Standards for Teaching and Learning about Water: A View across Disciplines

Earth Educators' Rendezvous
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Rationale for Water Literacy

- “All human and natural systems are influenced by the distribution, abundance, quality, and accessibility of water” (NSF, 2005, pg. 6)
- Science of people and water (Sivapalan et al., 2012)
- ‘Anthropocene’ and ‘Water Century’
- “Ensuring an adequate quantity and quality of freshwater for sustaining all forms of life is a growing challenge” (NSF, 2005, pg. 6)

Problem

- Emphasis on water in discipline-specific science standards (ESLI, 2010; NGSS Lead States, 2013)
- Gaps in students' knowledge of core hydrologic concepts across the K-16 continuum (Cardak, 2009; Forbes, Zangori, & Schwarz, 2015; Gunckel, Covitt, Salinas, & Anderson, 2012; Halvorson & Wescoat, 2002)
- U.S. adults (AMNH, 2005) - less than 10% could estimate the % of drinkable water on Earth, <25% identify groundwater as part of the water cycle, and <33% accurately identify agriculture as the dominant source of water use worldwide.

Towards a Solution

- Water is fundamentally interdisciplinary
- Key questions:
  - What should individuals learn about water?
  - How should these learning experiences be designed?
- To answer these questions, we need to look across perspectives from various disciplines
- A transdisciplinary view on outcomes for teaching and learning about water

NC-FEW Standards Crosswalks

- Focal standards and policy documents
  - STEM literacy (AAAS, 2009; NGSS Lead States, 2013)
  - Environmental literacy (NAAEE, 2019)
  - Agricultural literacy (National Agriculture in the Classroom, 2014)
  - Earth science literacy (Earth Science Literacy Initiative, 2010)
  - Energy literacy (U.S. Department of Energy, 2012)
  - Climate literacy (U.S. Global Change Research Program, 2009)
  - Geography literacy (GENIP, 2012)
- Organize around priority themes and food, energy, water

NC-FEW

- *National Collaborative for Research on Food, Energy, and Water Education* (NC-FEW)
- Hub of innovation for education research on FEW-Nexus educational programming at all levels and in a variety of settings
- An emergent professional community involving a broad array of transdisciplinary collaborators who represent STEM and FANH sciences and span traditional STEM/FANH departments, education, and agricultural and natural resources
- http://ncfew.org/

A Preliminary Summary of Water Standards

I. Nature of water and natural water systems
- Water is one of four Earth systems
- Water is constantly on the move and distributed unevenly on Earth, and this movement of water is important as the hydrosphere interacts with and influences other Earth systems.

II. Relationships between water and humans
- Water is a resource for humans
- Humans, in turn, impact water and water systems.

Water on Earth

- Overarching ideas
  - "Earth's water cycles among the reservoirs of the atmosphere, streams, lakes, ocean, glaciers, groundwater, and deep interior of the planet. The total amount of water at Earth's surface has remained fairly constant over geologic time, although it's distribution among reservoirs has varied" (Earth Science Literacy standard 5.5).
  - It's one of the primary "physical processes that shape the patterns of Earth's surface" (Geography standard 7).
- K-5 students should identify stocks and flows of water
  - "develop a model to represent the shapes and kinds of land and bodies of water in an area" (NGSS Science Standard 2-ESS2-2 Earth's Systems)
  - "Waves, wind, water, and ice shape and reshape the earth's land surface by eroding rock and soil in some areas and depositing them in other areas, sometimes in seasonal layers" (AAAS: Benchmarks of Science Literacy standard 4C/E1)

Water on Earth

- Middle School (grades 6-8)
- Emphasis on interactions between Earth systems and relationships between processes, stocks and flows, and time
  - “describe the major processes…that form Earth and relate these processes, especially those that are large scale and long term to characteristics of Earth…explain how changes in one system (hydrosphere, atmosphere, geosphere, and biosphere) result in changes to another” (NAAEE: Strand 2.1.A Earth’s Physical Systems)
  - “construct an explanation based on evidence for how the uneven distribution of Earth’s mineral, energy, and groundwater resources are the result of past and current geoscience processes” (NGSS standard MS-ESS3-1 Earth and Human Activity).
  - “The earth’s surface is shaped in part by the motion of water (including ice) and wind over very long times, which acts to level mountain ranges. Rivers and glacial ice carry off soil and break down rock, eventually depositing the material in sediments or carrying it in solution to the sea” (AAAS: Benchmarks for Science Literacy standard 4C/M2b)

Water on Earth

- High School (grades 9-12)
- Continued emphasis on systems interactions
  - “learners describe characteristics of Earth’s physical systems, including air, water, and land. They explain how these systems interact with one another and identify changes in the physical environment over time. They provide examples of how physical systems affect living organisms, including humans” (NAAEE strand 2.1.A Earth’s Physical Systems)
- Emphasis on data analysis
  - “analyze geoscience data to make the claim that one change to Earth’s surface can create feedbacks that cause changes to other Earth Systems” (NGSS standard HS-ESS2-2 Earth’s Systems)

Human Impact on Water

- "…human activities have important impacts on all four [Earth] spheres" (Earth Science Literacy standard 3.1)
- K-5 students should focus on practices to limit impacts of humans on water
  - Learners should "communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment" (NGSS standard K-ESS3-3 Earth and Human Activity)
  - "identify land and water conservation methods used in farming systems (wind barriers, conservation tillage, laser leveling, GPS planting, etc.)" (National Agricultural Literacy Outcome standard T1.3-5)

Human Impact on Water

- Middle School (grades 6-8)
- Continued emphasis on conservation (i.e., not overexploitation)
  - "…Water in rivers, lakes, and underground can be depleted or polluted, making it unavailable or unsuitable for life" (AAAS: Benchmarks for Science Literacy 4B/M8)
- Increased focus on problem-solving and planning
  - "discover how natural resources are used and conserved in agriculture (e.g., soil conservation, water conservation)" (National Agricultural Literacy Outcomes standard T1.6-8.d)
  - describe "why and how farmers conserve water" (Pillars of Agricultural Literacy standard 1.E).
  - "apply scientific principles to design a method for monitoring and minimizing a human impact on the environment" (NGSS MS-ESS3-3 Earth and Human Activity)

Human Impact on Water

- High School (grades 9-12)
  - “Evaluate the various definitions of “sustainable agriculture,” considering…water resources” (National Agricultural Literacy Outcome standard T1.9-12.f)
  - “Give examples of specific water conservation and purification practices used by farmers” (Pillars of Agricultural Literacy standard 1.B)
- Emphasis on data analysis
  - “Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity” (NGSS HS-ESS3-6)
- Increasing focus on iteration of proposed solutions
  - “Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity” (NGSS HS-LS2-7).

Overall Observed Trends

- Elementary (grades K-5)
  - Developing understanding of ‘what’
  - Describing and communicating
- Middle (grades 6-8)
  - Developing understanding of ‘why’ and ‘how’
  - Designing and explaining
- High School (grades 9-12)
  - Working with data and models
  - Iterating design solutions

Special Issue on Water Literacy

- Journal *Water*
- Deadline for manuscript submissions: 21 August 2020
- https://www.mdpi.com/journal/water/special_issues/Water_Literacy
- Impact Factor: 2.544 (2019) ; 5-Year Impact Factor: 2.709 (2019)

Consider submitting your water education work ☺

Thank You!

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