
Analysis & Applications: Students will analyze data to address the situation. 12.4.2
1. Make inferences and justify conclusions from sample surveys, experiments, and observational studies. 12.4.2.a
Probability: Students will interpret and apply concepts of probability. 12.4.3
1. Calculate the expected value of a random variable and interpret it as the mean of a probability distribution. 12.4.3.a
2. Determine possible outcomes of a decision by assigning probabilities to outcome values and finding expected values. 12.4.3.b
3. Evaluate and compare strategies on the basis of expected values. 12.4.3.c
4. Analyze decisions and strategies using probability concepts (e.g., medical testing and product testing). 12.4.3.d

Reference:
NEBRASKA MATHEMATICS STANDARDS (Rep.). (n.d.). Retrieved https://www.education.ne.gov/math/Math_Standards/Adopted_2015_Math_Standards/2015_Nebraska_College_and_Career_Standards_for_Mathematics_Vertical.pdf