A Learning Progression for Understanding Water in Socio-Ecological Systems: Shifts from Force-Dynamic to Scientific Discourse

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Introduction

In a world where human actions increasingly affect the natural systems on which life depends, we need educated citizens who can make informed decisions about environmental issues. Our project focuses on how science education can help prepare citizens to participate in environmental decisions. We believe citizens must understand the models and principles that underlie scientific arguments in order to evaluate experts' arguments about environmental issues and recognize policies and actions that are consistent with their own values. A central goal of our work is to develop and validate an upper elementary through high school learning progression for understanding water in socio-ecological systems.

Discourses, Knowledge & Practices Framework

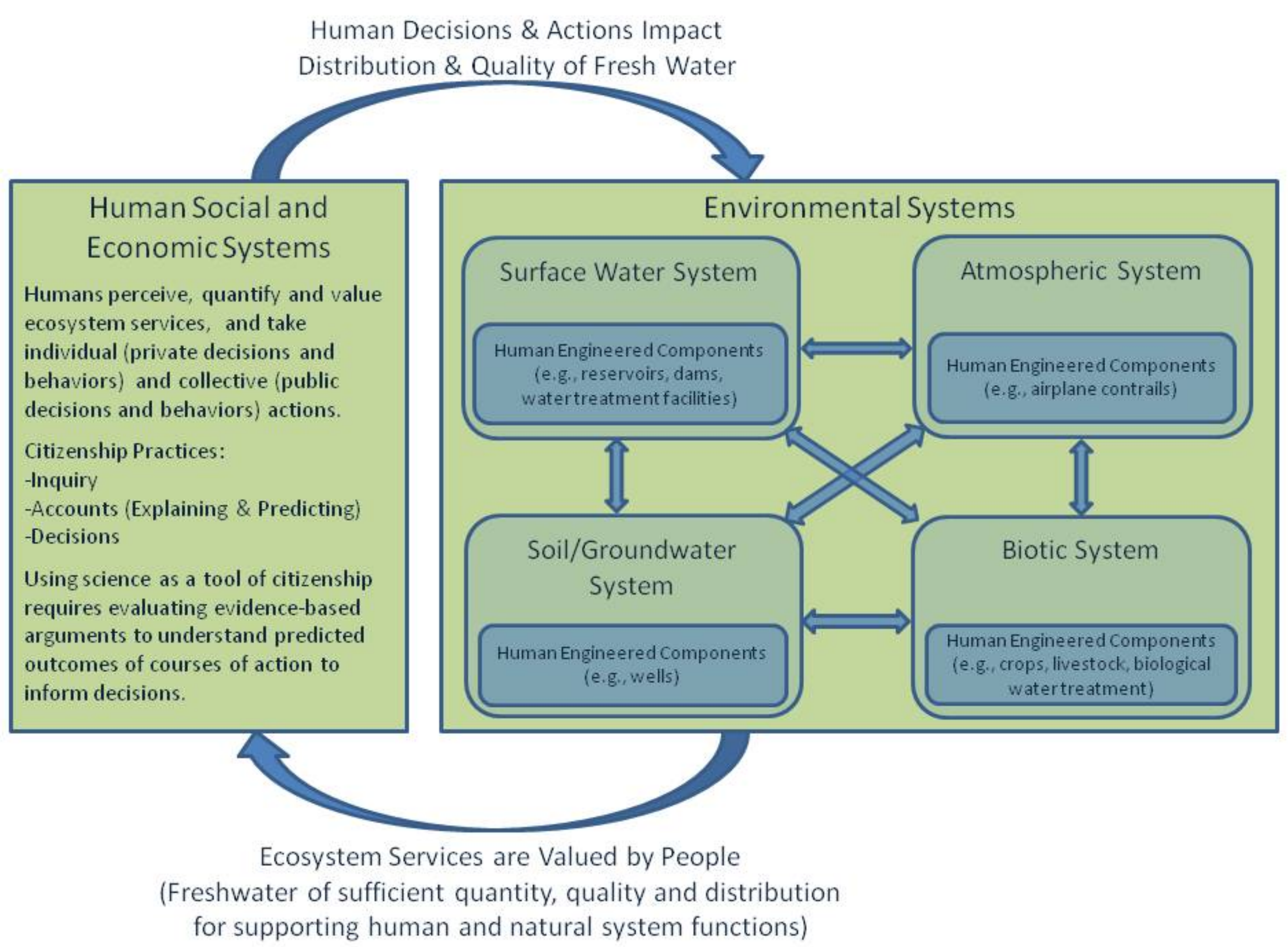
We conceptualize learning as the process of mastering a new Discourse (Cobb & Hodge, 2002; Wenger, 1998). Discourses are ways of talking, thinking, and acting that identify a socially meaningful group. Discourses are enacted in communities through the practices in which members of the community engage (Gee, 1991). Participating in the practices of a community, in turn, requires knowledge.

Discourses: We are interested in helping students transition from the primary Discourse of force-dynamic reasoning to the secondary Discourse of scientific model-based reasoning.

Practices: We are interested in helping students develop capacity for four citizenship practices of investigating (inquiry), explaining, predicting and deciding. In this poster, we focus on explaining and predicting practices.

Knowledge: The Water System Loop Diagram (below) shows the domain of knowledge about water in socio-ecological systems necessary for informed decision making.

Water System Loop Diagram



Learning Progression Framework with Example Responses

Levels of Achievement	Level Descriptions	Progress Variables: Moving Water	Progress Variables: Substances in Water
4: Qualitative Model-Based Accounts	•Systems composed of enduring entities (e.g., matter, energy) change according to principles (e.g., conservation laws) •Knowledge of connected human engineered and natural water systems and structures •Can describe matter and processes across scales •Can describe invisible and hidden matter, structures and processes.	Q: Can the water in a puddle end up in your bathtub? R: Yes…The heat of the sun turns the standing water into a water vapor or gas that evaporates into the clouds (which are made up of water molecules). The coulds [sic] are carried by the wind, and when it rains again, some of the water seeps into the ground…and we get our water supply from wells situated beneath the ground; we also get our water from lakes which are full of rainwater (HS). Q: How does water get into a well? R: Water in the well comes from the groundwater flow that percolates into the open spaces in the well (Tchr).	Q: If you had to make ocean water drinkable, how would you do it? R: The most important thing is to remove the salt which makes ocean water hypertonic to our cells. I'm not a chemist, but the idea of distilling pure H_2O from water seems logical, though very energy intensive (Tchr). Q: What happens to salt when it dissolves in water? R: The salt breaks up into its ions of Na^+ and Cl^- (HS).
3: School Science Narratives	•Tells school science narratives •Uses macroscopic scale only •Stories do not recognize principles that govern processes	Q: Where does a puddle go? R: It evaporated and soaked into the ground (HS). Q: Can the water in a puddle end up in your bathtub? R: Yes. Because it could soak into the ground and then be picked up by your well. (HS)	Q: What happens to salt when it dissolves in water? R: The salt molecules spread out in the water (HS). Q: Can a landfill cause water pollution in a well? R: Yes. The pollution could seap [sic] from the area into the well area (HS).
2: Force-Dynamic w/ Hidden Mechanisms	•Recognizes water can move and that there are hidden mechanisms moving water •Thinks of water quality in terms of bad stuff mixed with water •Invokes actors or enablers to move or change water	Q: How does water get into a river? R: Water gets into a river by a pipe (MS). Q: Why is there still water flowing in rivers even when it hasn't rained recently anywhere along the river? R: Water still flows in rivers even when it hasn't rained because a river has another water source that continuely [sic] pumps water into the river. Plus rivers have a strong current that pulls the water along (HS)	Q: If you live by the ocean, will your rain be salty? R: No. Because the clouds are like a natural filter for it (HS). Q: How would you make ocean water drinkable? R: I would make a filter which will clean the water and make it drinkable (MS).
1: Force-Dynamic Narratives	•Events are human-centered dramas •Water in landscape serves needs of and is manipulated by actors •Focus on personal /immediate events •Focus on visible/macroscopic world	Q: Why is there still water flowing in rivers even when it hasn't rained recently anywhere along the river? R: Because it is still water in there from people tiolets [sic] and sink when they flush and run water (MS).	Q: How would you make ocean water drinkable? R: I would not be very happy because I would have to drink uncleaned water (MS). Q: What happens to salt when it dissolves in water? R: The water overpowers the salt by making it disappear (MS).

Research Methods

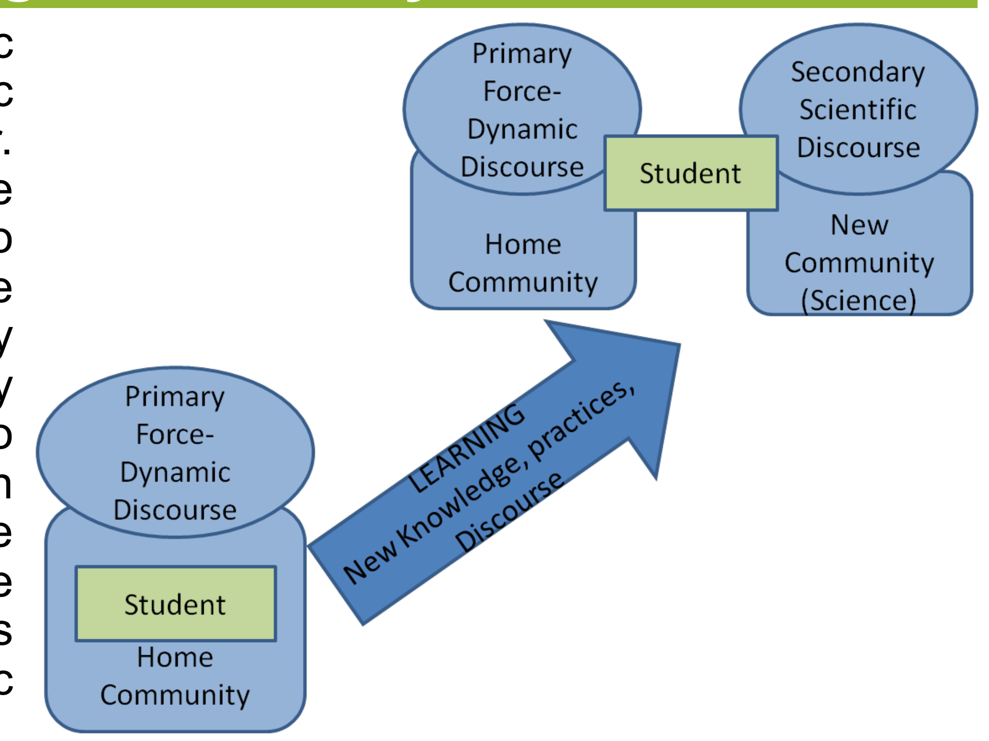
We use an iterative design-based research approach (Barab & Squire, 2004) to develop our learning progression (LP) framework. We began by identifying key conceptual understandings that citizens literate about water systems must have. These understandings form our Upper Anchor. We then developed initial assessment items to probe students' thinking. Assessments were administered to students in grades 4-12. For each item, responses were pooled and a sample of responses were ranked from least to most sophisticated. We were then able to use patterns in the rankings to identify groups of responses with similar characteristics.

This process allowed us to identify features in student responses that were changing from less to more sophisticated. We used these features to build an initial framework for the LP. Responses in the least sophisticated group represent the Lower Anchor of the LP. Characteristics of responses in between the Lower and Upper Anchors were also identified.

Once we had an initial framework, we continued to conduct successive rounds of assessment design, administration and analysis to refine the LP framework. Each round provided new insights into student reasoning, often resulting in significant revision of assessment items and analysis frameworks.

In four iterations of assessment administration and framework revision, we have collected data with about 390 students ranging from grades 4-12. In our latest assessment iteration, we also collected data with about 60 K-12 teachers.

Learning as Mastering a Secondary Discourse



As students develop scientific Discourse, force-dynamic thinking does not disappear. Students at lower levels have only their primary Discourse to frame the way they view the world. As students gain mastery of secondary Discourses, they have more tools available to use. Their practices depend on the Discourses of the communities in which they are participating. Thus, students may be able to provide scientific accounts of phenomena, but choose to provide force dynamic accounts if they judge that is what the community they are participating in expects.

Recognizing that what is shifting is students' use of knowledge and practices embedded in different Discourses casts limitations in scientific knowledge not as problems located in individual students, but as indicators of the sociocultural contexts that shape student thinking. Such framing will help educators better understand the source of student knowledge and practices and better design curriculum and instructional strategies to support students in reaching higher levels of achievement.

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