Water Grand Challenges: Education & Outreach

Formal Water Education in Texas

Background – In Texas, all formal water resource curriculum adheres to the Texas Essential Knowledge and Skills (TEKS) that are developed through the Texas Education Agency (TEA).[1] The State Board of Education (SBOE) forms a TEKS review committee comprised of community members who have "expertise in the subject matter in which he or she is appointed [as reviewer]."[1] These standards clarify what students should know upon graduation from elementary, middle, and high school in all subjects including science and water-related studies.[2] In 2009, the science TEKS were revised to include a more interdisciplinary approach to science and resource management.[1] Introductory science courses in elementary and middle school integrate water resources into general science, but formal aquatic science is only available to high school students in grades 10 and above (see table 2).

Elementary Science Standards – Science education begins in elementary school when students begin to use scientific processes to make informed decisions.[2] The TEA introduced revised science TEKS in 2009 to include the National Academy of Science definition of "science" and to encourage "classroom and outdoor investigations for at least 80% of instructional time in kindergarten and grade 1, 60% in grades 2 and 3, and 50% in grades 4 and 5."[2] In order to establish general scientific knowledge, elementary school students receive instruction in the four disciplines of science: physics, chemistry, life science, and earth and space science.[2]

An element included in the revised TEKS emphasizes the importance of recognizing recurring themes that "transcend disciplinary boundaries" in mathematics, technology, and sciences.[2] This allows teachers to combine information from different disciplines, thereby introducing to interdisciplinary subject matter in preparation for middle school. With regard to water in science, elementary school students are expected to graduate with an understanding of the water cycle, conservation methods, and the basic properties of water.[2]

Table 1: Water-related elements in K-8 TEKS[3,4]

Grade	Scientific Reasoning	Earth and Space	Organisms & Environment	Matter and Energy	Force Motion
Elementary (K-5) TEKS	1. Water conservation 2. Problems associated with a lack of water in a habitat	1. Water uses and properties 2. Water cycle & weather patterns (sun and ocean relationship) 3. Water sources 4. Erosion process 5. Water as a renewable resource	1. Examine water as a basic need for organisms 2. Water and wildlife (fish) 3. How water moves through plants	1. Water properties - freezing, evaporating 2. Condensation	

Middle School (6-8) TEKS	1. Model effects of human activity on a watershed and groundwater 2. Water as a necessity for life in our solar system	1. Organism competition for water in an ecosystem	1. The role of Water in weathering

Middle School – Revised TEKS for grades 6-8 directly outline interdisciplinary methods for science instruction, but do so under the heading of specific courses: physical sciences (grade 6) organisms and the environment (grade 7), and earth and space science (grade 8).[2] Building upon basic knowledge about the hydrologic cycle and water resources received in elementary school, middle school students further explore the importance of water in the biosphere. Examples of this include modeling storm water runoff and the effect of diminished resources on life in an ecosystem. Students in middle and high school are expected to be able to "distinguish between scientific decision-making methods and ethical and social decisions that involve the application of scientific information."[2] This requires not only that students comprehend and have the capacity to demonstrate scientific skills, but also have the ability to design experiments to answer questions scientifically. Scientific instruction in middle school focuses on the following strands:

1. Scientific investigation and reasoning,
2. Matter and energy,
3. Force, motion, and energy,
4. Earth and space, and
5. Organisms and environments[4]

High School – The interdisciplinary science instruction that students receive in middle school allows for exploration into specific scientific fields using real-world case studies in high school. Students are required to take pre-requisite biology, chemistry, or physics courses before enrolling in upper-level science courses.[5] Once core courses have been successfully completed, upper-level courses allow students to explore specific earth and physical sciences. All of the upper level courses require some water resource-related TEKS incorporation (table 2).

Course	**Chemistry (Grade 11 or 12)**	**Earth and Space Science (Grade 12)**	**Aquatic Science (Grade 10)**	**Environmental Systems (Grade 11 or 12)**
Prerequisite	1 unit of high school science and Algebra I	3 units of science + 3 units of math	High school biology or chemistry. Chemistry can be taken concurrently	1 unit of high school life science + 1 unit of high school physical science
Water-related essential knowledge and skills	1. Water in chemical and biological systems 2. Predict products in acid base reactions that form water	1. Human-influenced environment changes (water pollution) 2. Time-scale of natural	1. The water cycle in the aquatic environment 2. Water sources and the amount of water in a watershed	1. Laboratory Water Quality Test kits 2. Diagram the hydrologic cycle, identify sources, water

			resource use 3. Natural processes, changes to the environment 4. Effect of resource use on the global environment 5. Global water circulation 6. Components and fluxes within the hydrosphere (effect of over pumping on groundwater and aquifers.)	3. Fresh and salt water adaptations in organisms 4. Energy and matter flows through fresh/salt water systems 5. The impact of water policy (Clean Water Act)	management, and quantity

High school students are also required to synthesize scientific knowledge and social ethics in order to explain environmental phenomenon and justify social action.[2] For example, the Aquatic Science course requires students to fully understand the water cycle and the effect of human influence on water quality and quantity. Using this information, students are able to understand the Clean Water Act and how science is used to create policy.

[1] Texas State Board of Education. "Process for Review and Revision of Texas Essential Knowledge and Skills (TEKS)." Texas Education Agency, January 21, 2011.
[2] Texas Education Agency. K–12 science TEKS revised 2009." Compiled by Charles A. Dana Center at The University of Texas at Austin. Austin, June 2011.
[3] Texas Education Agency. Chapter 112. Texas Essential Knowledge and Skills for Science Subchapter A. Elementary School." *19 TAC Chapter 112, Subchapter A.* August 4, 2009. http://ritter.tea.state.tx.us/rules/tac/chapter112/ch112a.html (accessed May 24, 2013).
[4] Texas Education Agency. Chapter 112. Texas Essential Knowledge and Skills for Science Subchapter B. Middle School." *19 TAC Chapter 112, Subchapter B.* August 4, 2009. http://ritter.tea.state.tx.us/rules/tac/chapter112/ch112b.html (accessed May 24, 2013).
[5] Texas Education Agency. Chapter 112. Texas Essential Knowledge and Skills for Science Subchapter C. High School." *19 TAC Chapter 112, Subchapter C.* August 4, 2009. http://ritter.tea.state.tx.us/rules/tac/chapter112/ch112c.html (accessed May 24, 2013).