A Design Framework for National Place-Independent Instructional Materials to Incorporate Local Phenomena

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Abstract: How can national scale curricula designed for NGSS support students in learning science through investigation of local phenomena? We present a framework for designing national place-independent curricula that supports teacher-led localization. Units are designed with supports that help teachers incorporate local phenomena by supplementing or replacing anchoring, related, or investigative phenomena. To illustrate an example of this approach in practice we describe a middle school ecosystems unit under development.

Equity oriented scholars argue that rooting science learning in local phenomena—including phenomena that are place-based, culturally relevant, or societally important—is one important way to nurture student interest and identity (Suarez & Bell, 2019), two crucial outcomes for engaging students and broadening participation in science (NRC, 2012). Yet this is not a reality for many teachers and students in the United States because: (1) many curricula designed for widespread use to meet the expectations of the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013) do not connect to local phenomena and, (2) curriculum that does incorporate local phenomena is often developed from the ground up by community members, requiring extensive time and resources that are not widely available. To support equitable access to localized science learning opportunities, we first present a curriculum design framework for national place-independent science instructional materials in which teachers integrate local phenomena. We then describe a middle school ecosystem unit under development to illustrate the potential for this approach in practice.

Design framework: Model-based inquiry that incorporates local phenomena

Our design framework is rooted in **model-based inquiry**, in which students develop, revise, and use scientific models as sense-making tools to understand phenomena in the natural world (see Figure 1) (Stewart, Cartier & Passmore, 2005). A unit designed with this framework, launches with a puzzling and complex ***anchoring*** phenomenon or problem. National NGSS units are designed for students across wide geographic contexts so the anchoring phenomenon or problem is generally not local for most learners. Students develop an initial model to explain the anchoring phenomenon and begin to engage in analogical reasoning to also explain ***related*** phenomena, or phenomena that seem to be similar to anchor. This prompts questions which students investigate by exploring ***investigative*** phenomena, phenomena that are smaller in scope through which students can figure out specific science ideas. Students gather evidence through the exploration of multiple phenomena, use inductive synthesis to search for underlying commonalities, and iteratively test, evaluate and revise a general model. The general model represents an important outcome of students' work and becomes a powerful tool to explain and make sense of not only the anchoring phenomenon, but many related phenomena.

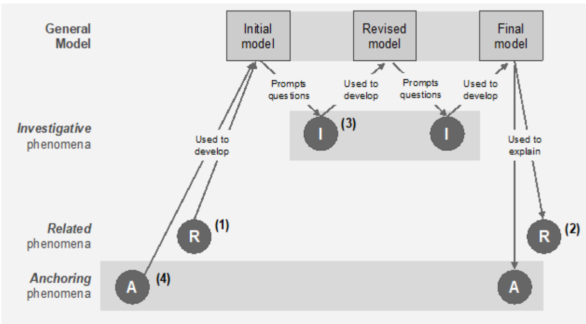

Figure 1. Model-based unit framework with designed-for places (1), (2), (3), and (4) to incorporate local phenomena.

We outline four places in a model-based inquiry unit where teachers could incorporate local phenomena (see Figure 1). A teacher could (1) introduce a local related phenomenon alongside the anchoring phenomenon that students regularly revisit, (2) develop a transfer task at the end of the unit where students use the general model to make sense of a local phenomenon or design solutions to address community problems, (3) supplement or replace investigative phenomena with local phenomena, and (4) replace the anchoring phenomenon with a local phenomenon, so the local phenomenon drives the entire unit of instruction. These approaches require teachers to identify appropriate local phenomena that produce similar patterns with relatively similar mechanistic explanations and modify the unit in different ways. ***Supplementing*** the unit by adding in new local phenomena will require less modification to the original unit, but local phenomena are a supplement, not necessarily driving instruction. Whereas ***replacing*** a phenomenon in the original unit will require greater modification to ensure coherence throughout the unit, with the potential to create stronger place-based unit connections. Intentionally designing for these two kinds of curriculum adaptation could encourage teachers to use their professional expertise to make materials more relevant to their students.

Ecosystems unit example

Our middle school ecosystems unit under development demonstrates an example of designing for teachers to ***supplement*** the unit with ***related*** phenomena at the unit launch, during investigation, and as a transfer task at the end of the unit (see Figure 2). Students are presented with the anchoring phenomenon: orangutan populations in Indonesia are declining due to changing land use from rainforest to monocrop oil palm plantations. As they develop an initial model to explain why this might be happening, they consider related phenomena of other changing land uses leading to population declines (R_1, R_2), including a local example that the teacher develops (R_3). Students develop general model ideas by investigating questions about orangutans and oil palm (I_1, I_2) and revisit the local related phenomena to investigate what kinds of local land use practices are happening that could help populations in decline (R_3). Students use the final general model to explain the anchoring phenomenon and related phenomena (R_1, R_2, R_3) and then engage in a teacher designed transfer where students apply new understandings a local land use issue (R_4). We designed supports to help teachers unpack original phenomena in the unit (A, R_1, R_2), understand the general science ideas, and select appropriate local land use change issues (R_3 and R_4) with relatively similar mechanistic explanations. In addition, these supports help teachers evaluate if the local phenomenon will be engaging and interesting for students, as well as feasible to investigate in the classroom, given available resources.

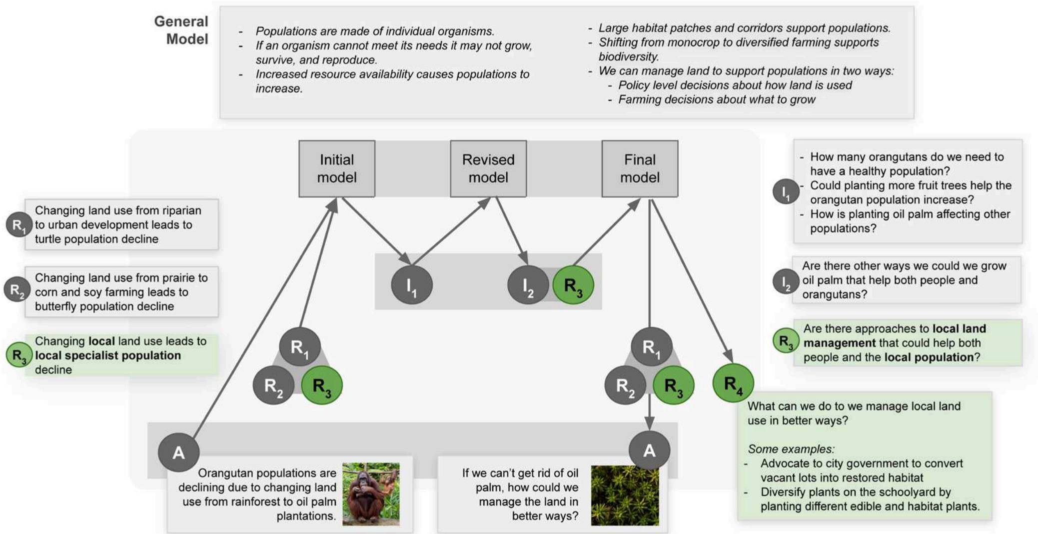

Figure 2. Example ecosystems unit under development.

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