frontiers | Frontiers in Environmental Science

TYPE Editorial
PUBLISHED 09 November 2022
DOI 10.3389/fenvs.2022.1074801



OPEN ACCESS

EDITED AND REVIEWED BY
Angela Helen Arthington,
Griffith University, Australia

*CORRESPONDENCE
Bridget K. Mulvey,
bmulvey@kent.edu

SPECIALTY SECTION
This article was submitted to Freshwater Science,
a section of the journal
Frontiers in Environmental Science

RECEIVED 20 October 2022
ACCEPTED 25 October 2022
PUBLISHED 09 November 2022

CITATION
Mulvey BK, Jefferson AJ, Ward AS and Bales J (2022), Editorial: Innovations in remote and online education by hydrologic scientists.
*Front. Environ. Sci.* 10:1074801.
doi: 10.3389/fenvs.2022.1074801



# Editorial: Innovations in remote and online education by hydrologic scientists

Bridget K. Mulvey[1]*, Anne J. Jefferson[2], Adam S. Ward[3] and Jerad Bales[4]

[1]School of Teaching, Learning and Curriculum Studies, Kent State University, Kent, OH, United States, [2]Department of Earth Sciences, Kent State University, Kent, OH, United States, [3]Department of Biological & Ecological Engineering, Oregon State University, Corvallis, OR, United States, [4]Consortium of Universities for the Advancement of Hydrologic Science, Inc., Arlington, MA, United States

KEYWORDS

**hydrology education, water science education, remote education, online education, educational resource platforms, educational innovation, open access educational resources**

Editorial on the Research Topic
Innovations in Remote and Online Education by Hydrologic Scientists

## 1 Introduction

Hydrologic science is essential for sustainability and resiliency on a changing planet, and educational innovations to support instructors and students in this area are critical to ensuring future professionals are ready to tackle the world's environmental challenges (Ruddell & Wagener, 2015). This research topic was motivated by the educational adaptations and innovations that emerged during the early days of the COVID-19 pandemic. When faced with an abrupt shift to remote instruction, instructors quickly identified, modified, and developed remote content, activities, and instructional strategies. Given the importance of hydrology-related teaching and learning, there is a great need for continued iterative development and sharing of evidence-based open-access curricular materials, models, applications, and more. This open-access collection of papers will increase findability and accessibility of effective and well-documented pedagogical tools. In doing so, we advance the goal of ensuring that all students, independent of their individual circumstances or institutional resources, receive the highest quality educational programming, even in exceptional times.

The research topic contributions illustrate just how far the hydrologic science community has come in collaborating to develop, share, and test educational resources since the beginning of the COVID-19 pandemic. Together, the papers promote broader use and continued development of these supports for science education overall and hydrology education in particular well beyond the pandemic. The articles address the following themes: 1) visualizations and models for aquifers and water balance; 2) field experiences; 3) coordinated, collaborative resource development and sharing efforts; and 4) educational activities and strategies with broad applications. These articles share strengths in collaboration and visualization while highlighting areas in need of additional growth.

## 2 Research topic themes

### 2.1 Visualizations and models of hydrological concepts

One theme in this special issue emphasizes the power of visualizations and models as tools for teaching and learning, as represented by three papers. Lowry et al. present folded-paper aquifer models as an inexpensive way to support lower-scoring learners' ability to physically rotate aquifer models to support visualization and interpretation associated with three-dimensional problem solving. Another low-cost alternative is L. Gallagher et al. open-source interactive, gamified computer simulation, the ParFlow sandtank, which offers a variety of setup options compared to physical aquifer models. Illustrative outcomes for middle school and undergraduate science settings included that learners visualized and/or tested different scenarios to understand key hydrologic concepts and make decisions about water use. Gannon and McGuire highlight a web application and related activities involving user manipulation of model parameters to investigate water balance using NOAA climate stations. Student users in higher education hydrology classrooms reported that the application and activity promoted concept learning better than a spreadsheet or hand calculations. Overall, these articles offer suggestions for how to engage learners in reasoning through complex scenarios.

### 2.2 Field experiences

Three articles underscore the importance of engaging learners with outdoor and field experiences in hydrology courses, regardless of course delivery as in person, hybrid, or online/remote. Saup et al. adapted to the shift to remote instruction for a large-enrollment general education course by offering the choice for students to engage in either an in-person field-based lab activity or an online version. Students who opted for the in-person version scored better on the lab activity, compared to those who completed the online version, and increased enjoyment in learning about water whereas the online completers reported a decrease in their enjoyment. The authors note the importance of mitigating these disparities through enhanced interactions of teaching assistants and students in the online version. Schwarzenbach et al. migrated to a more accessible and flexible smartphone-based self-guided excursion, "Water in the City," compared to the pre-pandemic class trip. Built-in learner supports such as immediate feedback on question responses and ability to return to the locations and thus be reminded of the excursion may support stronger learner outcomes. Whether with instructors or application-based support, students benefit from connections with others during field experiences. Hinckley and Fendorf structured hands-on, small group collaborative learning about soil texture and color using kits that could be deployed in person or remotely. By integrating conceptual learning, hands-on experiences, and synthesis and interpretation, students gained both skills and interest in soil properties.

### 2.3 Coordinated, collaborative resource development and sharing platforms

Four articles explored instructor perspectives and student understanding using HydroLearn (www.hydrolearn.org), an open-access online platform for instructors to identify existing learning modules, adapt them, and collaborate to develop new modules. Recommendations for module development include instructor pairs co-creating modules, intensive training and use of curriculum design principles, consistent feedback, applicability to instructors' own course, and peer-review (M. Gallagher et al.). Instructors wanted accessible and adaptable shared curricular resources, yet there is a need for consolidation into one platform with the potential to test and iteratively improve resources and use workshops to bring instructors together to collaborate (Spackman Jones et al.). Roundy et al. and Byrd et al. shared meaningful improvements in students' conceptual understanding related to a snow and climate modeling module and 15 modules involving authentic, high-level tasks.

### 2.4 Educational activities and strategies with broad application

A final set of articles highlight educational activities, strategies, and courses that engage learners in authentic scientific and coding practices, with crucial support embedded in the learning materials and through interactions with instructors. This set of articles establishes evidence-based ways to support learners' enculturation into science and science communication. Thompson et al. highlight a shared constructivist, flipped classroom approach involving supportive, inclusive online instructional strategies used across four courses to promote diverse student engagement. The approach involved authentic learning and assessment that engaged students with the natural environment. Special attention was paid to development of supportive relationships with the instructor and other students. Kelleher et al. offer evidence-based recommendations for the effective incorporation of coding into hydrology courses across delivery methods. The main recommendations include making explicit the importance and benefits of coding early; going slowly; articulating each step; normalizing errors and seeking help, including explanations; and asking questions to promote student reflection. Jefferson et al. present faculty perspectives about an online, collaborative, multi-institutional graduate training course in hydrology, showing that it is perceived to widely benefit students, but that institutional administrative barriers may slow its growth within and beyond the hydrologic sciences.

Weaver et al. present an asynchronous online poster symposium–with substantial scaffolds over time to support quality posters and presentations–in a large introductory undergraduate environmental science course. Students identified the poster-related assignments as the course aspect through which they learned the most, and a large majority expressed confidence in their abilities to create a scientific poster. Informed by a community of inquiry framework, Gareis et al. share Wikipedia page-editing assignment guidelines and instructor-based outcomes involving support from a faculty mentoring network. Instructors considered the assignments to improve student motivation and scientific source reliability awareness while promoting STEM diversity, equity and inclusion discussions.

## 3 Conclusions and recommendations

Overall, this research topic documents important lessons learned regarding science teaching and learning, which we hope will promote long-term educational advancement in the hydrologic sciences and beyond. The scientific community in general and the community of hydrologic scientists in particular are poised to further develop flexible, accessible, and effective educational resources, activities, and assessments. We echo the call from a recent *Earth and Space Science* commentary to continue to foster integrated, coordinated, and networked open-science approaches to strengthen evidence-based, socially just teaching and learning (Fortner et al., 2022).

Additional professional development and peer-learning support will be critical to human resource development and the promotion of equity and justice in teaching and learning, especially as more learning is occurring *via* virtual platforms. More differentiated support for learners in needed, with stronger support for more novice learners and more flexible support for learners with higher initial knowledge and skills. Sustained structural and institutional support for collaboration and resource development can improve inclusive capacity building.

Another key need is the sustainment and continued development of online educational resource collections and databases with attention to accessibility. HydroLearn and other platforms offer an important start to collaborative curriculum development and sharing. Yet sustaining these platforms beyond the lifetime of the grants that supported their creation will require creativity and new resources. Also, much remains to be done to improve searchability and accessibility.

We call for substantial additional funding for these structural supports and continued development. In this way, the innovations identified and developed for use during the COVID-19 pandemic may act as a catalyst for future innovations. These educational innovations will help to prepare learners to address complex local and global problems.

## Author contributions

All authors contributed to the conceptualization and writing of this article. BKM developed the first draft. AJJ developed the second draft, with ASW, JB, and BKM providing final edits.

## Funding

Origins of this special issue were supported in part by NSF award EAR- 2028737.

## Acknowledgments

We dedicate this collection to the memory of Thomas Meixner, whose contributions to hydrology education and research were magnified by his generosity of spirit.

## Conflict of interest

JB was employed by Consortium of Universities for the Advancement of Hydrologic Science, Inc.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

# References

Fortner, S. K., Manduca, C. A., Ali, H. N., Saup, C. M., Nyarko, S. C., Othus- Gault, S., et al. (2022). Geoscience education perspectives on integrated, coordinated, open, networked (ICON) science. *Earth Space Sci.* 9, e2022EA002298. doi:10.1029/2022EA002298

Ruddell, B. L., and Wagener, T. (2015). Grand challenges for hydrology education in the 21st century. *J. Hydrol. Eng.* 20 (1), A4014001. doi:10.1061/(ASCE)HE.1943-5584.0000956