

**NATIONAL COLLABORATIVE FOR RESEARCH ON FOOD, ENERGY,
AND WATER EDUCATION**

SYNTHESIS OF NC-FEW EFFORTS AND OUTCOMES: 2019-2025



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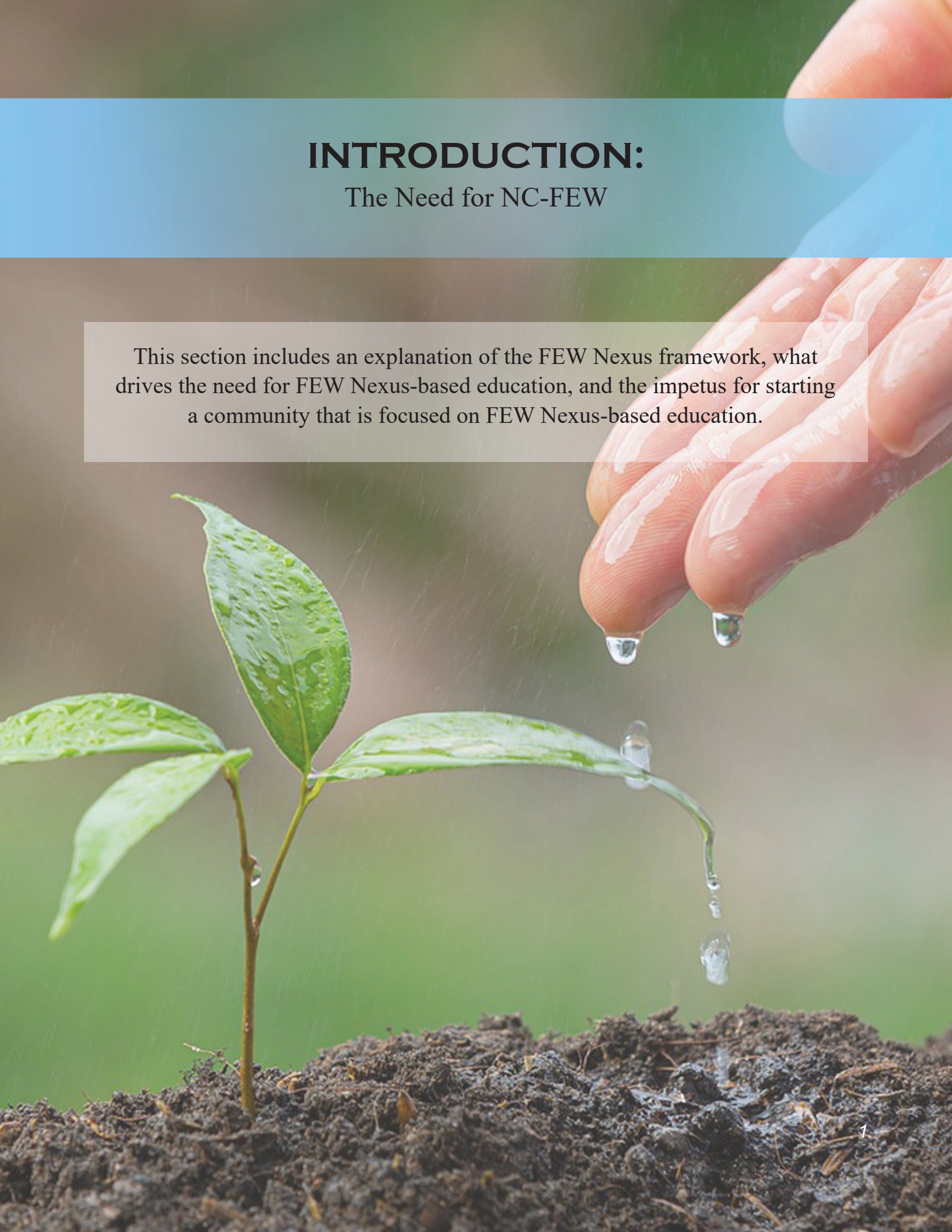
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INTRODUCTION:

The Need for NC-FEW

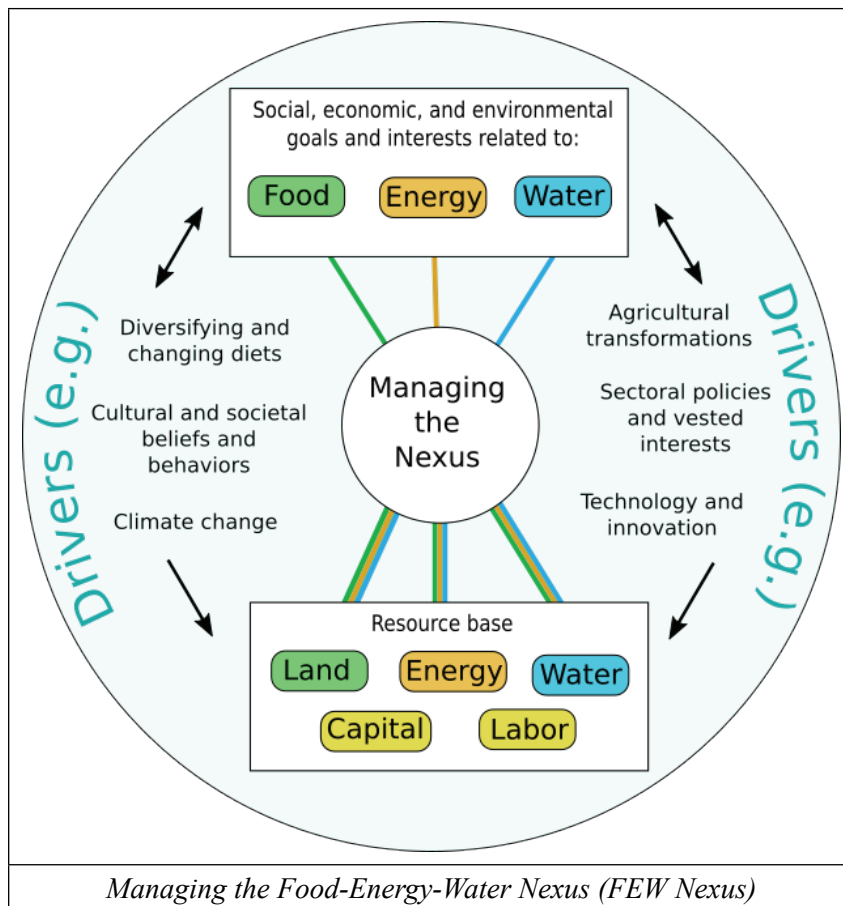
This section includes an explanation of the FEW Nexus framework, what drives the need for FEW Nexus-based education, and the impetus for starting a community that is focused on FEW Nexus-based education.



SECTION 1: Introduction

Defining the FEW Nexus

The greatest challenges of the 21st Century and beyond are defined by dynamic interactions and feedbacks between processes of natural and human systems that span a multitude of temporal, spatial and sociocultural scales. Providing the world's growing population with food, energy and water will lead to increasing competition for resources and will have significant implications for all facets of society, including economic development, poverty, international trade, education and workforce development, and regulatory mechanisms that span public and private domains. The Food-Energy-Water (FEW) Nexus (FAO, 2014) has emerged as a conceptual framework used to describe and aid in addressing the complex interrelationships associated with these systems. The interdependence and inter-linkages between water, energy, and food mean that changes in one system can have far-reaching impacts in other systems, resulting in significant ecological, economic, social and political consequences. The nexus serves as a tool to understand the interplay between these systems and their components. Doing so allows for more integrative problem-solving and decision-making that account for and balance trade-offs and synergies within and across systems.



The Role of FEW Nexus-Based Education

As the use of the FEW Nexus gained traction in research and policy sectors, the education component of FEW Nexus efforts initially was underemphasized and under-represented. This was despite compelling evidence for the very real and pressing global challenges in the FEW Nexus, the need to foster scientific understanding in America's citizenry, and necessity of meeting ever-evolving workforce needs (Goecker, Smith, Smith, and Goetz, 2010;

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National Association of Colleges and Employers, 2014; National Research Council, 2012). These challenges provide a rationale for sustained, systemic, and interdisciplinary education efforts focused on food, energy, and water issues in a wide array of educational contexts which have significantly expanded over the past decade.

Education about content within the FEW Nexus is important in its own right. Beyond content, however, the FEW Nexus represents an ideal context for achieving a variety of general learning goals that will equip learners for careers and lives in an evolving world. For example, the FEW Nexus inherently recognizes multiple interdependencies (Albrecht et al. 2018; Bazilian et al. 2011; Ojeda Matos, 2023; Yadav et al. 2021). Affording a greater ability to represent systems as holistic entities that go beyond a simple sum of their constituent parts allows for more integrative problem-solving and decision-making that accounts for and balances trade-offs and synergies within and across systems.

The need for systems thinking will only become more critical given the challenge of feeding a growing human population sustainably with a finite supply of natural resources. As another example, the complexity and scale of FEW Nexus issues demand understanding and reasoning abilities that extend beyond any one discipline. This makes it an excellent context for interdisciplinary training. Additionally, the FEW Nexus provides an ideal context to support scientific literacy that is developed through real-world, personally relevant societal issues, such as diet, healthcare, lifestyle, transportation, housing, and consumption that have local and global impacts. In sum, the FEW Nexus holds tremendous potential for educating change makers who will be equipped to facilitate societal transformation.

Need for Establishing a Collaborative Focused on FEW Nexus Education

As the FEW Nexus problem space is inherently interdisciplinary, so too is FEW Nexus education. Educators and education researchers from fields ranging from chemistry, to management, to psychology have found their own entry points into FEW Nexus education, often being the only one in their institution or within their discipline. Thus, there was a need to create a new interdisciplinary community to bring people together to foster connections across this burgeoning and dispersed community.

The National Collaborative for Research on Food, Energy, and Water Education (NC-FEW) is a direct response to these needs. It is novel in its focus on the FEW Nexus and mobilization of transdisciplinary expertise to catalyze education research around innovative FEW Nexus based educational programs. It is grounded in theory and research on teaching and learning in diverse disciplinary contexts and about specific contemporary challenges in coupled human-natural systems and their associated science, technology, engineering and math (STEM) and food, agriculture, natural resource and human sciences (FANH) concepts, which span FEW systems.

It also encompasses theoretical perspectives on pedagogical practices, student learning, and evaluation and assessment of FEW Nexus educational endeavors. Finally, because NC-FEW is unlike any existing professional community, it meets the need to support collaborations necessary to bring new, transdisciplinary, empirically-based perspectives to education and educational research grounded in the FEW Nexus.

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CENTRAL NC-FEW ACTIVITIES:

Fostering a Collaborative Vision

This section provides an overview of the central activities conducted by NC-FEW during the period of operation as a Research Coordination Network funded by the National Science Foundation.



SECTION 2: Central NC-FEW Activities

Goals for NC-FEW

As a National Science Foundation funded Research Coordination Network from 2019 through 2025, NC-FEW established five explicit goals that served to direct central activities during this time. These goals were to:

1. Synthesize current education research on educational programming grounded in the FEW-Nexus.
2. Identify and promote best practices in education research on educational programming grounded in the FEW-Nexus.
3. Foster collaboration among community members representing diverse disciplines, fields, expertise and institutions.
4. Enhance capacity for extramural funding in support of education research on educational programming grounded in the FEW-Nexus.
5. Cultivate a community identity among NC-FEW participants.

Here we synthesize the central activities that contributed to the achievement of the goals.

Establishment of Working Groups

Establishing and supporting working groups was a foundational and ongoing effort of NC-FEW. There were three working groups focused on FEW Nexus-based education research on educational programming in postsecondary (community college through graduate studies), formal PK-12 and informal/nonformal contexts. Each working group was led by a member of the leadership team and their stories are shared in Section Four of this document. Primary overall contributions of the working groups were to conduct synthesis efforts and provide thought leadership for other NC-FEW activities.

Establishment of the NC-FEW Listserv

Throughout the funded period, the NC-FEW listserv served as the central mechanism for connecting disparate members of the community of education researchers and educators interested in the possibilities of the FEW Nexus. Advertised initially through various channels, including existing professional societies and related educational organizations, the listserv was established in 2019 with ~150 members. It grew to include 432 members from 92 different institutions and organizations at the conclusion of the funding period. The listserv will remain an active communication channel for NC-FEW into the future. New members can join at [this link](#).

Virtual Poster Showcase

In 2020, as in-person activities were halted due to COVID-19, contributions for a Virtual Showcase were solicited from NC-FEW members. Four posters with abstracts were submitted and hosted on a publicly accessible [Virtual Showcase website](#). These posters served as early exemplars of educational efforts grounded in the FEW Nexus that provided grounding for next steps of community members.

Virtual Workshops

NC-FEW sponsored a quarterly virtual workshop series with panels, activities, and research presentations related to current FEW education topics. Each workshop was archived on an individual webpage with a recording, session description, resources for learning more, and a short synthesis document that highlights the central ideas from the session.

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Virtual workshop topics were:

[Indigenous Perspectives on Connecting Food-Energy-Water Nexus to People](#)

Emma Elliot, Nikki McDaid Barry, and Tim San Pedro; January 17, 2023.

[Colombia - USA Water-Energy-Food Nexus Alliance: Integrating Research, Education and Development for Peace Building, Sustainable Development and Climate-resilience](#)

Siela Maximova; May 11, 2023.

[Enhancing Transdisciplinary Capacities through a Food-Energy-Water Graduate Training Program](#)

Sybil Sharvelle; August 22, 2023.

[A Revised Dual Approach for Implementing the FEW Nexus into the Curriculum: Combining Design Thinking Across Experiential Learning](#)

Nirav Patel; November 13, 2023.

[Fulfilling the Land-Grant Mission in a Modern Context: Ensuring Equitable Education via Cooperative Extension](#)

Antonia Silas; January 24, 2024.

[Implementing an Experiential Curricular Model to Train Doctoral Students in Interdisciplinary Research at the Food-Energy-Water Nexus: A “How to” Approach from the UMD Global STEWARDS National Science Foundation Research Traineeship \(NSF NRT\)](#)

Amy Sapkota; April 10, 2024.

[Can Plants Help Clean Up Watersheds and Supply Renewable Energy? Explore a U.S. Department of Energy BRIDGES Bioenergy Case Study](#)

Kelly Sturner; September 12, 2024.

[Food, Energy and Water Community Science Data Talks](#)

Imogen Herrick, Shondricka Burrell, and Todd Campbell (facilitators); February 25, 2025.

Invited Conferences

NC-FEW hosted two invited in-person conferences, with archived materials publicly accessible on the NC-FEW website.

Advancing FEW-Nexus-based Education through Research, May 2023

Held in a workshop format, this event aimed to develop an updated NC-FEW community vision for FEW-Nexus-based education and new research teams and lay the groundwork for future NC-FEW efforts to inform educational practice. Activities included keynote presentations, working group presentations, opportunities for participants to share their own work, collaborative visioning exercises and small group reflection sessions. Through these efforts, participants helped shape the vision for FEW Nexus-based education and developed plans for future design-based education research that is grounded in the FEW-Nexus. There were 36 event participants and the [virtual poster collection](#) includes 18 archived posters.

Education Research and Practice in the FEW-Nexus, March 2025

The conference brought together participants from diverse disciplines to highlight significant accomplishments by FEW Nexus-based education researchers and practitioners. The goals were to: 1.) foster idea ex-

SECTION 2: Central NC-FEW Activities

change among education researchers and practitioners who are engaged in FEW Nexus-based education; and 2.) position participants to continue to collaboratively innovate NEW Nexus-based education past the conclusion of the INFEWS grant.

Activities included success stories shared by the Working Groups, contributed talks, poster sessions, breakout discussions, a grant-writing strategy session and a wrap-up session focused on what's next for the NC-FEW community. These activities enabled participants to share their achievements, learn about their peers' successes and plan for continued collaboration in the FEW-nexus education and education research spaces. There were 26 event participants and 19 [extended abstracts](#) were accepted and published in a collection (see Section 5 of this document).

Workshops at Professional Conferences

NC-FEW held workshops at annual conferences of other professional and academic associations with an aligned interest in the FEW Nexus. The aims of these workshops were to 1) broaden participation in NC-FEW from across different disciplines; and 2) solicit information about FEW Nexus education from the perspective of educators in diverse disciplines.

The leadership team developed a [common slide deck and script](#) that presenters modified to suit the specific audience of their workshop. In total NC-FEW members delivered eight workshops at conferences of professional associations:

- American Association of Geographers.
- Association of Environmental Studies and Sciences.
- Earth Educators Rendezvous.
- International Association for Society and Natural Resources.
- Geological Society of America.
- North American Association for Environmental Education.
- North American Colleges and Teachers of Agriculture.
- Soil and Water Conservation Society.

Additionally, NC-FEW leadership hosted a virtual version of the workshop which was open to anyone interested in attending. Artifacts from these workshops were collected for subsequent analysis, contributing to the expansion of the NC-FEW vision for FEW Nexus-based education (Section 3).

Quarterly Newsletters

To encourage sharing across the network, the NC-FEW published quarterly newsletters. Newsletter submissions from NC-FEW members were encouraged through an open call sent to the email listserv and a submission form. Community members shared relevant publications, resources, events and presentations. Feature articles were contributed by NC-FEW leadership team and other members. Additional standing newsletter sections were working group activities, notes from the directors, spotlight on professional societies and recap of virtual workshops. In total, 15 newsletters were published and [archived on a website](#).

SECTION 2: Central NC-FEW Activities

Scholarly Publications and Presentations

NC-FEW has supported development of several scholarly publications and presentations over the course of the federal funding period.

Publications

Lee, K., Burrell, S., Knobloch, N., Wang, H.-H., & Wang, R. (in preparation). *Mapping Food-Energy-Water Nexus Education in K-12 Settings: A Systematic Review of Practices*.

Scherer, H. H. & Lombardi, D. (in preparation). *Exploring the Foundations of FEW-Nexus Education Through Interdisciplinary Educator Perspectives*.

Romulo, C., Ajgaonkar, S., Azzarello, C., Estepp, C., Knobloch, N., Ogar, E., & Venkataraman, B. (in preparation). *FEW Nexus as a Multidimensional Lens for Knowledge and Understanding (working title)*.

Romulo, C., Venkataraman, B., Caplow, S., Ajgaonkar, S., Allen, C. R., Anandhi, A., Anderson, S. W., Azzarello, C. B., Brundiers, K., Blavascunas, E., Dauer, J. M., Druckenbrod, D. L., Fairchild, E., Horne, L. R., Lee, K., Mwale, M., Mischler, J., Pappo, E., Patel, N. S., . . . Vincent, S. G. (2024). Implementing interdisciplinary sustainability education with the food-energy-water (FEW) nexus. *Humanities & Social Sciences Communications*, 11(1), 928-917. <https://doi.org/10.1057/s41599-024-03332-7>.

Tabassum, S., Dauer, J., Scherer, H. H., Sintov, N., & Wang, H.-H. (2025). Understanding the emerging food, energy, and water nexus (FEW-Nexus) systems in science education. *Journal of Environmental Studies and Sciences*, 15, 55-70. <https://doi.org/10.1007/s13412-024-01000-5>.

Conference Papers, Abstracts and Presentations

Forbes, C., Scherer, H. H., Sintov, N., & Wang, H.-H. (2019, September). A national collaborative for research on food, energy, and water education (NC-FEW). *Geological Society of America Abstracts with Programs*, 51(5). <https://doi.org/10.1130/abs/2019AM-334540>.

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Wang, Hui-Hui (Chair); Lombardi, Doug (Discussant); Poster 1: Lee, K.; Poster 2: Wang, H. & Knobloch, N.; Poster 3: Campbell, T., Burrell, S., Fick, S. J., Herrick, I., McGowan, V. C., Fazio, X., & Lombardi, D.; Poster 4: Spencer, K., Whitten, C., Scherer, H. H., & Azano, A. P.; Poster 5: Ramsdell, C; Poster 6: Feldman, A. & Ortiz, R. (2024). *Collaborative Development of a Framework for Food-Energy-Water-Nexus Education [Structured Poster Session]*. American Education Research Association. Philadelphia, PA.

Scherer, H. H., Sintov, N., Wang, H.-H., Chaudhary, A. K., Lombardi, D., & Romulo, C. (2024). *Supporting teaching and learning in the Food-Energy-Water (FEW)-Nexus through a National Collaborative*. Earth Educators' Rendezvous. Philadelphia, PA.

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Jefferson, E., III. (2025). Impact of Urban Environmental Factors on Baltimore: A Community Science Data Talk. Graduate Research Symposium, School of Education and Urban Studies, Morgan State University, Baltimore, MD.

Practitioner-focused Publications and Presentations

Scherer, H. H., Forbes, C. T., Sintov, N., & Wang, H.-H. (2020). The Food-Energy-Water-Nexus: A new way to help students think about resource management in AFNR education. *The Agricultural Education Magazine*, 92(5), 5-8.

Scherer, H. H., Wang, H.-H., Sintov, N., & Forbes, C. (2021). *Workshop: A National Collaborative for Research on Food, Energy, and Water Education*. NACTA Annual Conference, Virtual.

NC-FEW nonformal/informal working group (2023). *Round table discussion session: Application of Food, Energy, and Water (FEW) nexus to extension programming*. National Association of Extension Program and Staff Development (NAEPSDP) Conference.

Campbell, T., Burrell, S., Fick, S. J., Herrick, I., Cassone McGowan, V., Fazio, X., & Lombardi, D. (2024). *Understanding how food, energy, and water decisions affect the thriving of local, regional, and global systems*. STEM Teaching Tool Brief #96. Available at: <https://stemteachingtools.org/brief/96>.

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THE NC-FEW VISION:

for FEW Nexus Based Education

This section describes efforts of NC-FEW community members to develop and deepen a collective vision of FEW Nexus based education, including the challenges and opportunities afforded by this innovative, interdisciplinary contest.

SECTION 3: The NC-FEW Vision

As a community of educators and education researchers from a wide array of disciplines, at its core NC-FEW is a hub for people who are interested in expanding and improving FEW-Nexus-based education through educational research and/or practice. Over the life of NC-FEW, our vision for FEW Nexus education has evolved through several iterations as the community has grown and experiences with FEW Nexus education and educational research have deepened. Three phases of these efforts are described here.

Initial Vision

A fundamental assumption underlying the vision for FEW Nexus based education at the proposal stage was that *STEM/FANH scientific literacy is the primary outcome of effective teaching and learning about the FEW Nexus that can be understood and effectively fostered through education research*. This vision was developed through connections to existing literature, the expertise of the proposal development team (led by Cory Forbes, then at University of Nebraska-Lincoln), and input from 1.) a Multistate Research Planning Committee - NCDC231: Collaborative for Research on Food, Energy and Water Education established in 2016; and 2.) participants at a 2018 invited conference funded by the USDA-NIFA Higher Education Challenge grant program, APLU's NSEC Research Action Cluster grant program, the University of Nebraska-Lincoln, and Virginia Tech.

NC-FEW Community Vision

NC-FEW leaders and participants at the 2023 invited conference extended this vision through collaborative brainstorming sessions. Following that event, the NC-FEW directors synthesized the ideas and developed a [visioning document](#) that was hosted on the NC-FEW website for public comment and input for the remainder of the project period. The purpose of this document was to provide a common vision of current challenges and emerging opportunities for FEW-Nexus-based education research and education for the NC-FEW community. The text of that document is provided here:

What is FEW Nexus Based Education?

The FEW Nexus has served as a productive framework for science and engineering research communities to describe and aid in addressing complex coupled human-natural systems and the most significant global challenges of today and tomorrow. These challenges provide a rationale for sustained, systemic and interdisciplinary educational efforts focused on food, energy and water systems in a wide array of educational contexts. A consistent description of what characterizes “FEW Nexus based education,” however, is not documented in the education research literature. For NC-FEW, we posit that the following are foundational to design and delivery of FEW Nexus based education:

- There is intentional integration of food, energy and water systems through interdisciplinary educational contexts.
- Decision making about management of natural resources, which support sustainable use and development, in a complex system is centered.
- The nexus perspective, which emphasizes connections between food, energy and water systems, is utilized in consideration of tradeoffs in potential solutions.

NC-FEW community members over the past several years have advanced this work, moving beyond consideration of education in food systems, energy systems and water systems separately (as is prevalent in the literature), to developing frameworks for how the FEW Nexus can be leveraged to promote education that is inherently inter-/trans-disciplinary, supports complex systems thinking, and is grounded in real-world sustainability challenges involving stakeholders at local to global scales. Additional areas of focus for FEW Nexus based education identified through NC-FEW efforts include argumentation/evidence-based reasoning, citizen science, equity and environmental justice, informed decision-making, STEM/FANH science literacy, and civic engagement.

SECTION 3: The NC-FEW Vision

For NC-FEW, education is defined very broadly to include formal, informal, and non-formal contexts across all ages and stages of life. NC-FEW currently has three Working Groups that focus on advancing FEW-Nexus-based education in 1.) formal (school-based) PK-12 education; 2.) higher education (including 2-year colleges through graduate programs); and 3.) in/non-formal education and communication. Within these contexts, particular efforts may be centered on learners/participants and/or educational practitioners.

Challenges in FEW Nexus Based Education

NC-FEW efforts (across the Working Groups and the community more broadly) center knowledge-generation through education research and evaluation as a tool to improve and expand access to FEW-Nexus-based education. Several practical challenges in promoting and implementing FEW-Nexus-based education have been identified. Many of these challenges share similarities with other interdisciplinary efforts, such as Integrated STEM education. Leveraging the unique opportunities afforded by the FEW-Nexus and previous work addressing these challenges in related arenas helps NC-FEW set priorities for future research.

1. Lack of consensus of goals and outcomes for FEW-Nexus education.
 - a. Everyone is working from their own purpose/ goals.
 - b. What sets the FEW-Nexus apart from other things, such as systems thinking or interdisciplinary learning?
2. Contextual factors.
 - a. Not all perspectives and ways of knowing are valued equally. For example, priorities and/or expertise that come from affected communities may be dismissed.
 - b. “Silo-ing” of the different domains, disciplines, and/or subjects: The structure of knowledge and knowledge construction, given the different disciplinary practices and epistemic assumptions that may or may not align across “silos.”
3. Limitations of existing educational structures (system level).
 - a. Little room to integrate new things in existing programs; sometimes limited by accreditations and the skillsets they are requiring.
 - b. Curriculum requirements in formal educational spaces and non-formal programs that align with formal educational standards.
 - c. Diversity of stakeholders (especially informal and non-formal settings).
 - d. Limited opportunities to collaborate: funding/time/other resources available to fully integrate and collaborate in terms of NC-FEW content, disciplines, teams, etc.
 - e. Professional/disciplinary training reflects silos, leading to limited perspectives on FEW-Nexus education.
4. Lack of educational resources (support), including:
 - a. Models for new courses and educational programs.
 - b. Interdisciplinary curriculum frameworks.
 - c. Opportunities for professional learning.
 - d. Effective ways to use the FEW-Nexus in education.
 - e. Funding for curriculum designers / communicators to put together modules.
5. Individual level barriers.
 - a. time to learn new things, engage in interdisciplinary collaborations, takes time and can have

SECTION 3: The NC-FEW Vision

- implications for career trajectories.
- b. Educators don't have the time/freedom to do interdisciplinary work.
- c. Educator knowledge of FEW-Nexus (e.g. self-efficacy).
- d. Identifying locally relevant FEW-Nexus phenomena; connecting with local expertise on FEW-Nexus issues.

Opportunities to Address Challenges in FEW Nexus Based Education

A primary goal for NC-FEW is to address these challenges (among others) through advancing education research, often embedded in practice, grounded in the FEW Nexus. NC-FEW community members have already begun this work. As an interdisciplinary collective, we can develop solutions to these common challenges that cut across educational settings and work to affect change at individual, structural, and epistemological levels. Generating opportunities for members to share their work, develop new collaborations, and build their capacity for conducting design-based education research are priority areas for NC-FEW. The collective expertise across the NC-FEW network is uniquely poised to generate new educational models and understandings that will help shape the future of FEW Nexus based education. Together, we can explore existing and generate new frameworks and models to integrate across domains, disciplines, and ways of knowing and make connections across education settings in a way that promotes interdisciplinary thought and action. Where do you see yourself contributing?

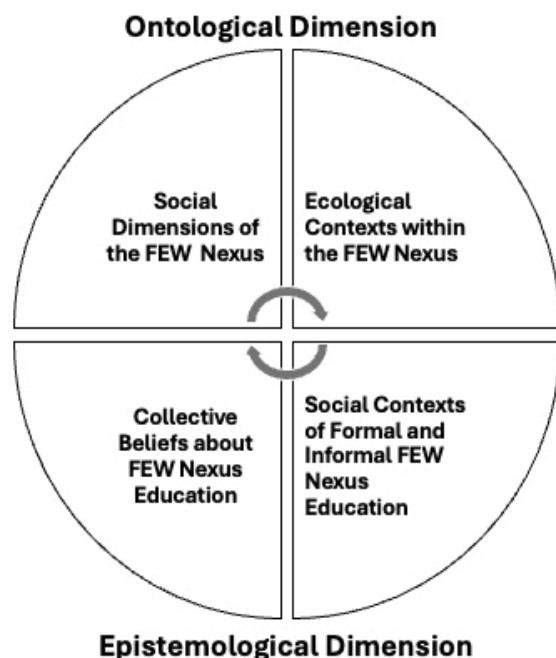
Expanding the Vision: Disciplinary Workshop Study

Through workshops held at annual conferences of other professional and academic associations with an aligned interest in the FEW Nexus, NC-FEW leadership team members Hannah Scherer and Doug Lombardi added to the vision for FEW Nexus based education through analysis of artifacts collected during the workshops. In these workshops, facilitators prompted participants to consider their role in educational research in addressing FEW sustainability and security by considering how the FEW Nexus relates to their specific contexts, the challenges to teaching and learning about the FEW-Nexus in their domains and situations, and their suggestions for addressing these challenges. The analysis was guided by the following research objectives:

From the perspective of education practitioners,

1. Define and describe the FEW Nexus;
2. Define and describe FEW Nexus based education; and
3. Identify and describe challenges with FEW-Nexus-based education.

Findings from this study will be communicated in a scholarly publication that was in preparation in August 2025. Highlights of the findings that help clarify the vision for FEW Nexus education are summarized here.



Dimensions to Guide FEW Nexus Education

Initial analysis revealed that participants' responses fell along ontological and epistemological dimensions, and the resulting framework was structured around these dimensions (figure left).

The ontological dimension captured how participants conceptualized the systems and phenomena that the

SECTION 3: The NC-FEW Vision

FEW Nexus is meant to represent, including both environmental processes and human social systems. For practitioners and researchers, understanding the properties that characterize the FEW Nexus itself is important for clarity in defining and describing educational outcomes. The epistemological dimension focused on participants' thoughts about education focused on the FEW Nexus. Articulating why and how FEW Nexus education occurs, and the opportunities and constraints offered by this context is important for designing new learning experiences and adequately supporting these efforts.

Themes: How Practitioners View the FEW Nexus and FEW Nexus Education

The framework of dimensions and the categories within them were used to structure the thematic content analysis that occurred next. Findings are presented in a codebook that is publicly available (<https://hdl.handle.net/10919/137639>) and themes are summarized here.

Themes within the Ontological Dimension

- Crosscutting theme: scale, complexity and systems.
- Ecological contexts theme: processes and consequences.
- Social dimensions theme: power, inclusion and justice.
- Social dimensions theme: governance, policy and decision making.
- Social dimensions theme: equity of access and interdependence.
- Social dimensions theme: critical social science and ontological reframing.

Themes within the Epistemological Dimension

- Collective beliefs theme: systems thinking as a core educational aim.
- Collective beliefs theme: civic and societal relevance of education.
- Collective beliefs theme: experiential and place-based learning.
- Collective beliefs theme: inclusive and equity-oriented pedagogy.
- Collective beliefs theme: interdisciplinary collaboration and integration.
- collective beliefs theme: student and instructor identity and agency development.
- Collective beliefs theme: cognitive and social construction of knowledge about FEW science and FEW interdisciplinarity.
- Collective beliefs theme: relevance of FEW to curriculum and student futures.
- Social contexts theme: student diversity in FEW Nexus education.
- Social contexts theme: expertise and educator knowledge of the FEW Nexus.
- Social contexts theme: educator support is needed to implement FEW Nexus education.
- Social contexts theme: tools for teaching with the FEW Nexus are desired.
- Social contexts theme: curricular structures and educational contexts to implement FEX Nexus education.
- Social contexts theme: human and financial resources.
- Social contexts theme: external connections and considerations.
- Social contexts theme: community defining the concept of FEW for education.

The findings of this study help deepen the conceptualization of FEW Nexus based education from the perspective of a broad, interdisciplinary set of participants. Developed through robust and systematic analysis, the themes presented here can be used to guide future work in both research and practice.

The background image shows a group of people in a collaborative setting. A man with short dark hair and a beard, wearing a grey blazer over a green t-shirt, is smiling and pointing towards a whiteboard. To his left, a woman with curly brown hair is looking at the whiteboard. In the foreground, a man with reddish-brown hair is looking down, and another person's arm is visible on the right side, also pointing towards the whiteboard. The overall atmosphere is positive and collaborative.

WORKING GROUP STORIES:

Efforts within Diverse Educational Settings

This section includes reflections from each working group in which they describe the identity of the working group and how that formed, key points of connection and catalysts for collective interest, and insights from the journey from initiation to the end of the project.

SECTION 4: Working Group Stories

Postsecondary Working Group

Working Group Members*

Chelsie Romulo, associate professor of geography, GIS, and sustainability at University of Northern Colorado (chair); Bhawani Venkataraman, associate professor of chemistry, The New School; Shamili Ajgaonkar, professor of biology and faculty chair of global education, College of DuPage; Craig R. Allen, University of Nebraska–Lincoln; Jenny Dauer, associate director of undergraduate education, School of Natural Resources, associate professor in science education, School of Natural Resources, University of Nebraska–Lincoln; Marizvkuru Mwale, associate professor, Institute for Rural Development, University of Venda, South Africa; Nicole D. Sintov, associate professor, The Ohio State University School of Environment and Natural Resources (past chair).

Identity of the Postsecondary Working Group

As teacher-scholars, members of the Postsecondary Working Group bridge the connection between education research and practice, often conducting our research in the same classrooms where we teach. The Postsecondary Working Group is interested in the diverse disciplines across higher education that incorporate FEW education into their teaching and curriculum, and how we can create and maintain connections with each other. So far, our working group has engaged scholars representing disciplines that include biology, chemistry, physics, psychology and educational psychology, science education research, anthropology, ecology, and interdisciplinary degree programs such as sustainability, geography, resilience, environmental studies and environmental sciences, tourism and outdoor recreation, biological systems engineering and environmental sociology. We also include all types of higher education institutions, including 2-year colleges, small liberal arts colleges, teaching-focused universities and research-intensive universities.

Points of Connection

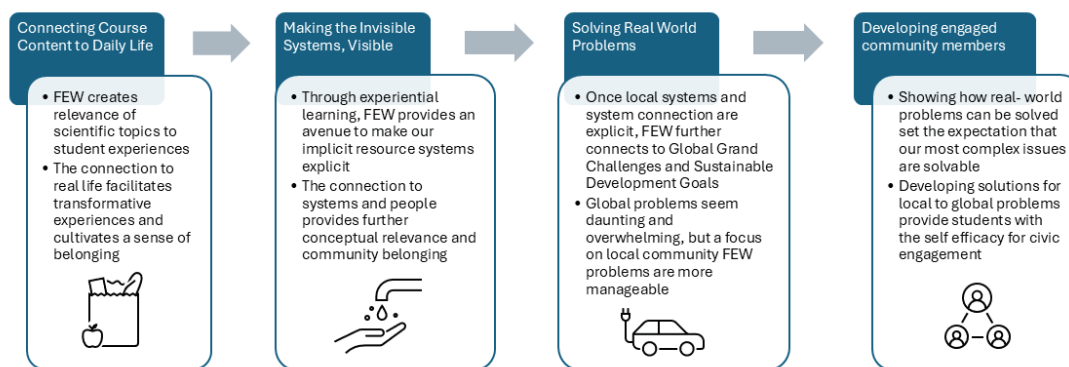
We are an inclusive group that leans into collaboration across institutions, and the NCFEW RCN has been very successful in connecting people who may otherwise have never met each other. Many of us met at the NCFEW invited conferences, or at the workshops held at disciplinary conferences. We were seeking others working in the FEW education research and practice space, and recognized each other based on our shared interest in FEW as a context for teaching systems thinking while creating topic relevance and place-based sense of belonging for our students. Further, we consider interdisciplinary education as a broad framework or input into a larger educational system, with the potential to yield a variety of outputs. Hence, we view interdisciplinary education as a core theme in NC-FEW to which many other themes can link. We connect with each other through our shared struggles in both research and practice of FEW Education, both in the epistemological and ontological senses, which is representative of the higher education NCFEW community as a whole.

A Conceptual Framework for FEW Education Research on Integrating Ways of Knowing

At the 2025 invited conference we developed a conceptual framework of how FEW provides us with a way to connect course content to daily life and makes our implicit and somewhat invisible resources systems more explicit and visible to students. A focus on place and local community creates a demonstrative way that students can apply their skills to solving real world problems as engaged community members and global citizens. At the moment we're developing this framework into a manuscript centered on the hypothesis that **the FEW Nexus is a way to know about the world, and for education it provides a context that brings together different ways of knowing, and because of that context, supports teaching and learning of different ways of knowing.**

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Figure: The FEW Nexus as a way to know and understand the world.



Catalyzing Moment - Publication on Teaching Sustainability Competencies with the FEW Nexus

The original five working group members identified a need for supporting FEW education and research in higher education and outlined a few manuscript ideas early in the life of the RCN, but struggled with how to move forward or coalesce the ideas in an authentic and practical way. However, at the 2023 invited conference, our working group members started a conversation with several other conference participants about the manuscript ideas and realized our ideas connect around FEW as a context for teaching sustainability concepts. This conversation led to several remote meetings, outreach to more connections, and eventually a group of 22 of us co-authored a publication on implementing interdisciplinary sustainability education.

Working Group Publication Citation: Romulo, C., B. Venkataraman, S. Caplow, S. Ajgaonkar, C.R. Allen, A. Anandhi, S.W. Anderson, C.B. Azzarello, K. Brundiers, E. Blavascunas, J. Dauer, D.L. Druckenbrod, E. Fairchild, L.R. Horne, K. Lee, M. Mwale, J.A. Mischler, E.E. Pappo, N.S. Patel, N.D. Sintov, C.S. Ramsdell, and S. Vincent. 2024. Implementing interdisciplinary sustainability education with the food-energy-water (FEW) nexus. *Humanit Soc Sci Commun* 11, 928. <https://doi.org/10.1057/s41599-024-03332-7>.

Success Story - Disciplinary Conference Workshops and Connections

Higher education working group members served as presenters for several of the NC-FEW workshops that were held at professional association meetings (see Section 2). This was an important opportunity for higher education working group members to engage with expanding the reach of NC-FEW and deepening connections with existing professional associations.

Success Story - Partnership with ESA

The Ecological Society of America's (ESA) [Transforming Ecology Education to 4D](#) (TEE) project teamed up with NC-FEW to host a Faculty Mentoring Network (FMN) in the fall of 2024. Participants explored, and incorporated, the [Four-Dimensional Ecology Education](#) (4DEE) Framework into their undergraduate courses through the modification of FEW related teaching materials. The goal of this FMN was to work as a community of practice to build a collaborative network of educators interested in enhancing the eco-literacy underpinnings of the FEW nexus. By integrating the 4DEE Framework into the undergraduate classrooms that are focused

SECTION 4: Working Group Stories

on teaching food, water, and energy concepts, participants were able to help students understand the relevant ecological terminology and concepts, and to grasp ecological problem-solving and decision making approaches for addressing the complex interactions and dependencies between these essential resources. The FMN supported the development of educational products that emphasized the importance of sustainability and interdisciplinary approaches to addressing global challenges. To focus our efforts, we asked faculty to bring to the FMN any FEW related teaching module they currently use, or one that they would like to use, which they would like to improve/revitalize by aligning to the 4DEE Framework. The 4DEE Framework includes core ecological concepts, ecology practices, human-environment interactions and cross-cutting themes—all of which have relevance to the FEW Nexus.

Success Story - What's next?!

The large co-author group paper was such a success in terms of both product and positive collaboration that the participants have been seeking other opportunities to work together and other NC-FEW members have expressed interest in joining in. Our group is working on a manuscript about the FEW Nexus as a way to know the world and working group members have connected with each other to collaborate on FEW education related proposals and manuscripts outside of the working group specific priorities.

While the process of networking and deepening connections across institutions was inherently valuable, the most valuable part of the experience of participating in NC-FEW was the opportunity to organize around specific products and projects. By participating in publications, workshop facilitation, and conference presentations, we were able to achieve meaningful milestones for our careers that also helped us contribute to the advancement of learning in the FEW Nexus. We also still have a list of potential paper collaborations that give us confidence that these connections will continue to result in tangible and meaningful projects beyond the life of the grant itself.

PK-12 Working Group

Working Group Members

Doug Lombardi, University of Maryland (chair); Shondricka Burrell, Morgan State University; Todd Campbell, University of Connecticut; Sarah Fick, Amplify Education Inc.; Xavier Fazio, Brock University; Imogen Herrick, University of Kansas; Veronica Cassone McGowan, University of Washington; Aaron McKim, Michigan State University (past member); Gilian Roehrig, University of Minnesota (past member); Hui-Hui Wang, Purdue University (past chair).

Identity of the Working Group

The PK–12 Working Group is a cross-institutional team of educators, researchers and practitioners committed to justice-oriented, place-based science and STEM education. The group began forming in the spring of 2018 during the development of a grant-funded proposal to support a national collaborative focused on FEW systems education. This vision became reality in the fall of 2019 when the project received funding and the PK–12 group began formal activities. From its inception, the group has worked to elevate the importance of FEW Nexus issues in pre-college education, with a strong emphasis on local context, interdisciplinary collaboration and systemic justice.

SECTION 4: Working Group Stories

Points of Connection

Members of the working group found early and enduring points of connection around a shared desire to support educators and students in addressing complex environmental challenges through meaningful, community-connected science learning. Despite differences in institutional roles and geographic settings, the group coalesced around a belief that FEW Nexus education must go beyond content delivery to engage learners in critical, affective and participatory ways. These shared commitments created the foundation for a collaborative ethos that emphasized co-creation, responsiveness to practice and sustained dialogue across roles.

Catalyzing Moments

One of the group's most significant turning points emerged from a period of collective frustration. In the early stages of our collaboration, we set out to write a conceptual framework article that would articulate how the FEW Nexus could inform justice-centered, place-based science and STEM education. Despite our shared commitments and strong ideas, the writing process proved difficult. The piece remained abstract and theoretical, and we struggled to find the right framing and perspective to effectively communicate our vision. The very complexity that animated our conversations became a barrier to clarity and coherence in the manuscript.

The breakthrough came when we decided to shift our focus from a traditional scholarly article to a practitioner-oriented product—a STEM teaching tool/practice brief. This pivot marked a significant change in both direction and energy. Where the conceptual manuscript felt limiting, the practice brief offered a way to distill our ideas into accessible, actionable strategies for educators. It allowed us to foreground local relevance, equity and student engagement while reaching a broader audience. The frustration gave way to momentum and clarity, transforming what had been a stumbling block into a productive reimagining of our goals.

A second catalyzing moment soon followed. As we developed the practice brief, discussions turned to how these ideas could be enacted in real classrooms through authentic engagement with local data. From these conversations, the concept of Community Science Data Talks (CSDTs) emerged. CSDTs were envisioned as structured opportunities for students to work with community-centered data related to FEW Nexus challenges, explore connections to their own lives and communities, and consider the implications of science for civic and environmental action. This idea took root quickly, becoming a unifying thread in the group's work. It offered a tangible, adaptable framework for site-specific implementation and deepened our commitment to working across research and practice in generative ways.

Evolution of the Work

Following the release of the practice brief, the group's focus expanded to include the design and implementation of an empirical project that builds on its foundational ideas. This work centers on the development of Community Science Data Talks (CSDTs)—instructional routines that engage students with local data tied to FEW-Nexus challenges. These learning experiences are co-developed and implemented by teams of graduate students, partner teachers, and university faculty across multiple educational settings, including elementary, middle, and high schools. The study examines how CSDTs foster student engagement with scientific and civic dimensions of environmental issues. Each site centers a different local phenomenon, such as urban heat islands, well water quality, and prairie ecosystems, providing rich comparative insights.

Transformative Aspects of the Work

Participants in the PK–12 Working Group have experienced the collaboration as not only enjoyable, but also

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transformative. The work has opened up opportunities to think together across institutional roles, regional contexts and disciplinary boundaries. Engaging in sustained dialogue—where ideas are welcomed, tested, and refined—has created space for both professional growth and new forms of partnership. The collaborative spirit of the group has been a source of inspiration, grounding members in shared commitments while allowing for intellectual risk-taking and innovation.

A particularly transformative element has been the reciprocal nature of the work between researchers, practitioners and graduate students. Graduate students have taken on leadership roles in designing, facilitating, and reflecting on instructional innovations, particularly through the development and implementation of CSDTs. Their contributions have shaped both the conceptual underpinnings and classroom enactments of the group's work, reinforcing the importance of mentoring, distributed leadership, and collaborative learning across roles.

Seeing students engage deeply with local data—making connections between community issues and classroom learning—has been especially meaningful. Students have expressed not only curiosity and excitement, but also a willingness to act on their science knowledge to address environmental concerns in their communities. These moments have affirmed the group's foundational commitments to place-based, justice-oriented science education. They have also generated new questions, insights, and pathways for future work. What began as a grant-funded collaboration has, for many, evolved into an enduring professional learning community—one that not only supports transformative teaching and learning, but also transforms how participants understand their roles as educators and researchers.

Challenges and How We Addressed Them

The working group encountered a number of challenges that shaped and ultimately strengthened its direction. One of the earliest was navigating the transition to a new leadership structure following a change in the project's principal investigator. The group responded by establishing a more distributed leadership model and clarifying internal roles, which helped ensure continuity and sustained engagement across partner institutions.

A major challenge involved the initial effort to collaboratively author a journal article articulating a framework for FEW-Nexus education in K–12 contexts. Despite a shared vision, the group struggled to balance theoretical rigor with the need for practical relevance. Differing disciplinary lenses and writing norms made it difficult to produce a manuscript that was both coherent and usable across audiences. This period of sustained tension and reflection eventually catalyzed a productive shift: the group pivoted to developing a practice brief that emphasized real-world applicability and supported practitioner use. This move not only resolved internal friction but also clarified the group's strengths and commitments.

At a deeper level, the group continues to wrestle with the core interdisciplinary challenge of FEW Nexus education—moving beyond siloed understandings of food, energy, and water systems. It has been relatively easy to pursue projects focused on individual domains, especially where existing expertise is strongest (e.g., water and agricultural systems). However, achieving a fully integrated and systematic approach to FEW learning remains an ongoing aspiration. In particular, the domain of energy has been more difficult to incorporate meaningfully within the group's work, highlighting a persistent gap between the conceptual promise of the FEW Nexus and the practical realities of curriculum development and implementation. While these challenges have not been fully resolved, they continue to push the group to reflect on its assumptions, expand its partnerships, and remain attentive to the complexities of interdisciplinary collaboration.

Finally, logistical challenges emerged as the group worked to implement instructional approaches across multiple institutions and school settings. Variations in school calendars, community priorities, institutional constraints, and personnel capacity demanded ongoing flexibility. These issues were addressed through adaptive timelines, regular

SECTION 4: Working Group Stories

communication, and a shared commitment to supporting each other's contexts. That collective adaptability has been critical to sustaining both the group's momentum and its values.

Informal/Non-formal Working Group

Working Group Members

Anil Kumar Chaudhary, Penn State (chair); Laurie Giarratani, Carnegie Museum of Natural History; Gregory D. Goins, NC A&T State University; Mary Van De Kerkhof, Two Roads Consulting; Christine Li, University of Missouri (past member), Jamie Loizzo, University of Florida (past member); K.C. Busch, North Carolina State University (past member); Kathryn Stevenson, North Carolina State University (past member); George Barnett, Boston College (past member); Hannah Scherer, Virginia Tech (Past chair).

Identity of the Working Group and How It was Formed

Our Informal/Non-formal Working Group is a diverse team of educators, researchers and practitioners dedicated to exploring and sharing new possibilities for FEW Nexus education and communication in informal and non-formal settings. This helps support science learning, environmental justice and sustainability. The group started forming in spring 2018 as part of the NC-FEW grant proposal process. This vision became a reality in the fall of 2019 when the project received funding and the Informal/Non-formal Working Group began its formal activities. Since the start, the group has worked to raise awareness about the FEW Nexus application in informal and non-formal education.

Points of Connection, Catalyzing Moments and Challenges

The group was established to enhance understanding and application of the FEW Nexus in informal and non-formal educational settings. These points of connection—bringing together diverse stakeholders in these broad educational contexts—served as a foundation and catalyst throughout the project. One of the main challenges the group faced was defining its identity, given the broad scope of the target settings. These settings ranged from museums and youth development programs to professionals promoting behavior change through various educational initiatives, including natural resource management. The wide scope made it difficult to delineate the group's focus and determine which stakeholders should be included. Additionally, there was uncertainty about how to apply the FEW Nexus concept within such diverse contexts and what tangible deliverables the group could produce to advance understanding and implementation. Despite these challenges, they became catalyzing moments, prompting the group to collaborate more closely and refine its purpose, ultimately strengthening its collective efforts.

Working Group Journey from Initiation to End of the Project

The working group was formed with the initial aim of broadening the understanding and application of the FEW Nexus concept within informal and non-formal educational contexts. Our journey began by establishing a clear group identity and outlining our project plans. In the first year, we took foundational steps by reviewing existing research, identifying key scholarly works relevant to each member's focus, and compiling a bibliography of 23 significant publications. This helped us understand the current landscape and set the stage for future work.

Early on, the group drafted goals for subsequent phases and communicated our intentions through a [newsletter](#), introducing ourselves and sharing upcoming activities. Over time, we held multiple meetings each year to progressively define the FEW Nexus in education settings outside formal classrooms and to explore its various

SECTION 4: Working Group Stories

applications. These discussions spanned diverse contexts, including science education, environmental justice, and sustainability.

Despite initial efforts, the group faced challenges in producing tangible, collaborative outputs. Members came from different disciplines and had varying visions, which sometimes hindered cohesive progress. Additionally, as many members volunteered their time, motivation waned when clear results were elusive. This led to some members leaving or becoming inactive over recent years.

Although the group didn't fully realize its original goals, our activities received positive feedback at two in-person conferences and workshops. Attendees from informal and non-formal educational backgrounds shared their work applying FEW concepts, often focusing on one or two areas rather than integrating all three. Through this experience, we learned that bringing diverse ideas together in a such diverse group is more challenging than in more cohesive groups, such as those working in PK-12 education.

Ultimately, our journey highlighted the importance of focus, effective catalyzing factors, and clear goals to unite participants. Although the project didn't produce the tangible results we envisioned, these lessons provide valuable insights for future efforts aimed at fostering collaboration and advancing understanding within the FEW Nexus community.

**Additional higher education NC-FEW members who participated as co-authors: Susan Caplow, Associate Professor of Environmental Studies, University of Montevallo; Aavudai Anandhi, Associate Professor, Biological Systems Engineering Program, Florida A&M University; Steven Anderson, Earth and Atmospheric Sciences, University of Northern Colorado; Caterina Belle Azzarello, Doctoral Student of Educational Psychology at University of Northern Colorado; Katja Brundiers, Clinical Associate Professor, School of Sustainability, College of Global Futures, Arizona State University; Eunice Blavascunas, Chair of Anthropology, Associate Professor of Anthropology and Environmental Studies, Whitman College; Daniel Druckenbrod, Professor, Department of Earth and Chemical Sciences at Rider University; Ennea Fairchild, Pacific Northwest National Laboratory; Lydia Horne, Associate Director of Sustainable Ecotourism and Recreation Programs, Unity Environmental University, Distance Learning; Kyungsun Lee, Assistant Professor of Geography, Department of History, University of Arkansas at Little Rock; John Mischler, Associate Professor of Sustainability and Environmental Education, Goshen College; Emily Pappo, Smithsonian Institution; Nirav S. Patel, Department of Environmental Studies, Binghamton University, Binghamton; Nicole D. Sintov, Associate Professor, The Ohio State University School of Environment and Natural Resources; Carla Ramsdell, Appalachian State University, Department of Physics and Astronomy; Shirley Vincent, Principal and Owner, Vincent Evaluation Consulting LLC.*

FEW NEXUS EDUCATION RESEARCH AND PRACTICE BRIEFS:

Proceedings from a National Conference

This section includes a description of the process of soliciting abstracts for the conference, a listing of the abstracts and the sessions in which they were presented, and a synthesis of themes across the suite of education research and practice briefs that represent the collection of abstracts that were presented.

SECTION 5: FEW Nexus Education Research & Practice Briefs

A major element of the 2025 NC-FEW Invited Conference: Education Research and Practice in the FEW Nexus was the presentation of extended abstracts representing the state of the field in FEW Nexus education and education research. As a collection, these abstracts serve as state-of-the-field education research and practice briefs that report on and guide future directions for FEW Nexus education.

As of August 7, 2025 (133 days after the conference), there were 249 abstract views and 540 abstract downloads from the collection. Viewers were from 73 different countries. The top seven countries were the United States (41%); Singapore (10%); Indonesia (6%); China (6%); Brazil (5%); Nigeria (4%); and India (2%).

Contributed Program Co-chairs

Bhawani Venkataraman, The New School (research co-chair); Neil Knobloch, Purdue University (research co-chair); Shamili Ajgaonkar, College of DuPage (practice co-chair); and Susan Caplow, University of St. Thomas (practice co-chair).

Process of Soliciting Abstracts

The call for abstracts was solicited to focus on either research or practice for FEW Nexus education. We encouraged people from different disciplinary perspectives who are interested in sharing education research findings and innovative ideas related to the NC-FEW vision. Professionals and researchers in educational spaces, including K-12, higher education and informal/non-formal education with different FEW Nexus entry points were all encouraged to join. We invited people with different FEW Nexus entry points with specialties in food, energy and/or water with intersectionality of FEW.

We asked that submissions be focused on and formatted for either the research or practice category: Research submissions focused on empirical, theoretical, and/or methodological educational research within the FEW Nexus. The intent of research submissions was to inform future educational research and best practices in the FEW Nexus.

Practice submissions focused on formal and/or informal practices describing FEW Nexus education processes (i.e., strategies) and products (i.e., learning modules, curriculum). The intent of practice submissions was to share educational strategies, materials and/or experiences that engage learners in the FEW Nexus. Reflections, what was learned and outcomes could be based on participants' and/or the educator's experiences. The purpose was to share practical examples that would promote networking and sharing of ideas.

In total we received 20 abstracts. After a peer review process 19 were published on the Purdue University ePubs platform.

Presentation of Abstracts in the Conference Program

During the conference we organized the presentation of the abstracts in the following way (all are housed on [Purdue's publication platform](#)):

Lightning Talks 1 – A Global Perspective on the FEW Nexus

In this session, we journeyed across the globe, from the Americas to Africa to Asia, and heard from five speakers who presented their FEW Nexus work with audiences ranging from school-aged youth to seniors in a variety of urban and rural settings. Following the presentations, our discussion explored how the commonalities across all regions as well as the unique challenges of each region and audience contribute to a holistic understanding of the FEW Nexus.

1005: [Empowering Young Innovators through School-Based Agricultural Education: Insights from a Nigerian](#)

SECTION 5: FEW Nexus Education Research & Practice Briefs

[Secondary School Teacher](#) by Mary O. Olumide-Oyanyi, Virginia Polytechnic Institute and State University.

1007: [Cultivating Place-Based FEW Nexus Awareness and Environmental Justice Through Community Science Data Talks](#) by Imogen R. Herrick, University of Kansas; Micheal Lawson, Kansas State University; Todd Campbell, University of Connecticut; and Shondricka Burrell, Morgan State University.

1009: [Creating Food-Energy-Water Education for Latine Communities in Miami](#) by Oriana Calagna, Florida International University and Kathleen Quadorkus Fisher, University of Notre Dame.

1012: [System Change, Not Climate Change: Collaborative Development of a FEW Nexus Experiential Learning Course for a Justice-Centered Comparative Study Abroad Program](#) by Sonya Ahamed, School for International Training.

1021: [Collaborative Knowledge in Water Food-Energy-Water Nexus and Conservation: A Spatial Collaborative Approach in Watersheds](#) by César Rojas, Universidad Distrital Francisco José de Caldas, Bogotá, Colombia; and Magnolia Longo, Universidad Jorge Tadeo Lozano, Bogotá, Colombia.

Lightning Talks 2 – Challenges and Opportunities of the FEW Nexus

The FEW Nexus offers an opportunity to meaningfully explore the intersection and interdependence of food, energy, and water—three vital resources for human society. Yet, it is also clear that each of these resources is essential in its own right and that the FEW Nexus can be complex and tricky to navigate. The result is that programs often emphasize one of the three resources rather than focus on the intersection of the three. In this session, we heard from three speakers where, in each case, their project focussed on one of the three elements of the nexus. Following the presentations, our discussion considered whether using one of these resources as a gateway facilitated or detracted from the nexus concept.

1002: [Designing Field Courses to Teach FEW Concepts Effectively](#) by Eunice L. Blavascunas, Whitman College.

1008: [Exploring the FEW Nexus through Community Engagement: A Watershed Restoration Case Study from Philipsburg, Pennsylvania](#) by Tolulope P. Akinbobola and Anil Kumar Chaudhary, The Pennsylvania State University.

1020: [Integrating Food, Water, and Agriculture Education in Early Childhood: A Baseline Study of Farm to ECE Programming](#) by Kyle Whitley and Kelsey Hall, Utah State University.

Poster Session

The remainder (i.e., 11 submissions) were included in a poster session.

1004: [An Integrated Framework for Food-Energy-Water Nexus Education and Educational Research](#) by Hannah Scherer, Virginia Polytechnic Institute and State University and Doug Lombardi, University of Maryland at College Park.

1006: [Addressing Local Food Insecurity Through a Problem-Based Learning Classroom](#) by Kaley Mumma and Aimable Mugabo, Purdue University.

1010: [Mapping Food-Energy-Water Nexus Education in K-12 Settings: A Systematic Review of Practices](#) by Kyungsun Lee, University of Arkansas at Little Rock; Hui-Hui Wang, Purdue University; Shondricka Burrell, Morgan State University; Neil A. Knobloch, Purdue University; and Rudan Wang, Purdue University.

SECTION 5: FEW Nexus Education Research & Practice Briefs

1011: [Teaching Disciplinary Ways of Knowing Using STEM in AFNR](#) by Elizabeth E. Ogar, Purdue University; Neil A. Knobloch, Purdue University; and Hui-Hui Wang, Purdue University.

1013: [The FEW Nexus: Using Soil to Grow Meaning and Relevance in Undergraduate General Education Earth Science Courses](#) by Katherine McCarville, Minot State University.

1015: [Learning Food Supply Chains through Generative AI–Tips, Techniques and Student Perceptions](#) by Subbu Kumarappan, Ohio State University Agricultural Technical Institute and Urmila Pal Chaudhuri, Kent State University - Stark Campus.

1017: [Integrating the FEW Nexus into an Agricultural Issues Course](#) by Christopher M. Estepp, University of Arkansas and Hannah Scherer, Virginia Polytechnic Institute and State University.

1019: [Lessons Learned from a Collaboration Process for Implementing Interdisciplinary Sustainability Education with the Food-Energy-Water \(FEW\) Nexus](#) by Chelsie Romulo, University of Northern Colorado; Bhawani Venkataraman, The New School; Susan Caplow, St. Thomas University; Shamili Ajgaonkar, College of DuPage; Craig R. Allen; Aavudai Anandhi, Florida Agricultural and Mechanical University; Steven Anderson, University of Northern Colorado; Caterina B. Azzarello, University of Northern Colorado; Katja Brundiers, University of Freiburg; Eunice Blavascunas, Whitman College; Jenny M. Dauer, University of Nebraska - Lincoln; Daniel L. Druckenbrod, Rider University; Ennea Fairchild, Pacific Northwest National Laboratory; Lydia R. Horne, Unity College; Kyungsun Lee, University of Arkansas at Little Rock; Marizvkuru Mwale, University of Venda; John Mischler, Goshen College; Emily Pappo, Smithsonian Institution; Nirav S. Patel, University of Colorado; Nicole D. Sintov, Ohio State University; Carla S. Ramsdell, Appalachian State University; and Shirley G. Vincent, Vincent Evaluation Consulting, LLC.

1022: [Co-learning About Interactions of the WEF Nexus in a Páramo Ecosystem: A Proposal to Bring Sustainability Education to Rural Communities in an Andean Region \(Colombia\)](#) by Magnolia Longo, Universidad Jorge Tadeo Lozano; Luz Angela Rodríguez, Pontificia Universidad Javeriana; and Paula Pinilla, Universidad Jorge Tadeo Lozano.

Themes Represented in the Collection

The majority of the abstracts placed more emphasis on educational initiatives, as opposed to pedagogical research. While we did not require formal evaluative data, the lack of formal assessment represents a possible area for future investment/skill sharing. Many of our participants showcased innovative programs, courses, units, or modules. For example, Mumma and Mugabo demonstrated how Problem-Based Learning (PBL) can be used to explore food security issues in a local context. Blavascunas described a new semester-away program in the Yakima Valley examining the convergence of hydropower, indigenous rights, salmon migration and agricultural communities. Experiential learning was another pedagogical approach applied in projects. For example, Ahamed outlined a study abroad program in which three countries were connected by an emphasis on the FEW Nexus and a changing climate.

Quite a few projects, in both education and research threads, worked meaningfully with community partners, reflecting a foundational best practice in the field and within the working group. On the education side, Longo, Rodriguez, and Pinilla connected local communities adjacent to Chingaza National Park in Colombia with local academics to improve conservation practices in the region. On the research side, Calgana and Fisher studied FEW themes in local environmental discourse to better understand how to tailor educational resources for the Miami Latine population. McBride connected middle school students with undergraduates in Wyoming on entrepreneurial projects to enhance concept comprehension and project innovation. In addition to having a strong community and

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civic engagement focus, these examples also centered on environmental justice, an important area for future work in the FEW Nexus.

We saw an impressive amount of geographic diversity, as programs featured work in various parts of the U.S. (Utah, Florida, Pennsylvania, Wyoming, North Dakota), as well as a variety of other countries including Colombia, Nigeria, Morocco, Nepal and Ecuador. We also saw programs serving diverse audiences, spanning early child education, K-12, higher education, informal spaces, with many engaging local communities.

We heard from many of the leaders of the NC-FEW Project on the ways they are advancing the field of FEW Nexus education research. Scherer and Lombardi presented initial findings using data from NC-FEW workshops on how education research can best help address challenges in both education and educational research in the FEW Nexus. Akinbobola and Chaudhary demonstrated how informal and formal education practices can be deployed simultaneously in a FEW Nexus-focused case to enhance outcomes.

Most excitingly, quite a few groups focused on inter-institutional projects, highlighting the importance of broad collaboration in the FEW Nexus. Herrick and colleagues described how four institutions collaborated with K-12 teachers to develop place-based Community Science Data Talks. Romulo and colleagues highlighted a variety of FEW teaching examples across institutions to explore how FEW can serve as an ideal space to achieve sustainability learning outcomes. And Lee and colleagues conducted a systematic literature review to identify ways the FEW Nexus appears in K-12 curricula.

As a collective, papers presented projects where the entry point to the FEW Nexus was primarily through one of the areas (food, energy, water) and then through the context or issue made connections to the other areas. For example, a project based in a community in Nigeria (Olumide-Oyaniyi) worked with students to construct a poultry farm for a community's sustenance, also had students use the waste from the poultry for raising fish. This project was a way of allowing students to educate family members. Another project that entered through the water lens (Akinbobola) was a community engagement project where high school students collected data to help educate the community on local water quality issues. A project entered through the energy lens (Blavascunas) involved a field course for students to understand and experience the impact of large scale hydropower plants on food and water availability and on local indigenous communities and their practices.

The papers as a collective also demonstrated areas for needs. While food and water related issues were present in almost all projects, connections to energy seems to be not as prevalent raising questions as to why this might be the case (is it harder to integrate all three and/or of the three is energy the one that is either more challenging or perhaps not as evident in issues or local concerns).

FOSTERING INTERDISCIPLINARY COLLABORATION:

Lessons Learned from Establishing and Maintaining a Network



This section includes a timeline of the main efforts to form and support NC-FEW and successes and challenges in building the network. Recommendations for others interested in similar work are provided.

SECTION 6: Fostering Interdisciplinary Collaboration

Timeline of Formation and Funding

Here we describe efforts to establish and support NC-FEW so others might learn from our approach.

Laying the Groundwork (2016-2018)

Establishment of NC-FEW began through the efforts of Dr. Cory Forbes, who held a partial administrative appointment as the science literacy coordinator for the Institute for Agriculture and Natural Resources at the University of Nebraska-Lincoln. In this capacity, he assembled an interdisciplinary team interested in the emerging FEW Nexus framework and how it could be applied in educational settings.

A key mechanism early on was the USDA/NIFA Multistate Research Committee structure available to faculty at land grant institutions. First as a 2-year planning committee (NCDC231) and then as a 5-year research committee (NC1207), members had access to travel funds for planning and collaboration meetings to determine the structure and focus of NC-FEW.

The initial convening was an invited symposium held in 2017 in conjunction with the Water for Food Conference at the University of Nebraska-Lincoln. This included a poster session, a panel discussion and a meeting of NCDC231. Outcomes of this symposium included distillation and identification of themes (challenges, contributions, etc.) in resources, models and tools across existing projects and critical “next steps” in efforts to develop resources, models and tools that enhance current and future FEW Nexus-focused education and education research efforts.

To further broaden our reach and build on insights from the 2017 symposium, we held a national invited conference titled Innovating Teaching and Learning in the Food-Energy-Water-Nexus: Toward a National Collaborative for Food, Energy, & Water Systems Education (NC-FEW) in spring 2018. This planning conference was funded through the USDA-NIFA Higher Education Challenge grant program, APLU’s Network of STEM Education Centers Research Action Cluster grant program, the University of Nebraska-Lincoln Agricultural Research Division, and Virginia Tech in the National Capital Region.

Outcomes from this conference about the direction of FEW Nexus education and educational research fed directly into the Research Coordination Network (RCN, Track 3) proposal we submitted in response to the 2018 NSF/NIFA Innovations at the Nexus of Food, Energy and Water Systems (INFEWS) Request for Proposals (NSF 18-545). This groundwork was very helpful in developing a successful proposal that was responsive to the RFP and reflected the interests of a growing community, not just the PIs.

Supporting the Network (2019-2025)

In fall 2019, NC-FEW was awarded the INFEWS/T3 grant from the National Science Foundation ECR-EHR Core Research program. We operated under Grant No. 1856040 from 2019-2022 with PI Cory Forbes and co-PIs Hannah Scherer, Nicole Sintov and Hui-Hui Wang serving as leadership team members and working group chairs. In spring 2020, our efforts were severely impacted by the COVID-19 pandemic, halting plans for in person conferences and impacting our ability to build community. In 2021, Cory Forbes announced his intention to step down from his role as PI and Director of NC-FEW due to a change in position.

After a nine month process of transferring the grant from University of Nebraska-Lincoln to Virginia Tech, we were able to resume work and from 2022-2025 we operated under Grant No. 2242276 with PI Hannah Scherer, co-PIs Nicole Sintov and Hui-Hui Wang, and new Working Group Chairs as senior personnel. We conducted a strategic planning session with the new leadership team to develop a new plan of work to guide the remainder of the NSF funding period, which included a 12-month no-cost extension. At this time, we also decided not to apply

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for renewal of the USDA/NIFA Multistate Research Committee because our leadership team and the broader NC-FEW community had grown such that we were no longer dominated by faculty at land grant universities. Despite these changes and challenges, we were still able to support NC-FEW through the activities and efforts described in this document during the period of NSF funding, allowing us to expand the network and deepen our efforts to advance education and educational research in the FEW Nexus.

Successes and Challenges in Building the Network

As proposed to NSF, NC-FEW was described as an emergent, transdisciplinary, community. Our aim was to serve as a hub of innovation for education research on FEW Nexus educational programming at all levels (PK-12, postsecondary, adults) and in a variety of settings (formal, non-formal, informal). NC-FEW was envisioned as a networked improvement community (NIC), one that involves a group of stakeholders from diverse backgrounds solving problems together through a purposeful cycle of action. As Russell and colleagues (2017) observe, “NICs are highly structured, intentionally formed collaborations among education professionals, researchers, and designers that aim to address a high leverage practical problem.”

In line with this framework, the leadership team viewed the goals for collaboration through the lens of establishing a distributed network. Our role was to help members find points of connection through intentional activities and then empower members to take ownership of the work moving forward. We were also working against the structure of academia that tends to limit the opportunities for cross-pollination; a goal in planning NC-FEW events and activities was to ensure that they were open and interesting to our broad interdisciplinary community that works in diverse educational settings. Finally, we aimed to connect education researchers with educators to spark knowledge generation. In working towards these goals, we experienced successes and encountered challenges.

Challenges and Lessons Learned

In carrying out our vision, we encountered several challenges related to establishing a distributed network. Members, especially early on, tended to look to network leaders to catalyze efforts around work projects rather than forging their own paths. We learned that in new teams, trust and reciprocity take time to establish and the structure and support offered by NC-FEW activities aimed at sparking collaborations could have been sustained more intentionally as potential new groups emerged. The working group structure was effective at this, likely due to there being a designated chair supported by the grant, however few additional groups formalized. Those that did were focused on specific scholarly outputs such as conducting a systematic literature review. Navigating the funding structure of an RCN focused on creating the conditions for research collaborations to be initiated, but not providing direct support for research teams (including graduate students) at a level sufficient to carry out the work was a challenge.

As discussed above, our activities were successful in engaging NC-FEW members, but sustaining collaborations was the challenge. The interdisciplinary and cross-sector nature of NC-FEW also made it difficult for emergent teams interested in a common theme (e.g., systems thinking) to identify appropriate grant programs or RFPs, as these tend to be situated in specific educational contexts or disciplines. A recommendation for future RCN-type proposals is to establish a fund within the budget that can be used for seed grant awards to emergent teams. An internal RFP structure could be used to award seed funding to teams with the potential to generate new knowledge that lays the groundwork for future efforts to secure funding.

Throughout the project, we weathered unanticipated external forces that impeded our efforts to build momentum for NC-FEW. COVID-19 took place early on in the project timeline, disrupting plans for in-person gatherings

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that were intended to catalyze new teams. While we were able to continue our network building by pivoting to online forums, people at the time were saturated with online offerings and participation suffered. As we were emerging from COVID, the pause in activities while we transitioned the PI and lead institution further attenuated our timeline and commitment from the broader community wavered. Finally, conducting our final conference and wrapping up the project against the backdrop of the new 2025 U.S. presidential administration's major cuts to science funding and associated unease in the academic community was challenging.

We pivoted grant-related goals for our final conference away from developing grant proposals to capacity-building activities so participants could build skills to use in developing future proposals. A recommendation for other networks is for the leadership team to remain committed to the goals and vision for the network and anticipate that there will always be unexpected conditions that will impact which activities can be carried out and how they are conducted. Across our efforts to navigate changing conditions, we grounded our decisions in our aim to continue working towards the NC-FEW goals. As a result, we were able to continue to make progress despite setbacks.

A third challenge area for NC-FEW was balance in representation across disciplines and educational contexts. While we succeeded in developing a network that represents our broad reach, there were some areas that were underrepresented compared to others. The energy sector, in particular, was not well represented, with most participants coming to the FEW Nexus from an interest in water, food and agriculture, or sustainability/environmental education. As such, the disciplinary foci of members were principally in social and natural sciences with very few engineers.

In retrospect, this was true even in our early network building efforts and we could have done a better job in those early planning conferences to ensure that we were reaching those audiences; the disciplinary foci of leadership team members were represented as we had access to people working in those contexts. Additionally, members were overwhelmingly situated in institutions of higher education; this was expected, however, it posed a particular challenge for the informal/nonformal education working group that aimed to engage other sectors such as museums. As a research coordination network, our aim was to engage educational researchers in collaborating with educators to build new knowledge around FEW Nexus education. In practice, though we had several educational researchers in the working groups, the majority of NC-FEW members that engaged in our activities were more focused on implementing FEW Nexus education in practice. This limited our capacity to foster new research-focused collaborations, however, we embraced the fact that using the FEW Nexus in education is in its early stages. We shifted our focus to supporting and documenting the innovations that were happening in practice as a mechanism to identify focus areas for future research. As participation in networks such as NC-FEW is voluntary, it is impossible to engage everyone that the leadership team aims to. We recommend developing a stakeholder matrix at the initiation of the network, with periodic assessments of progress toward engaging the range of desired stakeholders that guide new outreach efforts in sectors that are underrepresented.

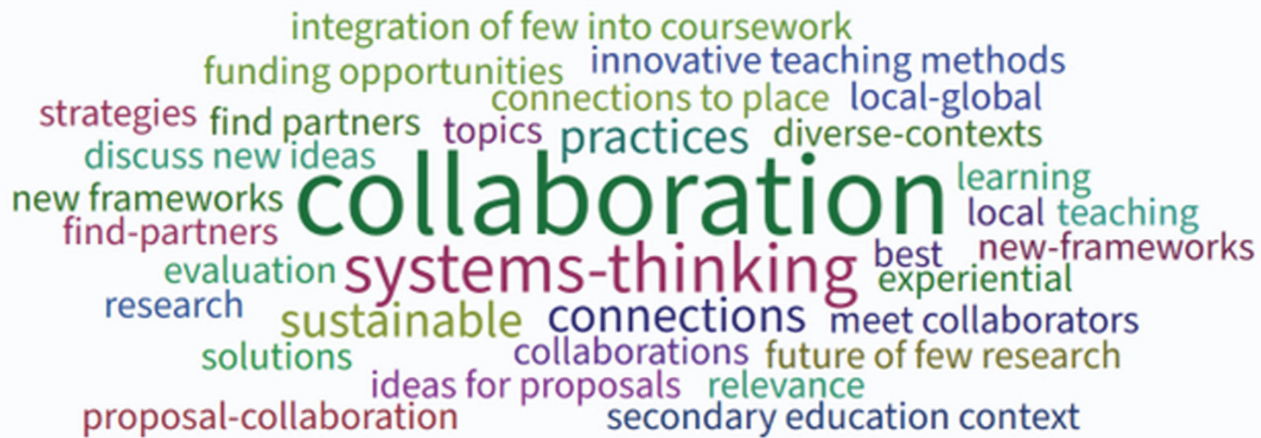
Successes

By the end of the NSF project period in summer 2025, the NC-FEW community included 432 members from 92 different institutions representing more than 50 different disciplines and sub-disciplines. We continued to add new members through the end of the project, with several people who had not previously participated in an NC-FEW sponsored event attending our final virtual workshop. Our two in person conferences, in 2023 and 2025 attracted people who were looking for collaborators, and those events were particularly effective in kick-starting new collaborative projects. An application process for the conferences helped us ensure that the people attending were engaged in relevant work and/or had authentic interest in moving towards doing this work collaboratively. This is evidenced in the word cloud generated at the beginning of the 2025 conference.

Grant funding allowed us to remove the financial barrier to attendance that typically excludes participants from

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NCFEW-What Are you Hoping to Learn?



institutions with resource constraints. Additionally, since this is an emerging area of scholarship, participants were less likely to have existing grant funding for conference travel. Using participatory approaches in the conference planning that included significant opportunities for structured small group discussions was impactful for participants.

Connections were sustained between the conferences by ongoing project work by individual teams and working groups, quarterly virtual workshops and newsletters with community submissions. Grant funding allowed us to provide financial support to teams working on specific projects, compensate virtual workshop presenters for their time, and hire a ghostwriter/graphic designer to develop virtual workshop synthesis documents and layout and copy edit newsletters. Our website, evaluation and logistics for virtual workshops and conferences were supported by a subaward to the Science Education Resource Center (SERC). The financial resources provided by the grant funding allowed the leadership team to focus on our roles, while having the right personnel in place to support our efforts.

Respondents to the end-of-project survey also provided insights into the overall impacts of our efforts. Respondents felt strongly that the NC-FEW community shares their goals, philosophy, and values for FEW Nexus education. They felt they were members of a community of like-minded educators somewhat or fairly well. They also felt that they grew their network of collaborators, increased academic productivity, and benefitted from opportunities to hone their skills as both teachers/educators and as researchers. Moreover, a number report having had opportunities to participate in grant writing teams and propose new projects.

Finally, those who participated most frequently in NC-FEW programming also rated their general and FEW Nexus education research skills as stronger than those who attended fewer events. Overall, our efforts as described in this document moved us closer to our goal of developing a networked improvement community.

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LOOKING FORWARD:

Recommendations for the Future of FEW Nexus-based Educational Research and Practice

This section includes recommended next steps for innovating FEW Nexus based education through practice, supporting educators, and conducting educational research.

SECTION 7: Looking Forward

The collective work of NC-FEW to date has demonstrated that there is significant interest and excitement about FEW Nexus based education and substantial room for educational research that builds on what we have learned through understanding and supporting practice. We have shown that NC-FEW brought together an interdisciplinary community of educators and education researchers who had room for building capacity around the FEW Nexus (Tabassum et al., 2025), that the FEW Nexus can be used in sustainability education in higher education to support the UN Sustainable Development Goals (Romulo et al., 2024), and the potential of the FEW Nexus to support STEM teaching and learning in K-12 educational settings (Campbell et al., 2024; Herrick et al., 2025).

Looking forward, we have several high-level recommendations in the areas of FEW Nexus-based educational research and practice.

Recommendations for Practice

To support practitioners in formal, informal, and nonformal educational settings from PK-12 through adult education in implementing FEW Nexus based education, we recommend the following for educators:

1. Use real-world FEW Nexus case studies to support learner outcomes such as systems thinking, identity development, agency, civic engagement, and interdisciplinary collaboration skills.
2. Apply the FEW Nexus framework to community-based science projects and citizen science initiatives.
3. Utilize the FEW Nexus, through its focus on what are traditionally considered natural resources, to engage the general public highlighting the relevance and importance of science and the environment. The FEW Nexus provides a unique opportunity to engage public audiences in decision making about how we will manage and sustain ecosystems and the interconnected services these ecosystems will need to provide to people in the future.
4. In agricultural settings, utilize the FEW Nexus in combination with more focused economic strategies to educate and empower stakeholders to create resilient systems that benefit communities by strengthening sustainable agriculture.
5. Implement strategies such as experiential learning, place-based learning, and interdisciplinary collaboration in FEW Nexus based education.
6. Collaborate with colleagues from different disciplines to strengthen interdisciplinary knowledge of social and ecological aspects of the FEW Nexus.

We recommend the following for those aiming to support educators:

1. Develop real-world FEW Nexus case studies and modules that can be used for teaching. Case studies could be linked to established frameworks such as the UN Sustainable Development Goals or broader goals such as teaching for social justice.
2. Establish mechanisms for education practitioners to develop and share FEW Nexus related

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educational resources, such as through a collection hosted through the Science Education Resource Center.

3. Connect FEW Nexus researchers in social sciences, natural sciences, and engineering with educators to foster knowledge exchange and innovate teaching and learning.
4. Foster interdisciplinary collaboration among educators from different disciplines and from different educational settings to support FEW Nexus education across the lifespan.
5. Provide opportunities for educator professional learning to expand FEW Nexus-related knowledge outside of their primary disciplinary background, targeting both in- and pre-service audiences at all levels.
6. Reform curricular/institutional structures to remove barriers to implementing FEW Nexus education that is interdisciplinary and connected to stakeholders.
7. Resource educators (time, funding, incentives, etc.) to enable innovation in designing and implementing FEW Nexus based education.
8. Support collaboration between practitioners and educational researchers to advance new knowledge about FEW Nexus based education that emerges from practice.

Recommendations for Educational Research

To support knowledge generation about FEW Nexus based education in formal, informal and nonformal educational settings from PK-12 through adult education, we recommend the following for researchers:

1. Use design-based educational research approaches that aim to support FEW Nexus based education through iterative design and collaboration between educators and researchers.
2. Collaborate with practitioners to systematically document and evaluate promising practices in FEW Nexus based education that have arisen from practitioner innovation and experimentation.
3. Explore the potential for the FEW Nexus to support educator and learner outcomes in established and emerging areas, such as systems thinking, identity development, agency, civic engagement, and interdisciplinary collaboration skills.
4. Identify synergies between emerging models for FEW Nexus education and established frameworks, such as integrated STEM education, through empirical and literature-based investigations.
5. Develop tools for evaluating and assessing outcomes of FEW Nexus based educational programs.
6. Investigate the effectiveness of promising pedagogical approaches, such as experiential learning, place-based learning, and inclusive pedagogy, in the design of FEW Nexus-based educational experiences.

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