Using the FEW-Nexus to Engage Middle Grade Students in Reasoning about Local Socio-Ecological Systems Issues

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Introduction/need for innovation or idea

For decades, scholars have been calling for an integrated, systems approach to resource management at a global scale. Boulding's (1966) framing of a "spaceship Earth" as a closed system with finite resources is a powerful concept and *The Limits to Growth* project (Meadows et al., 1972) demonstrated that the contemporary rate of consumption of natural resources was not sustainable. To prepare the next generation to be active participants in the ongoing struggle for long-term sustainability with equitable resource allocation — as encoded in the United Nations Sustainable Development Goals (United Nations, 2023) — agricultural, food, and natural resources (AFNR) education can play a central role.

These concepts at the global scale, however, may not resonate with learners and risk being abstracted to the point of neglecting their inherent complexity (Greenwood, 2012). Furthermore, there needs to be more explicit instruction in systems thinking to support learners in AFNR settings in developing the problem-solving abilities needed to address complex problems (McKim & McKendree, 2020). As rural spaces are traditionally sites of resource extraction and food production, rural learners need to be empowered to work towards the viability of their communities (Howley & Howley, 2010; Kuehl et al., 2022; Peine et al., 2020) and contribute to global solutions. To address these needs, we developed an interdisciplinary pedagogical framework that was used to design STEM learning experiences for a week-long summer camp for rural middle school students who were identified as gifted and talented.

How it works/methodology/program phases/steps

Our pedagogical framework integrates the Food-Energy-Water (FEW)-Nexus, systems thinking, and place-based education for rural learners. The *FEW-Nexus* is a framework for problem-solving that examines the interconnectedness of food, energy, and water as essential natural resources in modern society (Food and Agriculture Organization, 2014). The FEW-Nexus perspective has gained traction internationally in the past decade and has significant potential for achieving the UN Sustainable Development Goals (Simpson & Jewitt, 2019). FEW-Nexus-based education intentionally integrates food, energy, and water systems; centers decision making about management of natural resources in a complex system; and utilizes the nexus perspective in consideration of tradeoffs in potential solutions (NC-FEW, 2022). To emphasize connections within and among food, energy, and water systems for middle school aged youth, we draw from Meadows' (2008) general description of *systems thinking* as problem-solving that considers elements, connections, and functions of a system or interrelated systems. The "function" is broadly framed as providing resources for people in a way that promotes social, economic, and environmental sustainability. Critical place-based pedagogies (e.g.,Greenwood, 2012) necessitate that we *center the rural places* that youth come from in the curriculum and that we provide opportunities for them to explore real-world issues affecting their communities.

The STEM learning experiences for each of the 5 camp days included a classroom session, an experiential session, and group work on a case study project. Classroom sessions, such as a FEW-Nexus web activity in which youth had to identify connections between different elements, were designed to provide scaffolded systems thinking experiences to make mental models visible, elicit prior knowledge about FEW-related concepts, and deepen understanding of FEW-related issues affecting rural communities in their region. Experiential sessions included

hands-on activities (e.g., water filtration at the campus pond), field trips to campus labs (e.g., meat processing lab), and a guest speaker from a local conservationist group. These sessions served to connect classroom sessions to real-world settings and exposed youth to new experiences with different aspects of the FEW-Nexus. Finally, we created case studies about problems related to the FEW-Nexus affecting local communities using local news articles and information about local industries. Case studies were centered on a particular part of the FEW-Nexus, but prompted consideration of tradeoffs in other areas. For example, one case study presented information about the construction of a natural gas pipeline through a landowner's property and the group was asked to consider how the pipeline construction could impact natural resources, the environment, and local communities. Groups were tasked with identifying possible solutions to their cases and choosing one to present to the rest of the camp on the final day.

Results to dates/implications

40 middle schoolers participated in the summer camp in its inaugural year. The FEW-Nexus framework created an interwoven interdisciplinary lens to examine local industries and their connection to natural resource management. Campers created artifacts such as journal entries, drawings, concept maps, and models that we utilized to gain preliminary insights into learning outcomes. Through the sessions, youth used systems thinking to examine the multiple aspects of the FEW-Nexus and connect new concepts to what they knew about issues in their own communities. Campers drew on their own experiences, such as with the agriculture industry, pipeline construction in their community, and recreation in local rivers to make connections between the curriculum and their own lives. Findings from this pilot year are promising and point to the potential of our interdisciplinary pedagogical framework to inform AFNR education.

Future plans/advice to others

The summer camp will expand in its second year to service 20 returning campers and 40 new campers. The curriculum described here will be revised slightly based on the pilot and we will conduct a research study to systematically document learning outcomes. For the returning campers, we will include local agricultural and natural resource management industry partners and create more case studies to expand students' understanding of the FEW-Nexus. The case study project we developed is similar to the model recommended by McKim & McKendree (2020) to promote systems thinking in AFNR education and others could use our framework to develop their own local case studies. Though we centered the rural context, place-based education can be implemented in any setting, and our approach could easily be adjusted for urban and suburban educational settings. In general, this shifts the focus from issues related to production/extraction to consumption. We recommend the concept of FEWsheds (Brinkley, et al., 2022) as a starting point for this work.

Costs/resources

Personnel was the primary cost for developing the framework and curriculum, roughly equivalent to a one-semester graduate assistant funded through various internal sources and an external grant that supports the camp overall.

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