The Research

Summary of Research Relevant to Multidisciplinary Climate Change Education

What Research Says about Learning

In reviewing the diverse bodies of literature that have sought to document the process by which we come to know things and act upon that knowledge, we found striking similarities across theories. All of the theories we reviewed have at their heart the same purpose of education: to actively engage learners in work focused on transforming the world around them. For example, both action competence theory and activity theory focus on active participation in the world, and view learning as the process of engaging in experiences in both the social and physical world. Experiential education is at the heart of service learning theory, where learners engage in direct application of skills and reflection, geared toward changing the world around them.

This research indicates that those strategies that work best to promote engagement and learning are: experiential, place-based, active, student-centric, transformative, and cultivate systems thinking. Given what we know about the causes, impacts and possible solutions to climate change, and how to best engage learners on these issues, we have developed a set a strategies for teaching and learning about climate change. These strategies are derived from the education research reviewed and are focused on how to best support learning about complex issues like climate change. In an effort to bridge what can sometimes feel like the insurmountable divide between theory and practice, we have also included brief, general summaries of the literature we reviewed, and primary sources to refer to for a deeper exploration of a particular theory.

Relevant Learning Theories

The following summaries are not meant to be an exhaustive list of all learning theories. Many more exist that you may find helpful. But we encourage you to investigate those we have included here as an entry point for incorporating learning strategies based on research into your teaching practice.

Action Competence

Action Competence towards environmental goals means understanding and internalizing that our actions can have a positive effect on an outcome.

Building and strengthening a student's lasting capability and desire to help solve environmental problems increases action competence.   The understanding is that actions are intentional. In the long run, action competence can guide the extent to which we see ourselves as agents of positive change. As such, there is a guiding principle to consider when we think of climate change education: that environmental degradation issues should be seen as human societal issues (human use of natural resources is the problem itself). Some strategies to consider:

1. Engage and develop willingness in students to work as a group to identify things in their immediate environment that they want to see changed and to act on these to make their future environment one they'd like to see, such as reducing the number of cars idling in parking lots or supporting renewable energy technology.
2. Utilize the tool of identifying "Conflicts of Interest" to help students understand that environmental problems are complex and that there are many facets to consider (both science and societal). This method can help develop critical thinking skills towards the many different perspectives on climate change and thus onward to effective action.

DIVE INTO ACTION COMPETENCE:

Jensen, B. B., & Schnack, K. (1997). The action competence approach in environmental education. *Environmental Education Research*, *3*(2), 163-178.

Activity Theory

Based on the work of Vygotsky, Levontv, Engeström, to name a few, activity theory holds that through our power to act, individuals have the ability to change the world around us, and in doing so transform the world and ourselves. Learning then, is thought of as the active process of manipulating the physical and social world, and passing the results of those actions along in the form of tools like knowledge and language. It is through this mutually evolving process that we learn, are transformed and are able to transform the world around us. Because we don't live and act in a void, these changes to individuals alter the structure of the collective communities and systems in which we exist.

Learning then, is thought of as the process of human development, a process that calls for the active participation of each of us in the world (or classroom). Activity theory also holds that in order to develop, our interactions must be oriented toward transformation, or in the case of climate change education, oriented toward empowering our students to make more environmentally responsible decisions and actions.

DIVE INTO ACTIVITY THEORY:

Krasny, M. E., & Roth, W. M. (2010). Environmental education for social–ecological system resilience: A perspective from activity theory. *Environmental Education Research*, 16(5-6), 545-558.

Place-Based Educational Theory

Placed-based education (PBE) uses students' local environment, heritage, culture, and opportunities as the context and content of learning. PBE emphasizes the importance of interacting with the natural world and community focused projects as a means for learning through participation in a local real-world setting. Originating in some ways from Dewey's concern that what is learned in school stands apart from students' lives outside the classroom, contemporary theorists like Lane-Zucker, Elder, Sobel, and Gruenewald have expanded this idea of project-based educational experiences focused in and on the local place, to include economic, historical, cultural, political, and social dimensions of what and how we learn.

DIVE INTO PLACE-BASED EDUCATION:

Promise of Place: Enriching Lives through Place-based Education: http://www.promiseofplace.org/

Sobel, D. (2004). Place-based education. *Connecting Classrooms & Communities, Great Barrington, MA: The Orion Society*.

Significant Life Experience Literature

Significant life experiences (SLE) are those influential experiences that lead to positive environmental behaviors and attitudes among people in general, and specifically in those that lead to pursuit of an environmentally focused career. Since 1980, researchers have been exploring these influential factors, yielding a substantial body of literature. Over the years, the populations under study and the research methods have differed, but the conclusions reveal similar findings.

Participants (environmental educators, environmentalists, conservationists, young environmental leaders, etc.) consistently indicated that time spent outside; interacting with passionate teachers, mentors, friends and family members; and education were chief among the reasons for their involvement in an environmental field, and for their positive environmental behaviors and attitudes.

This body of work highlights the importance of ensuring that students have opportunities to engage with the natural world, the necessity of informed and motivated educators, and incorporating environmental issues like climate change into a student's educational experience.

DIVE INTO SIGNIFICANT LIFE EXPERIENCE:

Chawla, L. (2006). Research methods to investigate significant life experiences: Review and recommendations. *Environmental Education Research*, 12(3-4), 359-374

Systems Theory and Systems Thinking

Systems theory is a transdisciplinary area of study that identifies and explores the complex interconnected relationships and interactions among various elements in a system as a whole. Examples of social, technological and natural systems can include ecosystems, transport systems, physiological systems, education systems, the weather system, political systems and so on. Systems that are relevant to the specific context of climate change are self-regulating and are made up of objects, attributes, and internal relationships among its objects, all of which exist in an environment.

Some of the common characteristics in an open system include: interdependence, chain of influence, hierarchy, interactions with the environment, inputs/outputs, correlations, the need for balance, goal directed, subsystems, self-regulation, change, adaptability and perceiving causes (Gallopin, 2003).

Systems thinking, based on systems theory, emphasizes the linkages between the many systems that make up our world, and is an analysis tool that examines the interrelationships between and among the individual pieces within the framework of a larger system. The many systems this theory seeks to explore include the ecological, political, economic, social, and cultural, among others.

Systems thinking "unifies these into a holistic whole, revealing their interdependent nature" (Ben-Svi-Assarag & Orion, 2010, p. 1255). Rather than

focusing on discrete elements as separate entities standing apart from the system, it is possible to investigate how the processes between and among these various components affect other components and processes. In turn, impacting the whole system.

Systems thinking can be thought of as a set of habits or practices used to solve problems by examining how a system works in order to develop insights about the behavior of a whole system over time. It uses these insights to "improve decision-maker understanding of how to intervene and improve a systems performance" (Mathews & Jones, 2008, p. 76). For example, as students set out to examine climate change they will need to acquire an understanding of the complex, dynamic and cyclic nature of the four earth systems: the geosphere, hydrosphere, atmosphere, and biosphere through the context of the interrelationships among these systems as well as the social and technological systems that affect the earth over both space and time.

Systems thinking embraces the complexity of an issue such as climate change through the examination of the processes and components (natural, social and technological) as a whole, thus enabling students to see both the big picture as well as the individual actions that affect the earth's climate. Key tools used in systems thinking are feedback loops and computer modeling. Computer modeling facilitates the use of feedback loops which change human behavior through providing people with information about their actions in real time (or something close to it), then they are given the opportunity to change those actions, pushing them toward better behaviors, i.e. Action -> Information -> Reaction.

Everything about systems thinking is interdisciplinary. When examining any type of system all aspects of it must be considered, this includes social, economic, ecological, technological, etc. Thus, using systems thinking as a tool to examine issues such as climate change allows for the consideration of the interaction between the social, economic, ecological, technological, etc. systems that contribute to climate change as well as the potential actions that can be taken to mitigate its consequences. They are all part of the story and therefore must all be included in the efforts to create solutions.

DIVE INTO SYSTEMS THINKING:

Systems Thinking in Life, Systems Thinking in Schools: The Waters Foundation. http://watersfoundation.org/systems-thinking/overview/

Creative Learning Exchange: Systems Dynamics & Systems Thinking in K12 Education http://www.clexchange.org/

Service Learning

Service Learning theory draws directly from Dewey's premise that the interaction of knowledge and skills with experience is key to learning. Defined by the Alliance for Service-Learning in Education Reform (ASLER) service learning is,

> A method by which young people learn and develop through active participation in thoughtfully-organized service experiences that meet actual community needs, that are coordinated in collaboration with the school and the community, that are integrated into each young person's academic curriculum, that provide structured time for a young person to think, talk and write about what he/she did and saw during the actual service activity, that provide young people with opportunities to use newly acquired academic skills and knowledge in real life situations in their own communities, that enhance what is taught in the school by extending student learning beyond the classroom, and that help foster the sense of care for others.

Service-learning has moved beyond the more simple notions of community-service or volunteering. It can provide an opportunity for a deeper learning experience through the direct application of and reflection upon the skills and knowledge the students are learning in their classrooms. These opportunities allow students to make meaningful connections between what they are learning and how they themselves can directly impact the world around them, specifically their own community. The research indicates that linking curriculum to activities has multiple positive effects; however, particular efforts must be made in order for service-learning to achieve its maximum potential of empowering young people to address and solve problems within their community (Billig, 2011).

It is important to note that the many benefits associated with service-learning are dependent upon the opportunities including a number of design features which if not included can lead to little or no positive, long term learning or impacts. Shirley Billig identified six components typical to a successful service-learning design. These include: Investigation, Planning, Action, Reflection, Demonstration, and Celebration. In addition, a complete set of standards and indicators based upon research in the fields of service-learning and education have been created to guide educators and community partners. They include descriptive indicators which address: Meaningful Service, Link to Curriculum, Reflection, Diversity, Youth Voice, Partnerships, Progress Monitoring, and Duration and Intensity.

Educators from diverse disciplines such as science and social studies can implement service-learning to investigate and address climate change issues within their own community. Researching into the local historical roots and causes

of current environmental problems allows students to frame their service-learning experience from both disciplinary perspectives. By understanding the scientific and historical causes and effects they are better equipped to take informed action with a greater potential to make a significant impact on their community as well as their own learning.

DIVE INTO SERVICE LEARNING:

National Service-Learning Standards: http://www.servicelearning.org/library/resource/7509

Strategies for Teaching about Climate Change

- Build on the use of meaningful patterns of information. Use age-appropriate experiences, lessons, and resources to increase experience and knowledge through age-appropriate lessons on how the world works. Examples include using observational skills and data collection, and using cause and effect models in natural science/nature study with novice learners.

- We encourage you to plan lessons that are directly relevant for the learners you work with. Here we give examples appropriate for a school/community located near a marsh, but for a central city school/community, a more relevant focus could be learning about the carbon emissions from idling vehicles and the impact on asthma rates. Students might conduct an idling audit, tallying the number of cars, trucks, and buses that sit outside of their schools each day, comparing with school-wide rates of asthma, and brainstorming solutions to reduce the incidence of asthma. **For example**: Students in grades K-4 may learn about marshes through field trips to a local marsh to experience this ecosystem's physical traits and observe wildlife, plant life, and physical attributes. Grades 5-8 may study individual species found in the marsh, their adaptations, and population dynamics through transect studies and geologic formation. Grades 9-12 may study changes in depth of marsh peat, recent and past changes in coastal formations, as well as changes in population dynamics and species diversity. Inland schools may adopt a coastal school and, through social media "pen pals", can share their differences and experiences and learn about one another's natural resources. Older students can exchange ideas, thoughts, and observations regarding climate change and its effect on their particular environments.

- Transfer lessons learned to everyday life and experiences using recall and

knowledge applications (biological and ecological concepts such as the basic needs for life to population dynamics and how populations influence ecosystems). **For example**: Building on the base knowledge of marshes, students learn and internalize the importance of marshes to the overall health of neighboring ecosystems, the food chain that we are all a part of and the dynamic processes that contribute to our knowledge of how climate change is affecting our resources. With this knowledge, the importance of climate change can become concrete with rational and far-reaching thought and action.

- Emphasize students' life experiences for better transfer of information to the ultimate goal of action. Focus on learners' present life context; an urban student will view the natural world differently than a rural learner. **For example**: An urban high school may visit the docks where the fishing fleets come in to survey the catch of the day over a period of time and graph these results, along with tracing the individual species caught to the marsh through the food chain. Economic implications can be drawn to the effects of climate change on the commercial fisherman as well as the consumer.

- Keep the transfer of knowledge in the learner's present life context (an urban learner/student will view the natural world differently than a rural learner). Keep emphasis on their life experiences for better transfer of information to the ultimate goal of action. **For example**: An urban Boston high school may visit the docks where the fishing fleets come in to survey the catch of the day over a period of time and graph these results along with tracing the individual species caught to the marsh through the food chain. Economic implications can be drawn to the effects of climate change on the commercial fisherman as well as the consumer.

- Be a good role model – live what you teach (walk the walk and talk the talk) – Research shows that much is gained by students through this type of indirect learning. **For example**: Lead a sustainable lifestyle and act as a role-model by recycling, walking, drinking from reusable bottles for water, not wasting paper, turning off lights, etc. Track your classroom's carbon footprint on a daily basis to demonstrate to students that everyone has their part to play.

- Use questions to start a lesson and let the questions, and your students, guide the lesson. **For example**: Why do we care about marshes and why are marshes important to us? More generally, a well-known teacher uses "What questions do you have about yourself and what questions do you have about the world?"

- Use problem solving/solution seeking activities, creative play, and project-based learning to strengthen background knowledge as in interdisciplinary lessons. **For example**: Role play a town meeting with groups representing local commercial fishermen, coastal property owners, the Fish and Wildlife Service's shore nesting bird protection program, and the local chamber of commerce. Present the case that science shows a rising sea level. Have students considered what can and should our coastal towns do?

- Create effective learning environments which are knowledge-centered **and** learner-centered. Of these, community-centered environments can be very effective through collaborative participation and learning. **For example**: Form study/working groups of students with varying learning styles and abilities that meet regularly to help each other or complete projects.

- Use your local community (people, natural spaces, community organizations, topical issues, etc.) as teaching tools. Students relate to what is familiar and relevant, improving their ability to remember, and their likelihood of taking action. **For example**: Have students collect data outside their classroom, and compare to other aggregate data to investigate local fluctuations. Or ask students to identify a local environmental issue to research. Right now, in our own backyards and neighborhoods, this is what is happening….let's become aware!

- Use positive language, and frame problems as challenges to be solved. **For example**: Climate change is not a doomsday scenario, but instead gives us the opportunity to think creatively about how we can make a difference.

- Provide hands-on learning opportunities both inside the classroom/teaching space and outside. **For example:** Seek out activities for students to create models of ecosystems in the classroom, after having completed a field study around the school grounds and neighborhoods.

- Use the local environment as a subject of interdisciplinary learning and re search. **For example:** Use the changes in environmental quality of soil to teach about farming practices through history.

- Allow students the space to make their own decisions and take action in their own way on environmental problems. **For example:** Some students may decide they are able to advocate for more sustainable school practices at a school board meeting, while others may want to implement a recycling program, and others still will decide the best way for them to take action is

to remember to turn off the lights. All are valuable kinds of action, and if self-directed, can serve as powerful lessons of independence and action.

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