Enhancing Water Literacy: A Content Analysis of Next Generation Science Standards (NGSS) and Agricultural, Food, and Natural Resources (AFNR) Learning Standards

Lena Berens
New Mexico State University
ljberens@nmsu.edu

Mercedes Hazen
New Mexico State University
mdhazen@nmsu.edu

Shannon Norris-Parish
Texas A&M University
shannon.parish@ag.tamu.edu

Enhancing Water Literacy: A Content Analysis of Next Generation Science Standards (NGSS) and Agricultural, Food, and Natural Resources (AFNR) Learning Standards

Introduction

Groundwater is one of the most valuable natural resources. Not only is it crucial to sustaining agriculture, but it is also vital to sustaining life, which makes water education a critical topic to teach youth audiences. Yet, few high school science educators, outside of school-based agricultural education, likely teach lessons specifically related to groundwater principles and its impact on food production (Dickerson et al., 2007). Similarly, over the years, instructors have experienced several challenges when teaching topics, such as hydrology, groundwater, and sustainability to secondary audiences due to the complex nature of the subject matter (Ruddell et al., 2015). The successful implementation of hydrology-related education requires a variety of pedagogical approaches depending on the desired learning outcomes and social and cultural backgrounds of students. Certainly, curricula at all levels should balance field, laboratory, and classroom pedagogy into an integrative approach as teachers have found that an iterative instruction can lead to greater student motivation along with the advancement of theoretical and vocational knowledge (Gleeson et al., 2012). Related to topics in groundwater education, it is key to investigate what scientific learning standards support the delivery of lessons related to water. This research study aligned with the American Association for Agricultural Education (AAAE, 2023) research value, "Advancing Public Knowledge of AFNR Systems" as we sought to examine learning standards designed to support curriculum delivery of high school lessons related to water education.

Conceptual Framework

We used the Water Systems Matrix (Sadler et al., 2016) as the conceptual framework for this study. This matrix was originally designed to break down broader learning objectives into smaller and more conceptually defined material about water-related education. Using a two-dimensional matrix with an organizational scheme, Sadler et al. (2016) explored five different categories including: (1) processes and mechanisms, (2) energy, (3) scale, (4) representations, and (5) dependency and human agency. Additionally, Sadler et al. (2016) noted that the Water Systems Matrix posits that students should engage water education principles with "socio-ecology systems as part of their educational experiences" (p. 9). The Water Systems Matrix framework was particularly relevant to this study as it supports the evaluation of secondary educational standards supporting groundwater, surface water, hydrology, or other sustainable water practices.

Purpose/Objectives

The purpose of this study was to explore high school educational teaching standards that support water education, particularly as they intersect agricultural and food production topics. We used three research objectives to guide this study:

- RO1: Identify Next Generation Science Standards (NGSS) that support lessons related to water literacy at the secondary, high school level.
- RO2: Identify Agricultural, Food, and Natural Resources (AFNR) standards that support lessons related to water education at the secondary, high school level.
- RO3: Compare NGSS and AFNR standards to describe crosscutting themes.

Methodology

We conducted a qualitative content analysis (Creswell, 2012) of secondary (high school) educational standards from the NGSS (2026) and AFNR Career Cluster Content Standards (The Council, 2025) to identify common themes and topic areas. We identified all educational standards in accordance with the updated guidelines for the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al., 2020) to uphold a structured and systematic approach to selecting themes. For RO1 and RO2, we followed the PRIMSA statement guidelines to identify existing standards related to water and water education (RO1: NGSS, *n* = 88; RO2: AFNR, *n* = 33). We then excluded all standards that did not include "groundwater, surface water, hydrology, or other sustainable water practices" (RO1: NGSS, *n* = 86; RO2: AFNR, *n* = 27). We analyzed retained standards using thematic analysis to describe common themes and topic areas (RO1: NGSS, *n* = 2; RO2: AFNR, *n* = 6). For RO3, we used thematic analysis (Braun & Clarke, 2012) to identify crosscutting themes between the retained NGSS and AFNR standards to provide an overall picture of secondary (high school) teaching standards discussing groundwater, surface water, hydrology, or other sustainable water practices.

Results/Findings

For RO1, two NGSS standards pertained to "groundwater, surface water, hydrology, or other sustainable water practices." HS-ESS2-5: Earth's Systems and HS-ESS3-1: Earth and Human Activity remained. HS-ESS2-5 connects to themes of water properties and how it affects processes on Earth's surface. HS-ESS3-1 supports natural resource availability and human activity related to water. These themes support groundwater lessons related to food production. For RO2, six AFNR standards remained that pertained to "groundwater, surface water, hydrology, or other sustainable water practices." NRS.01.04, NRS.01.05, NRS.02.02, NRS.04.01, ESS.02.01, and ESS.03.02 remained. AFNR standards related to themes of agriculture's impact on water resources along with soil health and best management practices for protecting water sources. For RO3, shared themes between NGSS and AFNR standards were water sustainability, water resource management, and human behavior affecting water systems. Both standards showcased water needs as an interrelated network. However, no retained standard in either database explicitly discussed a connection to agricultural production practices, as it was only implied by the connection to natural resource systems and human behavior.

Conclusions/Recommendations

Although three crosscutting themes emerged, a noticeable gap emerged between socio-ecological water topics, which aligned with Sadler et al. (2016). Certainly, the NGSS standards are more fundamental, rather than applicable. Similarly, the technical context of AFNR standards allows for more practical lessons. Despite a keen focus on scientific principles, we recommend the NGSS authors evaluate opportunities to increase the number of standards that explicitly list potential impacts in agricultural context to connect basic scientific course material and learning outcomes to food production. Similarly, this increased focus on the connection to agricultural production can reinforce opportunities for hands-on instruction and practical application of water literacy. Finally, due to a steadily increasing need for water literacy, we recommend implementing crosscutting lessons with secondary science teachers and agricultural educators to add rigor and relevance between agricultural science topics. In short, we suggest placing a greater emphasis on real-world and agriculture-related examples in agricultural science courses, particularly as they relate to food security.

References

American Association for Agricultural Education (AAAE). (2023). *AAAE research values.* https://aaaeonline.org/National-Research-Values

Braun, V., & Clarke, V. (2012). *Thematic analysis*. American Psychological Association.

Conejero, J. M., Hernández, J., Jurado, E., & van den Berg, K. (2007). *Crosscutting, what is and what is not? A formal definition based on a crosscutting pattern*. (Technical report; No. TR 28/07). University of Extremadura, Spain.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Pearson Education.

Dickerson, D. L., Penick, J. E., Dawkins, K. R., & Van Sickle, M. (2007). Groundwater in science education. *Journal of Science Teacher Education*, *18*(1), 45–61. https://doi.org/10.1007/s10972-006-9019-2

Gleeson, T., Allen, D. M., & Ferguson, G. (2012). Teaching hydrogeology: A review of current practice. *Hydrology and Earth System Sciences, 16*(7), 2159–2168. https://doi.org/10.5194/hess-16-2159-2012

Next Generation Science Standards. (2026). *The standards*. https://www.nextgenscience.org/

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*, 1–9. https://doi.org/10.1136/bmj.n71

Ruddell, B. L., & Wagener, T. (2015). Grand challenges for hydrology education in the 21st century. *Journal of Hydrologic Engineering*, *20*(1), 1–8. https://doi.org/10.1061/(asce)he.1943-5584.0000956

Sadler, T. D., Nguyen, H., & Lankford, D. (2016). Water systems understandings: a framework for designing instruction and considering what learners know about water. *WIREs Water, 4*(1). https://doi.org/10.1002/wat2.1178

The Council for Agricultural Education (The Council). (2025). *National AFNR content standards*. https://www.thencae.org/afnr-standards