Educating for a Changing Climate: Helping Students Learn to Live Sustainably and Equitably as Global Citizens

Tina A. Grotzer
Project Zero Classroom
June 27, 2023

HARVARD GRADUATE SCHOOL OF EDUCATION
NEXT LEVEL LAB

Take a minute to consider your climate moment. When did you realize that it is really happening and begin to grapple with its implications?

Preview:

- Overview of Climate Change as an Existential Threat, Educators on the Front Lines, and A Broad Consideration of Some Take-Aways from Research on Climate Education with Resources for Follow Up
- Engaging Learners 1. Analogical Reasoning About Our Collectivity on Earth
- Engaging Learners 2. Whose Voices are at the Table?: Moral Musical Chairs
- (Engaging Learners 3. What is EarthXDesign?: Learning Earth Resonant Design Moves)
- Wrap Up

Climate Change Education is a multifaceted problem space that involves challenges on many levels--social justice and inequity, medical and mental health, legal, economic, quality of life issues, innovation, science, design, and technology.

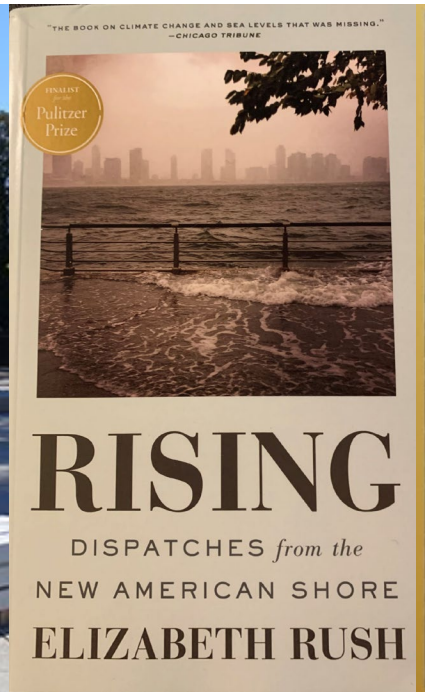

Lakeburst in Bhutan

Teachers are in a particularly challenging position when it comes to teaching about climate…

The Science Involves Many Challenges:

1. Earth's processes include many complex, dynamic, and interacting systems.
2. Earth supports complex life forms by providing two essential requirements—free oxygen in the atmosphere and a moderate and stable climate. It is a habitable planet.
3. Earth's systems involve homeostatic mechanisms that buffer change but also can reach tipping points due to inherent feedback loops.
4. Humans are a large enough force in the dynamics of the planetary systems that we are shifting processes responsible for a moderate and stable climate. This period has thus been labeled the *Anthropocene* (constituted of 'human' and 'recent').
5. The science of climate change presents many challenges for deep understanding. For instance, deep understanding how trees play a role in sequestering carbon requires an understanding of photosynthesis and the counter-intuitive understanding of the role that carbon plays in the biomass of trees. Even by high school, many students do not reason about carbon transforming processes at levels that enable them to understand its role in climate change.
6. Albedo effect refers to the feedback loop in which increased melting of ice on the surface of Earth results in increased heating/melting because lighter surfaces (such as ice) reflect more of the sun's rays than darker surfaces do. Our planet is habitable, in part because of Albedo effect.
7. Some greenhouse gases are needed to make our planet warm enough to inhabit, but too much greenhouse gas lead to overheating and changes to weather patterns. Analogies such as the "greenhouse effect" and "bathtub models" can support understanding but they can also undermine it without careful attention to how they are used and taught.

Climate Education cannot only be the domain of the science classroom!



How Humans Reason About Complexity Contributes to the Challenges:

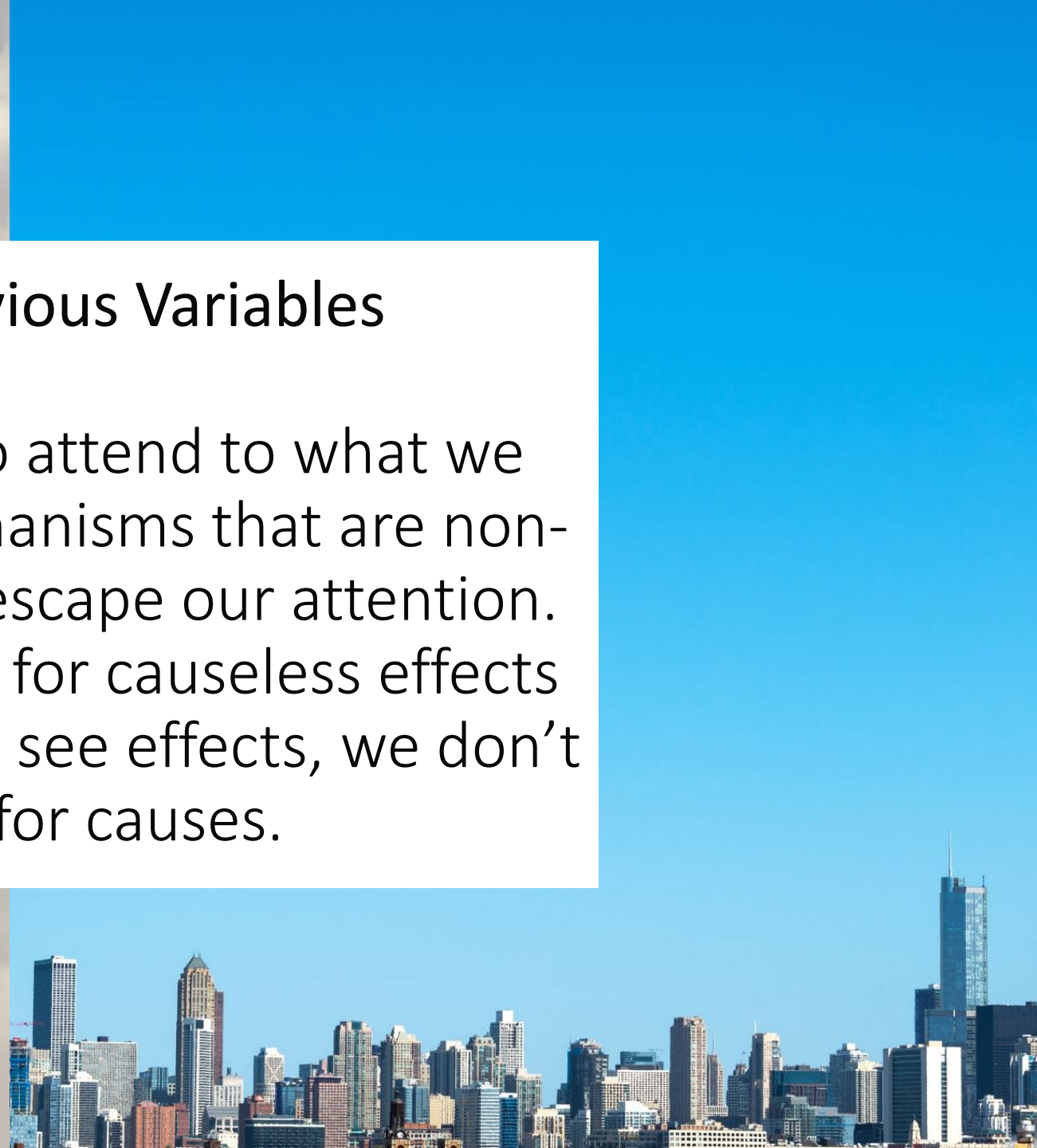
1. Feedback loops complicate our understanding of the causality of climate change. The concepts of cycles, feedback loops, and equilibrating systems are central to understanding the habitability of Earth.
2. Thinking about patterns over different time scales can be especially challenging because we carry forth assumptions related to shorter time horizons to longer ones. Reasoning about “deep time” is very different from reasoning about human time scales and children conceive of time differently than adults.
3. Our planet is an n of 1. Therefore, scientists look across time in reasoning about our planet. This is different than reasoning across cohorts as we do in so many other areas of pattern detection.
4. Knowing how to think about the additive, collective, and synergistic features of distributed causes and effects can help us to recognize the outcomes of uncoordinated, unintentional actions and to consider coordinated, intentional actions that can be taken to mitigate climate change. Sources and solutions to climate change can generate from either pattern.
5. The feature of emergence in climate change phenomena makes it difficult to reason about and contributes to scientific uncertainty about the details in predictive models.

Humans find it difficult to reason about:

- Extended, Indirect Effects
- Feedback Loops
- Time Delays
- Spatial Gaps
- Non-Obvious Causes
- Reasoning at Different Levels (Individual Organisms and Population Levels)
- Interdependencies
- Scale Processes and Steady States
- Reasoning About Balance and Flux
- Emergence and Distributed Causality
- Non-Incremental Effects/Tipping Points

Non-Obvious Variables

It is difficult to attend to what we can’t see. Mechanisms that are non-obvious often escape our attention. We don’t allow for causeless effects but until we can see effects, we don’t look for causes.



Action at an Attentional Distance

Refers to instances of spatially discontinuous causes and effects in which the causes and effects reside in <u>different attentional frames.</u>

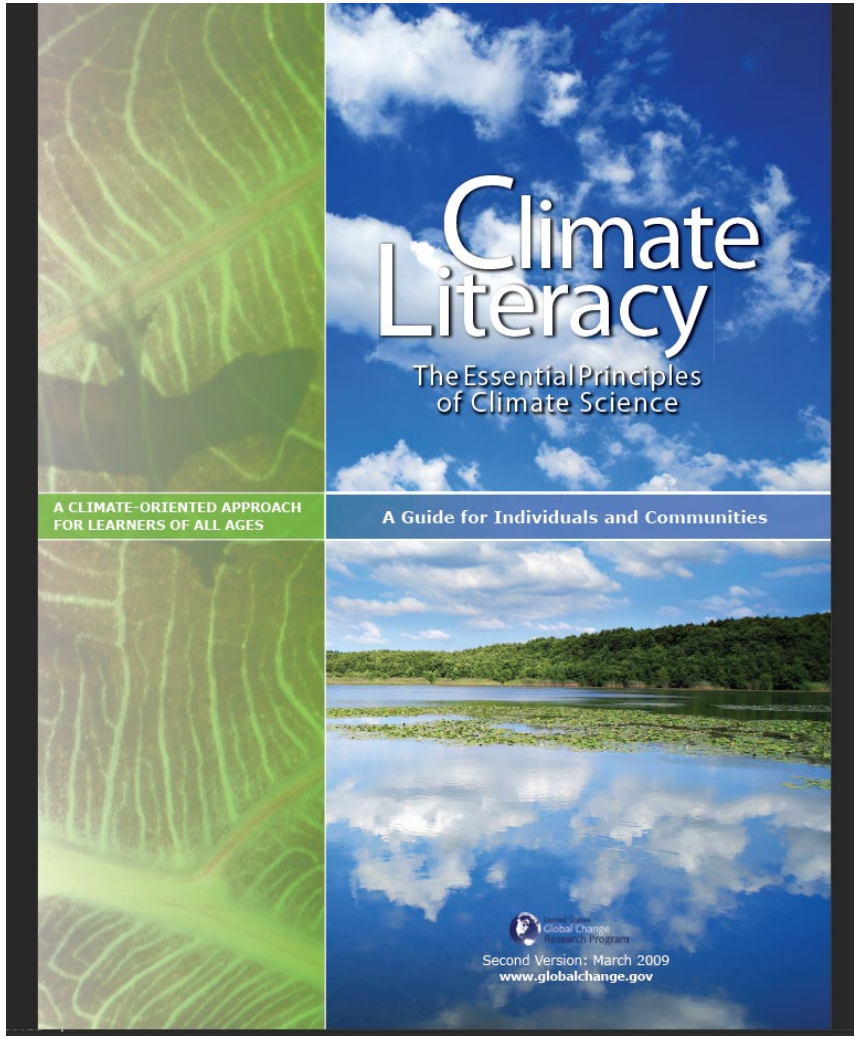
Distributed Causality

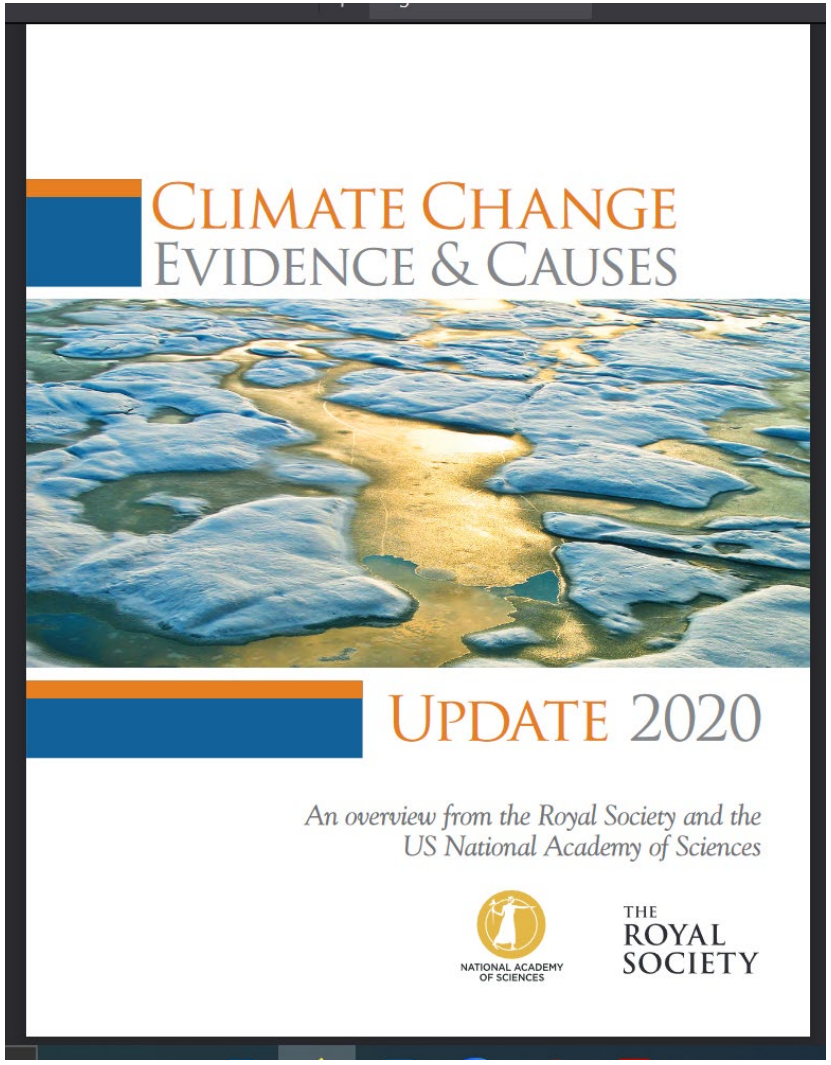
A causal structure in which agency is distributed across multiple actors

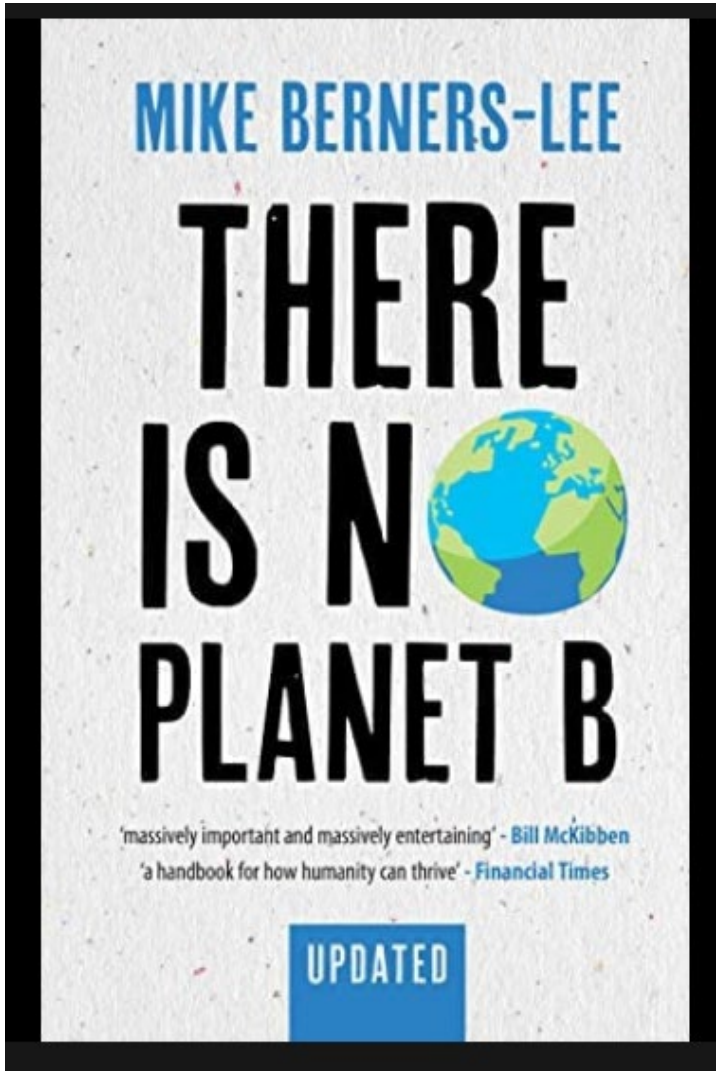
whose actions collectively result in emergent outcomes. The emergent effects are:

- on a much larger scale than the individual ones;
- may be aligned with individual intentionality or not;
- may be part of one's awareness or not.

Resources on the Science of Climate Change







The Habitable Planet: A Systems Approach to Environmental Science

What makes Earth unique among the planets? Explore the natural functions of Earth's systems and Earth's ability to sustain life.

according to intentionality (as in the wars the US fought following 9/11) and ignore those that are

Cognition in a Complex World Lab

Supporting the Development of Climate-Informed Global Citizens for a More Just and Sustainable World

Curriculum Modules on Climate and Complexity from the CLiC Project!

Curriculum modules focused on collective action and impacts at an attentional distance for middle school...

ABOUT US

We are a research group at the Harvard Graduate School of Education within Project Zero. We focus on topics at the intersection of cognition

CLIC PROJECT NEWS

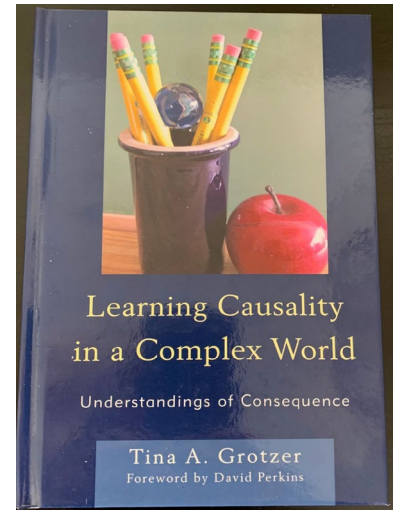
Planet Classroom's Net Zero Features Tina Grotzer

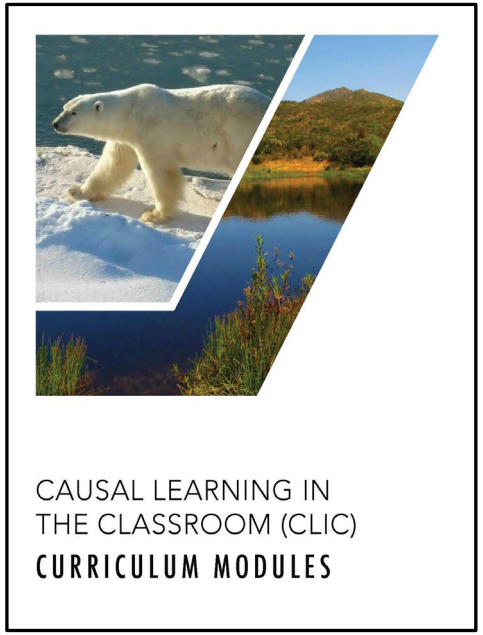
February 1, 2023

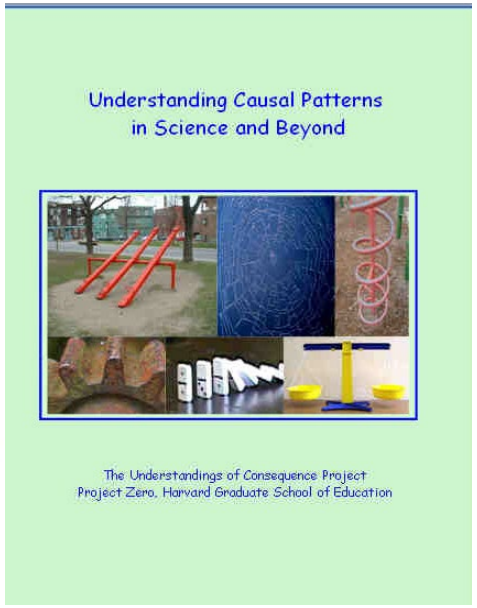
Learning to Teach About Complexity: Books and Curriculum Resources for Educators

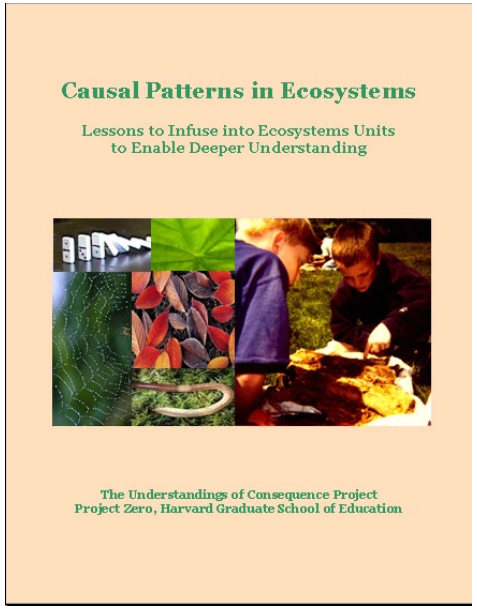
HARVARD GRADUATE SCHOOL OF EDUCATION

http://www.causalpatterns.org



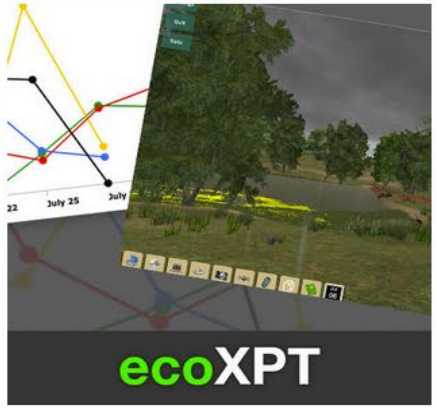






This work was supported by the National Science Foundation, Grant Nos. NSF#0845632 to Tina Grotzer
All opinions, findings, conclusions or recommendations expressed here are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Welcome. EcoLearn is an educational research group at the Harvard Graduate School of Education that explores the use of advanced immersive technologies to support learning about the complex causal dynamics of ecosystems.



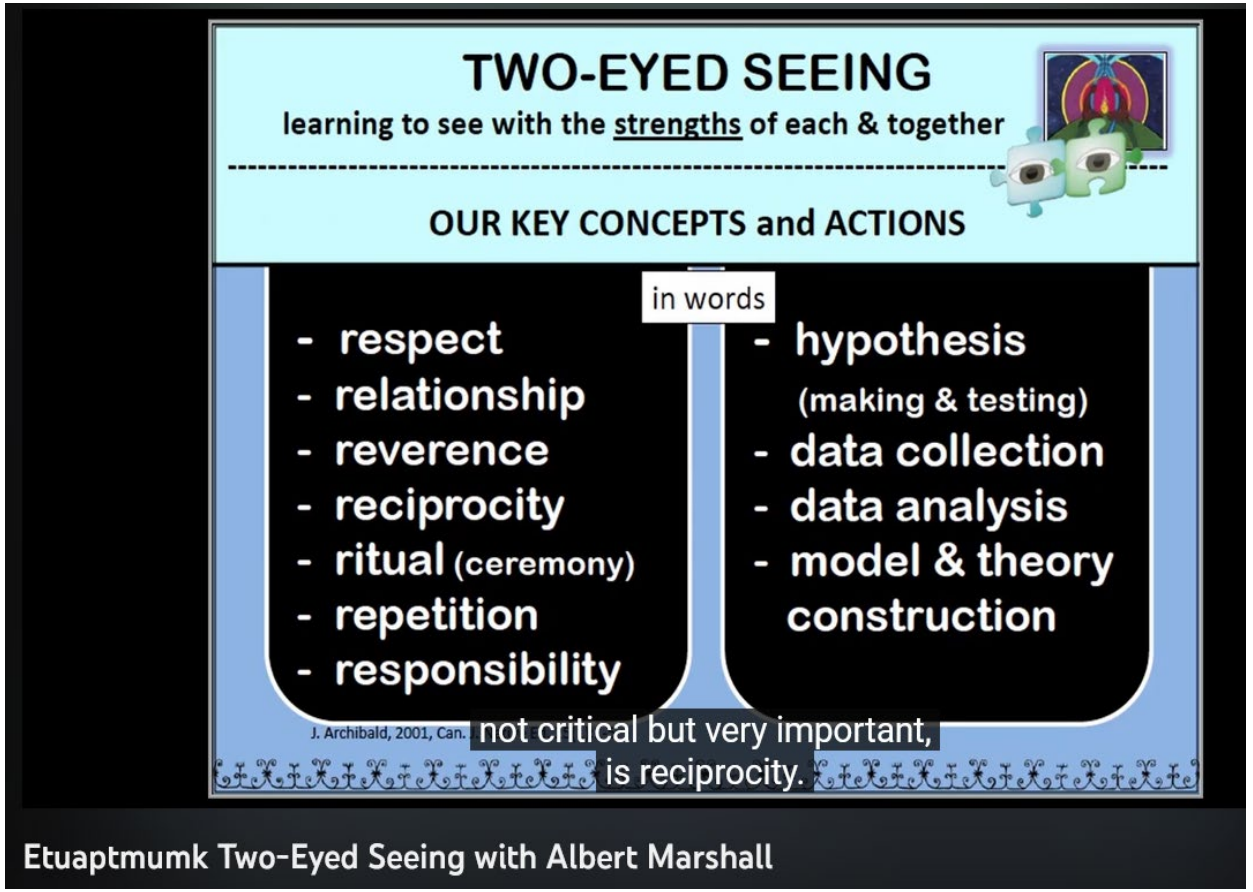
Some Cultures Embody Wisdom About Living Sustainably on Earth:

1. There are different ways of knowing Earth and these can contribute to our ability to see it through different eyes and over different time horizons.

2. Different ways of knowing bring different forms of wisdom. Some forms are especially helpful in understanding relationships, connection, complexity, and how to live sustainably.

3. Culturally responsive pedagogy involves sensitivity to how culture influences beliefs, language, perception, modes of engagement, and learning. These influences are not always apparent, they can be tacit and subtle.

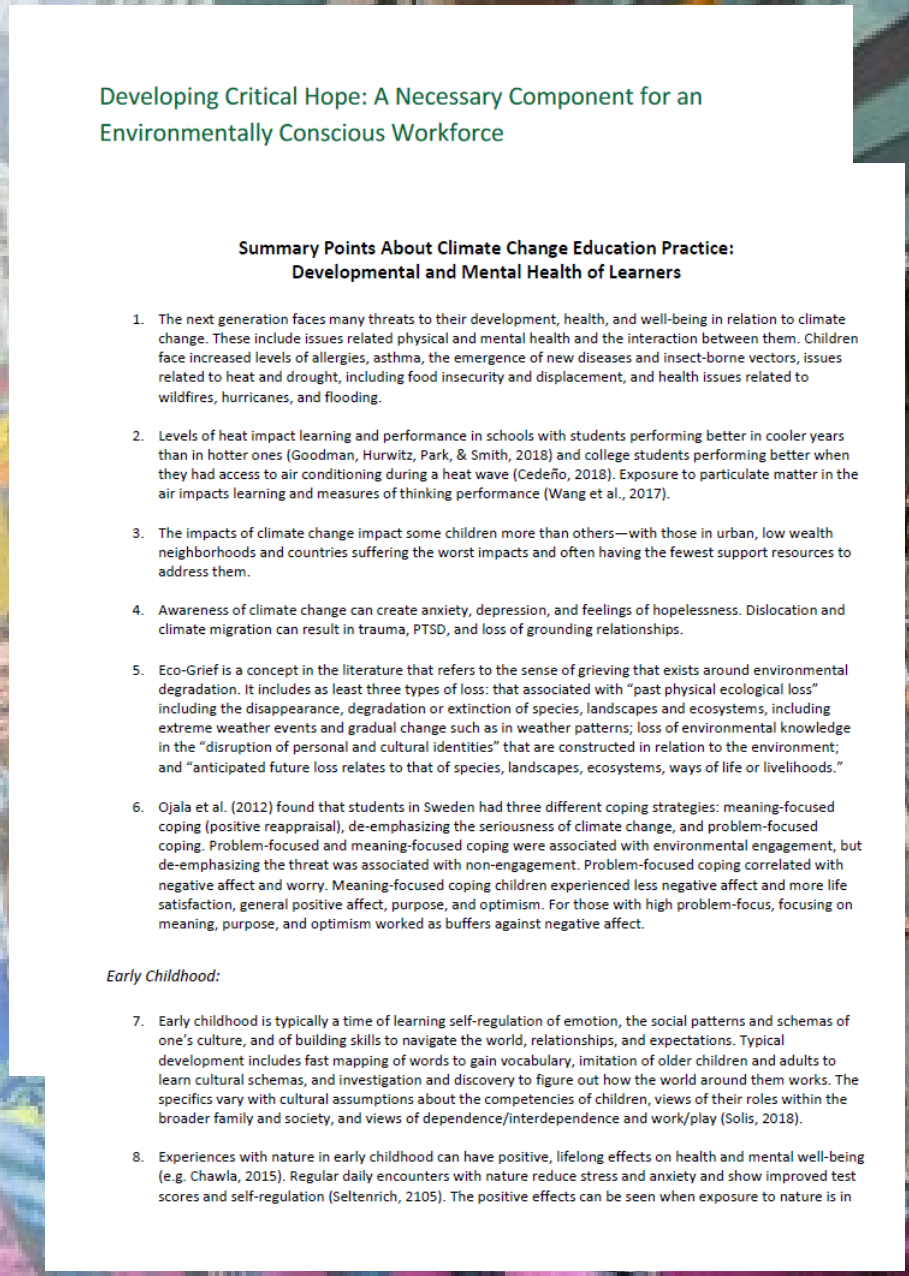
4. Increasingly, resources that focus on sustainability adopt diverse ways of knowing and support learning through epistemological pluralism.



Mi'kmaw Elder Albert Marshall" on Two-Eyed Seeing

Hope and Eco-Anxiety: Supporting Mental Health While Educating about the Climate

1. Extending the arc of human existence on the planet requires deep changes to how we live.
2. Asking young people to contemplate these concepts and our potential demise is emotionally fraught. At the same time, action can be empowering and distributed action can be very powerful.
3. Empowering people towards action and innovation is important for mental health. We need to engage young people in the space in a way that protects mental health and ability for creative, thoughtful engagement.
4. Environmental changes are already resulting in and will continue to result in considerable injustices in our world.
5. Uniting around common ground is critical to coming up with climate change solutions--local and non-local. There are different ways to think about our "collectivity." Different framings can result in very different world outlooks and outcomes.



Developing Critical Hope: A Necessary Component for an Environmentally Conscious Workforce

Summary Points About Climate Change Education Practice: Developmental and Mental Health of Learners

1. The next generation faces many threats to their development, health, and well-being in relation to climate change. These include issues related physical and mental health and the interaction between them. Children face increased levels of allergies, asthma, the emergence of new diseases and insect-borne vectors, issues related to heat and drought, including food insecurity and displacement, and health issues related to wildfires, hurricanes, and flooding.
2. Levels of heat impact learning and performance in schools with students performing better in cooler years than in hotter ones (Goodman, Hurwitz, Park, & Smith, 2018) and college students performing better when they had access to air conditioning during a heat wave (Cedeño, 2018). Exposure to particulate matter in the air impacts learning and measures of thinking performance (Wang et al., 2017).
3. The impacts of climate change impact some children more than others—with those in urban, low wealth neighborhoods and countries suffering the worst impacts and often having the fewest support resources to address them.
4. Awareness of climate change can create anxiety, depression, and feelings of hopelessness. Dislocation and climate migration can result in trauma, PTSD, and loss of grounding relationships.
5. Eco-Grief is a concept in the literature that refers to the sense of grieving that exists around environmental degradation. It includes as least three types of loss: that associated with "past physical ecological loss" including the disappearance, degradation or extinction of species, landscapes and ecosystems, including extreme weather events and gradual change such as in weather patterns; loss of environmental knowledge in the "disruption of personal and cultural identities" that are constructed in relation to the environment; and "anticipated future loss relates to that of species, landscapes, ecosystems, ways of life or livelihoods."
6. Ojala et al. (2012) found that students in Sweden had three different coping strategies: meaning-focused coping (positive reappraisal), de-emphasizing the seriousness of climate change, and problem-focused coping. Problem-focused and meaning-focused coping were associated with environmental engagement, but de-emphasizing the threat was associated with non-engagement. Problem-focused coping correlated with negative affect and worry. Meaning-focused coping children experienced less negative affect and more life satisfaction, general positive affect, purpose, and optimism. For those with high problem-focus, focusing on meaning, purpose, and optimism worked as buffers against negative affect.

Early Childhood:

7. Early childhood is typically a time of learning self-regulation of emotion, the social patterns and schemas of one's culture, and of building skills to navigate the world, relationships, and expectations. Typical development includes fast mapping of words to gain vocabulary, imitation of older children and adults to learn cultural schemas, and investigation and discovery to figure out how the world around them works. The specifics vary with cultural assumptions about the competencies of children, views of their roles within the broader family and society, and views of dependence/interdependence and work/play (Solis, 2018).
8. Experiences with nature in early childhood can have positive, lifelong effects on health and mental well-being (e.g. Chawla, 2015). Regular daily encounters with nature reduce stress and anxiety and show improved test scores and self-regulation (Seltenrich, 2105). The positive effects can be seen when exposure to nature is in

Climate Must be Taught Across the Curriculum and in Ways That Invite Critical and Creative Thinking!

1. Climate change and sustainability can be taught across the curriculum -- inviting many points of opportunity to help learners engage with sustainability.
2. The power of narrative and the arts are some of our most compelling ways to communicate about climate issues to engage whole humans--as social, emotional, cognitive, embodied beings.
3. Action-oriented projects are often interdisciplinary and draw upon and build skills across the curriculum.
4. Innovation and design in all aspects of life will be essential for continuing to meet the challenges of a warming planet.
5. While there is significant research to support what powerful innovation and design looks like, the climate crisis will require new, high leverage forms of innovation and autonomous adaptation. It will also require local and non-local approaches.
6. Careful analysis of embedded assumptions across the curriculum is important to realizing implicit messages or hidden curriculum that implicitly serve agendas related to unsustainable progress, development, and economic systems and that work against sustainable, planetary level systems.

Three Climate Education Activities related to “Thinking Like an Earthling” that invite Critical and Creative Thinking and Active and Deep Processing:

-Analogical Reasoning about Global Collectivity
-Designing for Moral Musical Chairs
-Earth Resonant Design Moves

Educating for Global Collectivity: Thinking Like an Earthling

Dr. Jill Tarter

Astronomer, Chair Emeritus of the Center for SETI Research (Search for Extraterrestrial Intelligence)

"…if you sit and listen to me talk or anyone talk or think about SETI, you got to realize that it is putting on a mirror up to everyone on the planet and the message is, "You, you are all the same when compared to something else out there. And I think that this is the perspective, the cosmic perspective that we need globally in order to attack the challenges that we heard about earlier with respect to energy and water security and food security. We need to think and act as one species. We are earthlings. [Quoting Scharf, he says] "On a finite world [that's us], a cosmic perspective isn't a luxury, it is a necessity." So you all have a homework assignment. When you get back to your social media, go into your profiles and change the first thing that you say about yourself to the fact that you are an earthling and then act like it."

Thinking about our Collectivity on Planet Earth

A Silent Film

Analogy as a means to think about complex relationships can be powerful depending upon how analogy is used and how deeply processed it is. Where does the analogy fit? Where does it break down?

Balance: A Short Film

Working in Small Groups to Reason About Our Collectivity Through Analogy:

- Consider the video analogically in relation to climate change and the fate of Earth's peoples and other organisms. How do the aspects of and interactions in the film map to dynamics related to climate change?
- Recall that analogies can be powerful for considering complex issues, but they can also be difficult to map and to hold the relationships in mind. For yourselves and for students, how might you download the cognitive load involved in mapping it?
- Imagine that you are using this analogy to talk with middle or high school students about the need for human cooperation, issue of competition, and our ability to engage for the common good. What guiding questions might you ask to help them to focus on the dynamics and lessons from the film?

Bringing Multiple Perspectives to the Conversation

Our values, experiences, and life circumstances often contribute non-obvious forms of complexity.

Shona saying:

“Kakova kanozara nemadirirano”

“The river is flooded by tributaries”

“All ways of knowing must be valued.”

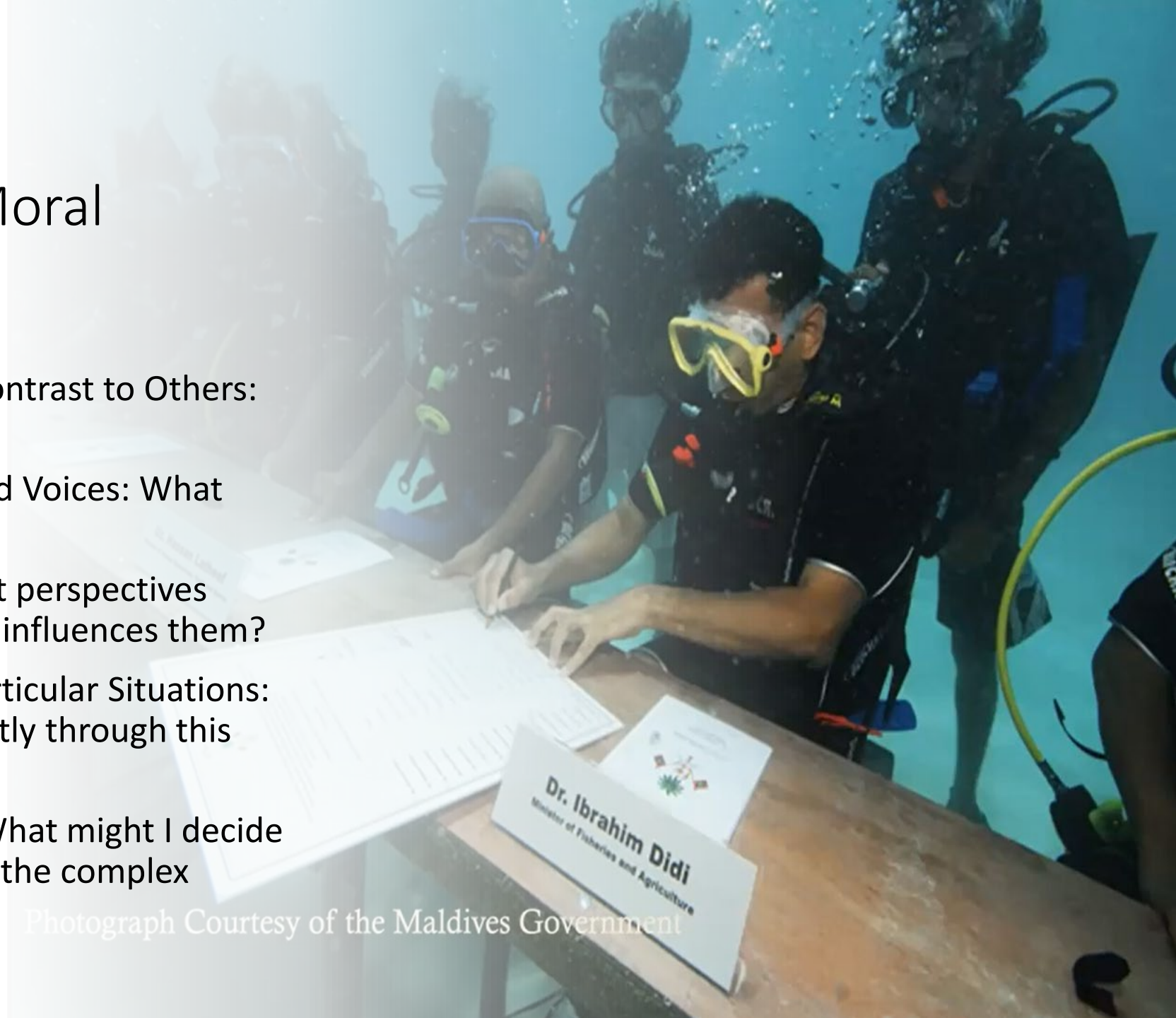

Moral Musical Chairs

How it works…

- Learners consider what perspectives might relate to the situation with support from their teacher in helping them to consider what voices should be at the table.
- They gather information about each—being mindful of the need to set their own lenses aside as much as possible and supported by the teacher in this preparation.
- They play MMC with one chair per role to consider the perspectives (imagining that they could be anyone in the scenario).
- The teacher lightly facilitates as needed to help to deepen the conversation through questions to explore different perspectives and conflicting needs.

Perspective Taking in Moral Musical Chairs

- Realizing My Own Lens Through Contrast to Others: What perspective do I hold?
- Recognizing Dominant and Silenced Voices: What voices am I not hearing?
- Understanding Other Lenses: What perspectives might other voices bring and what influences them?
- Adopting Other Lenses to View Particular Situations: How do I see the situation differently through this lens?
- Stepping Out of my Own Stance: What might I decide to do if I didn't know which role in the complex situation I will inhabit?



Photograph Courtesy of the Maldives Government

Examples

- Issues related to water usage
- Persons displaced by climate change
- Freedom of religion
- Availability of medical care
- Issues related to civil war

Working in Small Groups to Plan a Moral Musical Chairs Conversation

- Choose an issue of focus related to climate change. Try to choose one that will invite differing perspectives to the conversation.
- What voices would you help students to include in the discussion?
- How might you help them to begin to understand the perspectives of those voices? How will you help them in understanding the different “ways of knowing” within the perspectives?
- What ideas do you have for inviting deep processing and empathy while encouraging humility about what can be known of another’s perspective?

Some Related Resources:

PBL: The World Peace Game

Chivian and Cizik

The Common Good Unit

Causal Patterns in Science Distributed Causality Unit.

The World Peace Game and Other Fourth Grade Achievements (Extended Trailer)

Eric Chivian and Richard Cizik

Scientists and evangelicals slept side by side last summer on the floor of a preschool in the Alaskan village of Shishmaref. We were there to see for ourselves the devastation of climate change on the Inupiaq Eskimos, whose island is eroding into the Chukchi Sea…

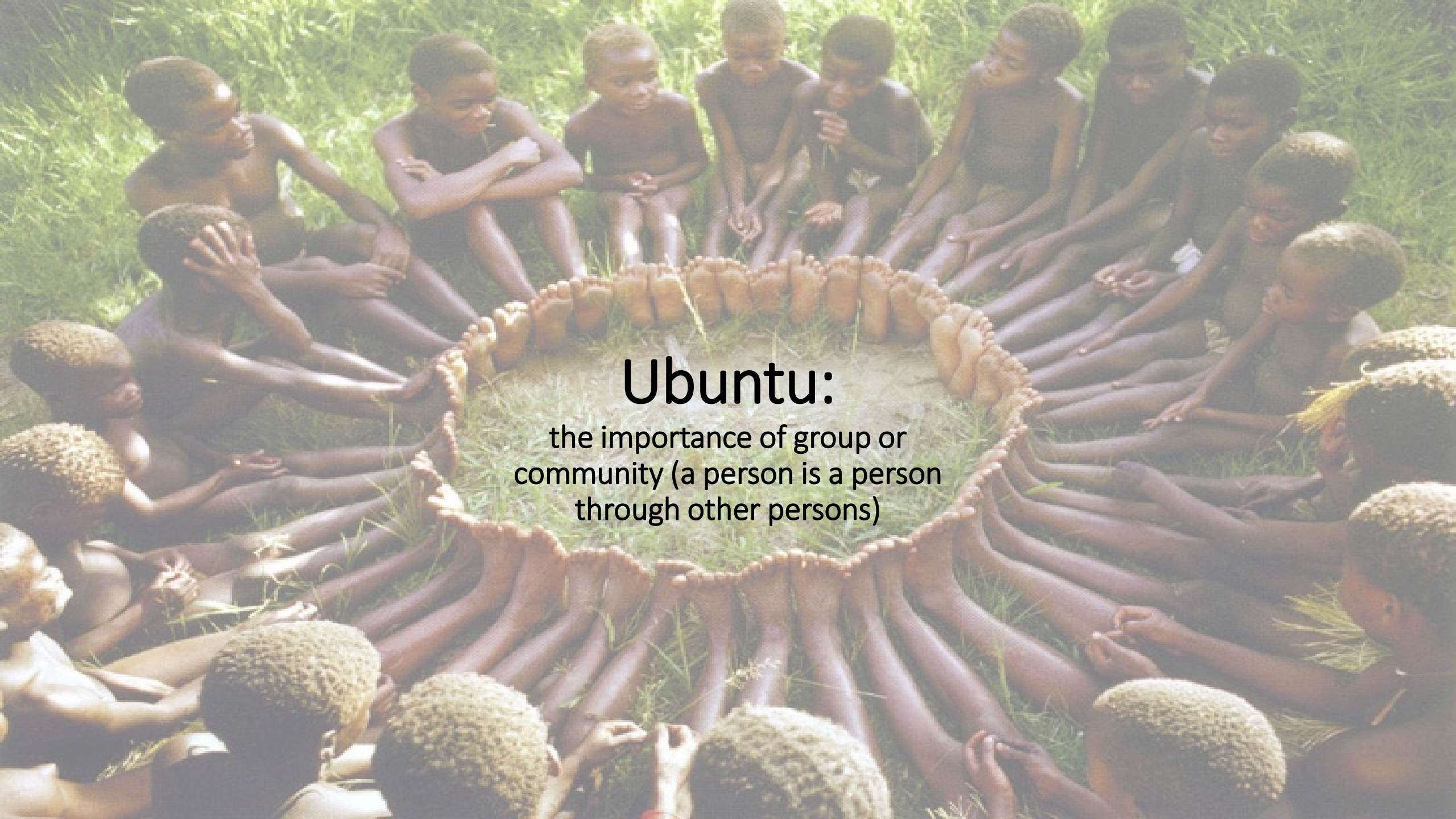
Time 2008

The Idea of a Common Good (Shawn Lavoie, 2013)

Invited the students to conceive of it and offered a few possibilities of definitions:

- The common good is the aggregate of individual goods.
- The common good is what the majority of people believe to be good.
- The common good is the highest, most abstract ideal that people can agree upon.
- The common good is a compromise between competing ideas.
- The common good is material wealth or resources that individuals share (water, air, parks, etc.)
- The common good is that which enables us to experience individual goods within a community (e.g. unifying ideals, the law, etc.)

"Central to all of these definitions, and hence central to this unit, is the tension between individuals and collectives in defining the common good." Is there necessarily a tension? How might one think about possible tensions?


Ubuntu:
the importance of group or community (a person is a person through other persons)

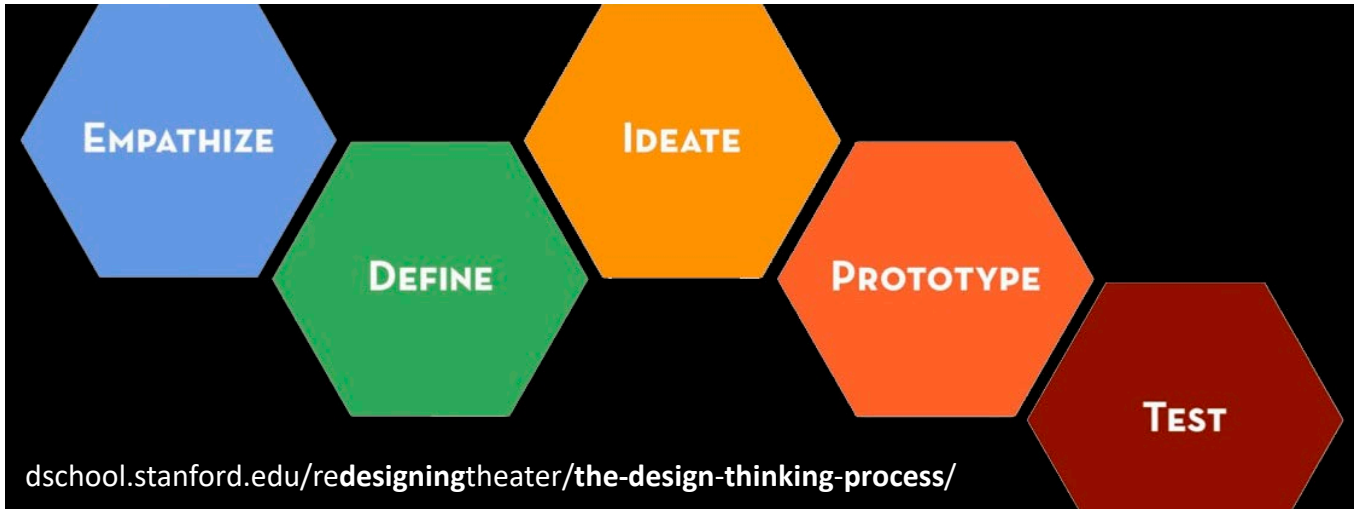
EarthXDesign

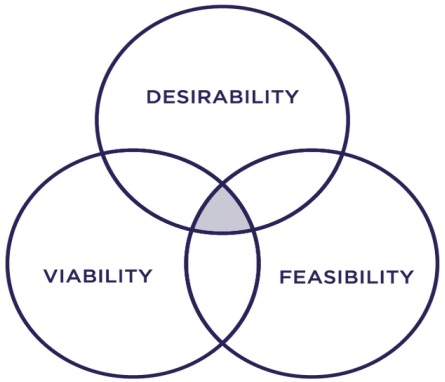
What do people usually think of when they hear the words “design thinking”?

IDEO

Design thinking brings together what is desirable from a human point of view with what is technologically feasible and economically viable.

- Desirability: What makes sense to people and for people?
- Feasibility: What is technically possible within the foreseeable future?
- Viability: What is likely to become part of a sustainable business model?



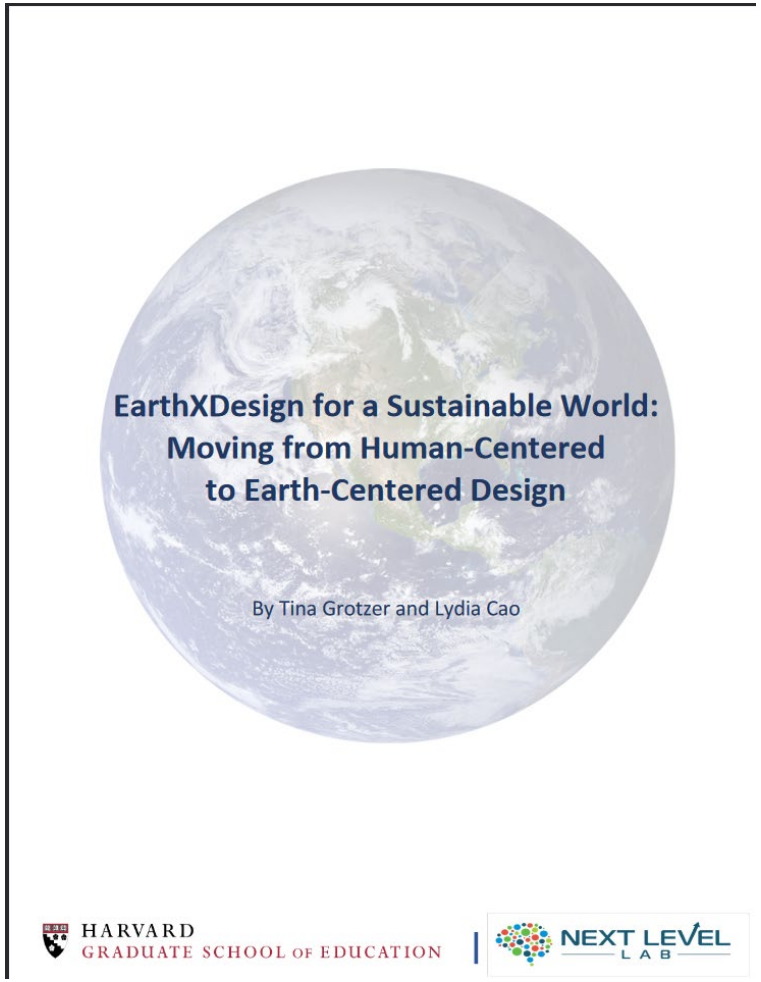


Why do We Need EarthXDesign?

- Innovation and design in all aspects of life will be essential for continuing to meet the challenges of a warming planet.
- While there are approaches to innovation and design, much of it is human-centric and not particularly well-suited to issues of sustainability and the climate crisis.
- Human experience depends upon Earth systems and dynamics.
- The climate crisis requires new, high leverage forms of broad innovation in terms of non-local approaches and autonomous adaptation in terms of local design.
- Existing research on creative thinking can be leveraged to inform earth-centric approaches to design.
- UX Design and EarthXDesign should not be in competition!

Shifts for Innovative, Sustainable Design		
UX Design	⟹	**EC Design**
Focus on:	⟹	Focus on:
Human-Centric	⟹	Earth-Centric
Decontextualized, Broadly Marketable Solutions	⟹	Deeply Contextualized in Relation with Nature
Noncultural Narratives	⟹	Narratives Embedded in Local Wisdom and Culture
Function-Oriented	⟹	Systems-Embedded
Immediate Temporal and Spatial Scale	⟹	Extended Temporal and Spatial Scales/Long Time Horizons and Global Implications

We are developing instructional materials to support a set of EarthXDesign Moves…



What Does Design Thinking Look Like in EarthXDesign?

Here is a set of ten EarthXDesign Thinking Moves that we are developing and testing. We will be developing materials and case studies of each move.

1. **Rethink Assumptions:** Analyze underlying assumptions in the problem space. We often make assumptions that limit how we approach a design challenge, for instance, that garbage is waste or that agricultural plantings should be homogeneous instead of mixing crops together.
2. **Think Inside Out**: Switch the problem to its opposite focus. Instead of solving the problem of how to transport fresh vegetables to the locations where they are needed, find ways to grow them in that locale using solar energy. Or instead of finding ways to keep disease-bearing mosquitoes off people with sprays, modify the mosquito so that it cannot breed successfully breed or won't be attracted to humans.
3. **Mimic Nature***:* Look for functional and visual analogies in nature.[9] Biomimicry can be a powerful source of Earth Resonant design concepts. Consider how the termite towers in the desert allow for convection current cooling or how slime molds come together into a super-organism for certain purposes, but also act as individual micro-organisms at other times.
4. **Empathize with the Voiceless:** Include the voices of those who are not represented at the design table and empathize. Ask which people and organisms may be impacted and represent their voices. This includes those who are microscopic, non-obvious, unempowered, and voices from the future.
5. **Recast Causality:** Consider alternative causal structures relating to possible designs.[10] For instance, design for decentralized solar power grids such as those in Bangladesh instead of fossil-fueled, centralized ones that are conducive to sabotage and breakdown. Design for cyclic instead of linear use of resources.
6. **Leverage Local Knowledge**: Mine local wisdom that is essential to the Earth-Resonant success of designs. Invite autonomous adaptation of solutions so that they can be adjusted to work in local contexts.[11] Look for traditional, indigenous, and local knowledge and practices that already work.[12] For instance, Playpumps were an innovation to bring water to communities in Africa that worked as children played on playground equipment. Their success hinged upon the amount of time children were able to play, size of the communities served, and characteristics of the underground aquifer.[13]
7. **Reassess Needs and Wants**: Ask whether what we deem to be desirable is truly desirable (e.g., why do we like it? Is it a cultural practice that we are socialized into or the result of an unexamined assumption?) Consider whether you really need designs that make minor tasks easier but are not necessary.
8. **Consider Scales of Impact:** Think about the potential outcomes of a design decision at different levels. Consider it in increasingly broad, concentric circles, from the individuals immediately adopting a design towards more global reach. Recognize the interconnectedness of the system and consider how the design holds impact at different scales.[14]
9. **Think Long Term:** Envision the long-term impact of the design. For instance, a plastic bag solves the short-term problem of carrying groceries from supermarket to the parking lot, but in the long term, it harms ecosystems and health of organisms on the planet, including humans.[15] The large floating plastic mound in the Pacific Ocean exemplifies the problem. Food wrapping that is used to "protect" food from contaminants ends up in the landfill, then burying garbage in landfills creates long-term pollutants and seepage into aquifers that poisons land which can no longer be used to grow crops.
10. **Prioritize Regeneration:** Consider how to renew and restore beyond mitigating negative impacts or avoiding harm.[16] Look for win-win possibilities that create assets from what might be considered negative. Some communities engage in pee-cycling—using human urine as natural fertilizer that does not

Mimic nature

What are inspirations from nature that can inform the design?

Termite mounds and Eastgate Centre

The New York Times

TRILOBITES

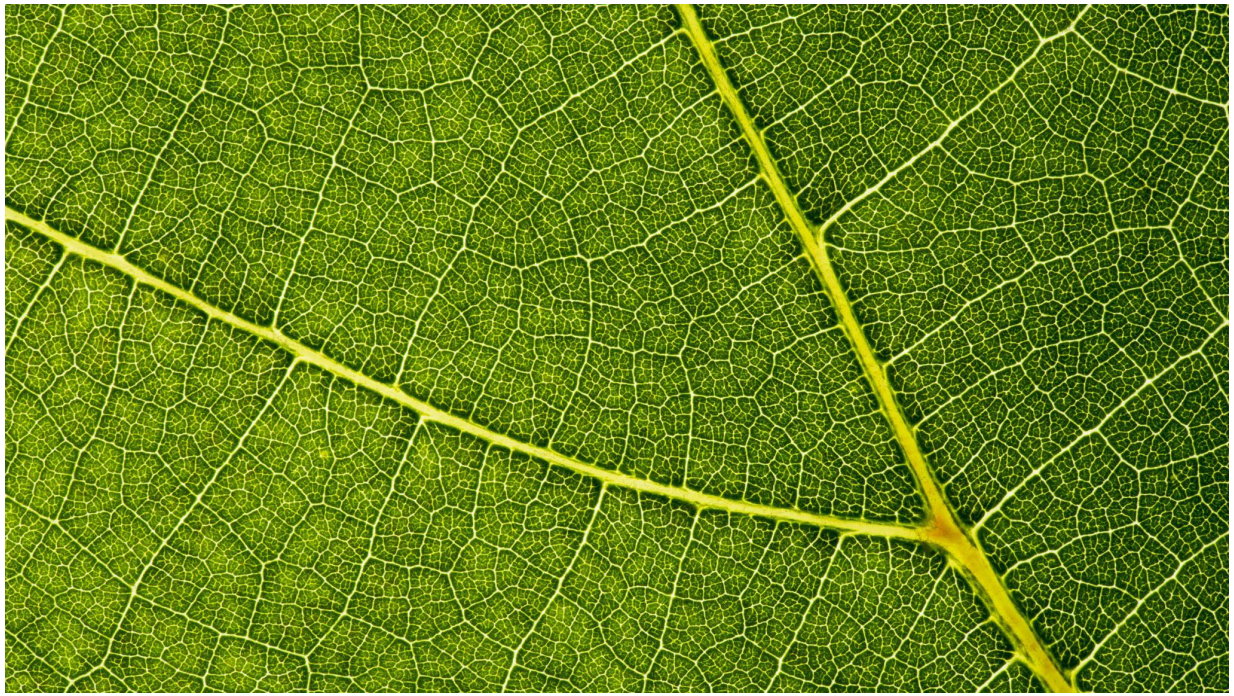
What Termites Can Teach Us About Cooling Our Buildings

"We think humans are the best designers, but this is not really true," a researcher said.

https://www.youtube.com/watch?v=620omdSZzBs

https://www.nytimes.com/2019/03/26/science/termite-nest-ventilation.html

Solar Cell Inspired by Leaf Design



nature › scientific reports › articles › article

Article | Open Access | Published: 16 July 2019

Leaf Anatomy and 3-D Structure Mimic to Solar Cells with light trapping and 3-D arrayed submodule for Enhanced Electricity Production

Min Ju Yun, Yeon Hyang Sim, Seung I. Cha ✉ & Dong Yoon Lee

Scientific Reports **9**, Article number: 10273 (2019) | Cite this article

Empathize with the voiceless and invisible

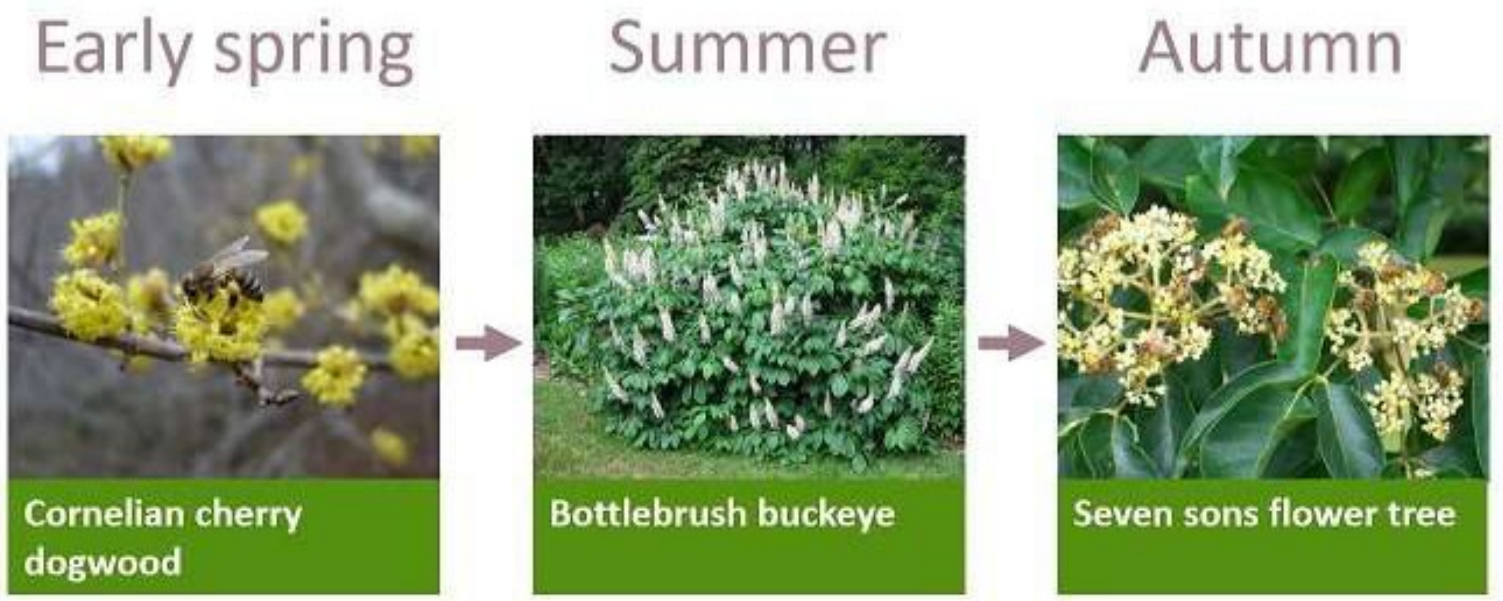
Who will be impacted by the design?
Whose voices are not represented at the design table?

Wildlife Bridge

Passages beneath or above roadways that are designed to facilitate safe wildlife movement across roadways.

Bee-friendly urban landscaping

Plant a combination of flowers, trees, and shrubs that bloom and provide nectar in each season.



What about designs that already exist around us? How can we make them more Earth-Resonant?

Ask a set of questions to analyze *how Earth Resonant* the features of a design are.

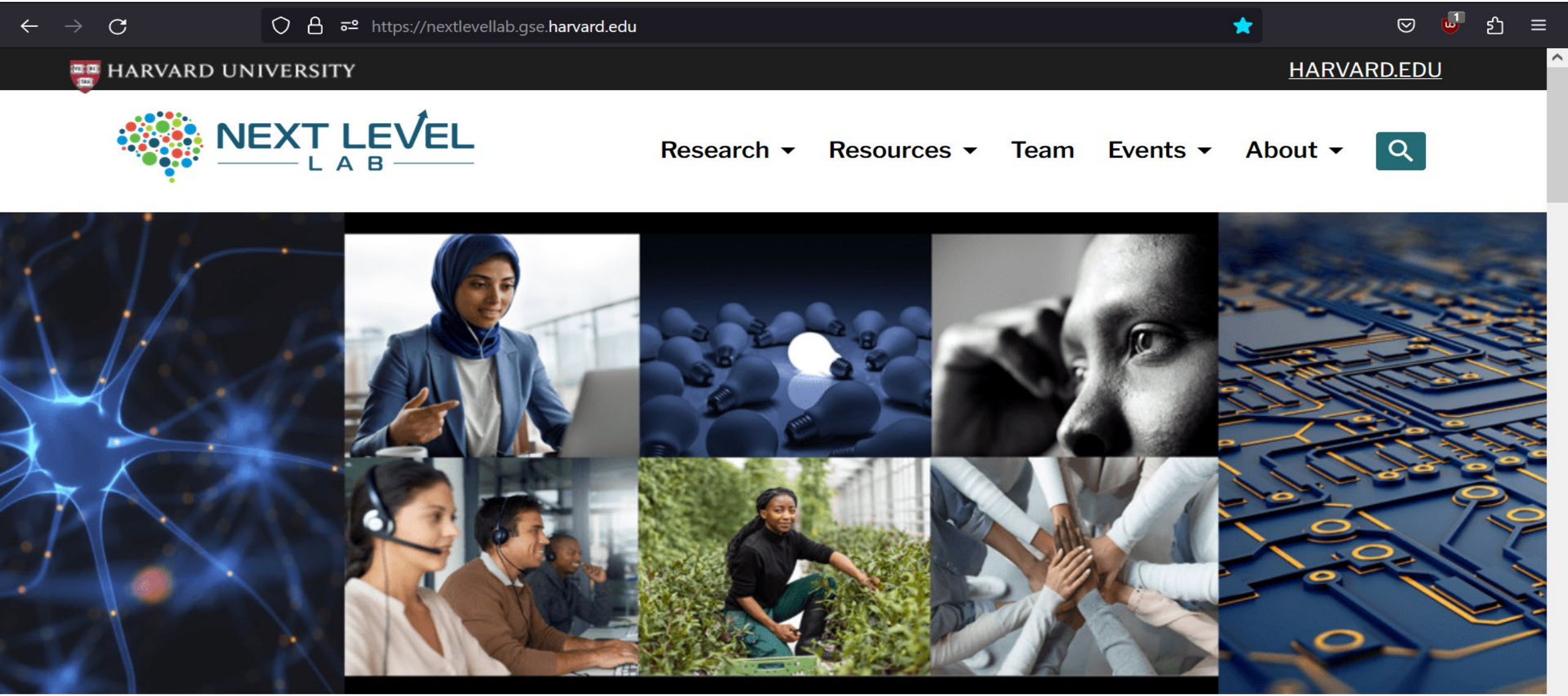
- Does it include consideration for the planet? For non-human inhabitants of the planet? Or only people?
- Can it be sustained over time? Does it introduce new problems?
- Are implicit assumptions revealed/analyzed/re-considered? Turned inside out?
- Are the extended, possibly unanticipated effects traced out and considered?
- Does it address sensitivity, ability and inclination to enact behavior change?
- Does it address environmental issues? injustice issues? health issues?
- Do you see paths to acceptance?
- Are there opportunities for autonomous adaptation? local wisdom? centralized, but non-local expertise? An integration of the two?



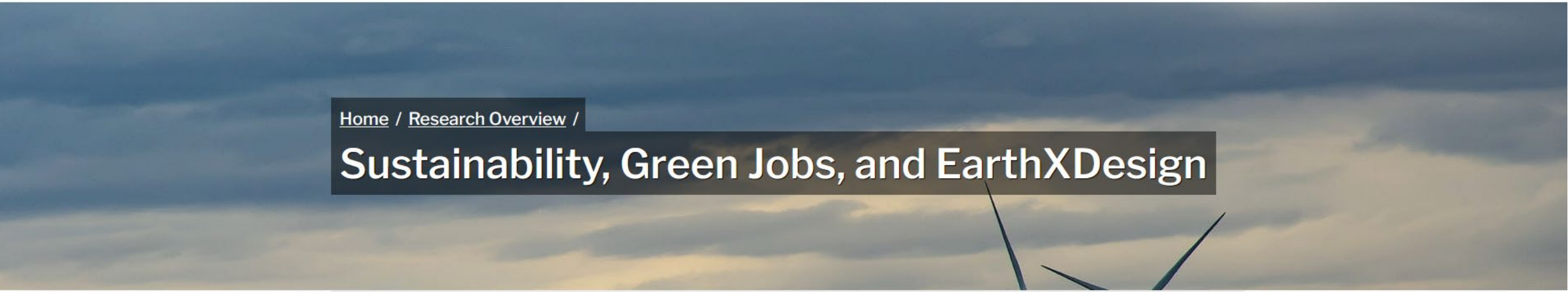


How might knowing EarthXDesign Moves influence the work that you do with young people?

Explore our website to learn more about the Next Level Lab….



Established with Funding from Accenture Corporate Giving



Sustainability, Green Jobs, and EarthXDesign

Participating fully in the future of work requires developing skills related to green jobs.

PROJECT DESCRIPTION PUBLICATIONS RESOURCES NEWS

Project Description

Participating fully in the future of work requires developing skills related to green jobs. As existing jobs become greener and new green jobs emerge, the workforce will need skills related to understanding complexity, innovation, and problem-finding and -solving. We are developing an inventory of green jobs skills by researching relevant component skills, vetting the inventory with practitioners in Workforce Development, and engaging in a testing and validation study with learners ages 16-24.