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Infusing Climate and Energy Literacy Throughout The Curriculum: Challenges and Opportunities

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Energy and climate are inextricably linked, as local energy choices directly influence global climate change. Due to this powerful relationship, there is an emerging need for a scientifically literate citizenry that understands the significance of its energy choices on climate and the other components of the Earth system in order to minimize impacts and respond appropriately.

Climate and energy literacy is currently lacking in the United States for both adults and children. Though a majority of the American public recognizes that the climate is changing, a 2012 Pew Research Poll found that only 42% of Americans believe that this warming is mostly due to human activity (Pew Research Center, 2012). Students are not any more scientifically literate about climate and energy science than their parents, with fewer than 15% of American teens reporting that they feel very well informed about how the climate system works or the causes of climate change. Auspiciously, however, 70% of those same teens said that they would like to know more (Leiserowitz, Smith, & Marlon, 2011).

What are climate literacy and energy literacy? These forms of scientific literacy include not only the accumulation of information but also the ability to use that information for critical thinking and decision-making (Dupigny-Giroux, 2008). Since decisions about energy use are rarely individual in their scope, the latter necessarily includes the ability to discuss the information collectively, recognizing and discounting personal biases and interests. Thus, beyond proficiency in the sciences, climate and energy literacy require both a sense of agency—a feeling that one's own decisions can affect the world—and a motivation to act upon the information in appropriate circumstances (McNeill & Vaughn, 2012).

Therefore, energy-literate people will understand basic scientific principles relevant to making informed decisions about energy. To do this, they must understand how energy works, where it comes from, and how it is used. They will need to be able to connect those sources and usage to environmental impacts and trade-offs. Moreover, energy-literate people can both assess and communicate that information to others to make thoughtful decisions based in science.

Similarly, climate-literate people will understand basic scientific principles relevant to making informed decisions about climate change. Through their scientific

understanding of deep time, they can distinguish historical climate changes over geologic intervals from recent human-caused climate change that have occurred over shorter periods of time. Moreover, they will understand that humans can take actions to reduce climate change and its impacts.

Since both energy choices and climate change will affect students throughout their lives, it is vital to ensure they have key knowledge about these 21st century challenges through formal science education. Whether students become politicians or simply voters, they will require the scientific background to make thoughtful decisions as adults. An investment in their education now is an investment in their future.

There are many challenges ahead. How can educators assist students in learning the basic science behind climate change science and energy choices? How can they teach students about the trade-offs inherent to energy usage and environmental impacts without accusations of indoctrination? Moreover, where can teachers find scientifically accurate and pedagogically sound information to support a more climate-and-energy-literate society? We will start to address these many and varied questions in this chapter.

Challenges to Teaching Climate and Energy Literacy

There are innumerable obstacles to attaining both climate and energy literacy, ranging from emotional and psychological barriers to the sheer complexity of the science. For these reasons, educators must be cognizant of the many challenges they will face when addressing climate and energy issues in their classroom. Well-prepared teachers will create an illuminating environment for students to engage with the material without becoming burdened by conflicting counterarguments or misinformation.

Unsurprisingly, one of the greatest challenges that teachers face when addressing climate and energy literacy is science denial. Often science denial, particularly when related to climate change, is rooted in fears and deep personal values rather than the science itself (Rosenau, 2012). This dissent is not inherently anti-science, but airing it in the science classroom can confuse students' understanding of how science works by focusing on political, moral, or social debate rather than utilizing scientific evidence to support ideas. For example, unguided discussions of climate change or energy usage can easily turn from expounding the details of the science to extolling the virtues of free market capitalism. Science teachers thus may find themselves in the middle of a debate of liberal versus conservative political values rather than a discussion of how the greenhouse effect works. Moreover, conducting

or allowing such discussions can lead to teachers being accused of indoctrinating students and attempting to promote behavioral change.

Ironically, as a way of avoiding potential conflict, educators will often opt to "teach the controversy," allowing for supposedly scientific debate in the classroom on the basic science of climate change, whether conducted by students themselves, guest speakers, or supplementary teaching materials like videos (which are often provided by organizations promoting climate change denial). However effected, "teaching the controversy" is both scientifically inaccurate and pedagogically inappropriate, since it misrepresents the scientific consensus on climate change. As the voice of the scientific community in the classroom, a science teacher has a responsibility to convey the scientific consensus accurately and without reservation. To do otherwise is fundamentally unfair to students, since it leads them to believe, wrongly, that the basic science of climate change is not credible or is currently under deliberation.

Though the science is clear, there are still many questions that students can deliberate regarding ways and means of mitigation and adaptation to global climate change. Such a debate could be responsibly addressed in a social studies course or in an advanced science class that addresses moral, political, and ethical issues after a thorough explanation of the evidence. Climate change denial itself might be responsibly addressed in such a class, too, just as the Scopes trial and later manifestations of creationism are sometimes addressed in advanced biology or social studies courses. But, of course, such learning activities should not be used to promote science denial as though it were a scientifically valid viewpoint. Teachers should also be aware that questioning the science in and of itself isn't necessarily "denial". Given the challenges inherent in confronting student apathy, inquiry into the process of science is to be encouraged if it comes from genuine interest and not an ideological agenda.

In addition to understanding the range of science denial and be prepared to address it, educators should be concerned with the emotional aspects of discussing the potential implications of climate change, since the implications are undeniably severe. Hicks and Bord (2001) found that teachers attempting to address these issues with their classes unintentionally alarmed, dismayed, and demoralized their students. Who, after all, wants to hear that climate change is going to disrupt the human environment and affect the biosphere as a whole, or to learn that these changes are largely due to human activity? At the same time, though, Hicks and Bord argued that it would be a betrayal not to "awaken" students to current challenges posed by climate change. This is a conundrum: how can educators discuss the seriousness of the effects of climate change while not creating undue alarm or disillusionment?

One way for teachers to address potential student angst is to focus on human ingenuity, emphasizing ways in which historical environmental challenges were overcome, and discussing ways to mitigate impending changes ahead. This technique could give students a greater sense of agency when addressing a scientific challenge. The value of agency in providing the foundations for climate and energy education was further described by Ojala (2012), who found that the use of hope encouraged more pro-environmental behaviors. Ojala defined hope in terms of creating goals, knowing a pathway towards achievement, and possessing motivation to move forward. The idea is that teachers can utilize students' hopes to promote positive thinking about solutions to climate change challenges. The objective for teachers would be to utilize this hope without giving prescribed answers to climate and energy challenges ahead.

Even those teachers who are willing to teach the scientific consensus on climate change and able to manage the psychological components often feel unready to teach such a complex topic (Johnson *et al.,* 2008). Since climate and energy literacy have long been neglected in science education, many teachers lack the appropriate scientific background themselves. Moreover, persistent misconceptions within the teaching community are an additional hurdle. A study by Lambert, Lindgren, and Bleicher (2012) found that both pre-service and in-service teachers suffered from misconceptions about climate change that persisted even after they were taught about the subject. For example, although the teachers were able to learn about the carbon cycle and causes of global warming, they continued to struggle with how the greenhouse effect worked.

The fact that such misconceptions are both prevalent and tenacious even among science teachers suggests that they may be equally so among their students. And indeed, many of the misconceptions that teachers hold are shared by middle and high school students (Choi, Niyogi, Shepardson, & Charusombat, 2010). In addition to the confusion regarding the greenhouse effect that teachers also have, students struggle to grasp the idea of the carbon cycle and understanding the human dimensions of climate change. Moreover they often make such fundamental mistakes as conflating the ozone hole or pollution such as nuclear waste with climate change (Cordero, Todd, & Abellera, 2008; Madsen, Gerhman, & Ford, 2007; for a detailed overview of common misconceptions about climate, see McCaffrey & Buhr, 2008). Moreover, students' grasp of the concept of deep time was connected to their ability to differentiate between weather and climate, a key component to understanding global climate change (Lombardi & Sinatra 2012).

Teachers therefore would benefit from adopting pedagogical techniques that help to identify and correct such misconceptions. In many cases, teachers have the ability

to counter these misconceptions by specifically exposing and refuting them directly in the curriculum (Gaultier, Deutsch, & Rebich, 2006). For example, when McNeill and Vaughn (2012) addressed the common fallacy of confusing holes in the ozone layer with climate change in their classroom, their high school students did not report this belief in their post-course testing.

Although students' understanding of the earth system can be both narrow and simplistic (Shepardson, Niyogi, Choi, & Charusombat, 2009), several studies have demonstrated that they may have a better understanding than their written responses suggest (McNeill & Vaughn 2012; Jakobsson, Mäkitalo, & Säljö 2009). McNeill and Vaughn (2012) found that students who did not demonstrate a basic level of understanding of climate change in writing were nevertheless able to express a deeper comprehension orally over several survey questions. This further highlights the complex nature of climate change science, suggesting that it is a topic that requires more than a few lessons. Rather, it should be integrated into a larger lesson plan.

Although climate is inherently a global issue, teachers are more likely to discuss climate change and energy choices if they have curriculum that addresses these issues from a local perspective (Johnson et al., 2008). Regional forecasts, for instance, can be helpful in showing students how climate change may affect their local communities in future decades. A useful source of regional information about the anticipated impacts of climate change is the US Global Change website's homepage http://globalchange.gov/ (under the "Regional Climate Information" tab).

Pathways to greater climate and energy literacy

Climate and Energy Literacy Network

Since climate change and energy literacy are rarely integrated into current state science standards, students are reliant on pioneering teachers to bring this information to them. Although many educators may feel highly motivated to engage their students in climate and energy literacy, they require scientifically accurate and pedagogically usable content that fits into already established standards.

The Climate Literacy and Energy Awareness Network (CLEAN) was designed for teachers interested in addressing climate and energy literacy in their classroom. CLEAN is a project funded by the National Science Foundation that was developed by members of the Climate Literacy Network, a community of educators, policymakers, community leaders, students, citizens, and scientists interested in fostering greater climate and energy literacy. The CLEAN website (http://cleanet.org) includes a catalog of reviewed and annotated online materials

that have been vetted for educators to use in their classroom along with tips for teachers on how best to teach specific concepts at appropriate grade levels.

CLEAN is a tool to help integrate climate and energy topics into already established courses, such as earth sciences or biology. As science standards move towards prescribing integrated courses that involve multiple scientific disciplines, there will be additional changes to bring climate and energy concepts into the classroom. One such opportunity is through the Next Generation Science Standards.

Opportunities ahead: the Next Generation Science Standards

The Next Generation Science Standards (NGSS) are an opportunity to integrate climate and energy literacy into public school education across the nation. NGSS are a new set of K–12 science standards intended to provide guidance to teachers as they educate their students to become scientifically literate members of society. The standards are being developed through a state-led collaboration, and sponsored by the National Research Council, the National Science Teachers Association, the American Association for the Advancement of Science, and Achieve Inc. There are 26 lead states that have been involved in the process and it is anticipated that the standards will be adopted by other states across the country as a pioneering effort to bring science standards into the 21st century.

Climate change, energy, human impacts on earth systems, and sustainability are all topics outlined in the NGSS. Although found throughout the standards, climate change is addressed primarily in both the life and earth sciences, beginning with the basics of seasons and how weather and climate differ in primary grades, with a more specific focus on human impacts on climate and the Earth system in later grades. In the life sciences, it is integrated into discussions of evolution and adaptation, since climatic impacts will have powerful implications for biological systems. This represents current ecological research well and offers a thoughtful way to discuss environmental resources and biodiversity. In the earth sciences, climate change is addressed through discussing utilizing modeling systems for evidence and predictive measures, as well as the potential for engineering solutions.

By emphasizing the science of climate and energy while addressing the context within the community and technical innovations as potential responses, the NGSS provide opportunities for students to connect the science to their community. Moreover, these standards emphasize the value of technology in people's lives, how this technology supports our lifestyle, and also how it can contribute to human impacts on the environment. This brings into the science classroom the challenges of both maintaining current lifestyles in the United States and dealing with the impacts this lifestyle can bring. A scientifically literate populace that understands

the causes and impacts of climate change will be able to consider their energy usage and choices within a scientific context and make informed decisions based on accurate science.

Though the Next Generation Science Standards highlight human ingenuity in addressing climate impacts, they do not address specifically how students *should* respond to climate change or emphasize behavioral change. Ideally, science learned in science classes can be synergistic with and complement issues learned in social studies courses to encourage students to use the science to inform policy decisions, as they would as adult decision-makers. This would give them the tools needed to engage in decision making in the future, identify quality science, weighing their options of energy and resource usage, and making thoughtful choices for the future. The Next Generation Science Standards are an important first step for students to learn about the background information to help them make thoughtful decisions for the future.

A common language: climate and energy literacy frameworks

In order to talk about climate and energy literacy, a common language must be adopted. What are the common themes of these forms of scientific literacy that should be integrated throughout all lessons?

Climate Literacy: The Essential Principles of Climate Science was developed through the input of multiple scientific governmental and non-profit organizations, including the National Oceanic and Atmospheric Administration and the American Association for the Advancement of Science and is endorsed by the United States Global Research Program.

Although scientific understanding is an integral part of literacy, because of the strong social and political implications, climate literacy requires an integrated approach. This approach utilizes the science to inform the social and political implications. As a result, the principles of climate literacy are broken into seven topics that build upon each other, starting from the science and ending with the social and political consequences.

The principles are as follows:

1. The sun is the primary source of energy and the Earth's climate system.
2. Climate is regulated by complex interactions among components of the earth system.
3. Life on Earth depends on, is shaped by, and affects climate.

4. Climate varies over space and time through both natural and man-made processes.
5. Our understanding of the climate system is improved through observations, theoretical studies and modeling.
6. Human activities are impacting the climate system.
7. Climate change will have consequences for the earth system and human lives.

(Source: U.S. Global Change Research Program, 2009)

The Guiding Principle for informed climate decisions, which provides a societal context for the other principles, emphasizes that humans can take actions to reduce climate change and its impacts and articulates the range of responses without advocating for a particular solution.

The Principles of Energy Literacy were developed by the U.S. Department of Energy, working with other federal agencies involved with the United States Global Research Program and numerous education partners across the country.

As with the Principles of Climate Literacy, the goal of the Principles of Energy is not to enforce a specific behavioral change or political choice, but to have choices be rooted in core science to help students make thoughtful choices as adult decision-makers. It is important to give them the tools to understand the science when evaluating the information.

Like Climate Literacy, the Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education begin with the basic science and build to the social and political consequences of energy choices. Framed by a Guiding Principle for Teaching and Learning, energy literacy principles include:

1. Energy is a physical quality that follows precise natural laws.
2. Physical processes on the Earth are the result of energy flow through the Earth system.
3. Biological processes depend on energy flow through the Earth system.
4. Various sources of energy can be used to power human activities, and often this energy must be transferred from source to destination.
5. Energy decisions are influenced by economic, political, environmental and social factors.

6. The amount of energy used by human society depends on many factors.
7. The quality of life of individuals and societies is affected by energy choices.

(Source: Department of Energy, 2012)

Ultimately, the goal of both climate and energy literacy is to engage learners in the science to make thoughtful decisions about how to address and reduce the impacts of their choices. This can include energy efficiency, climate mitigation, or societal adaptation. The decision-making must be based on the science, which should be generated and assessed by the scientific community, though, not on the representations (or misrepresentations) of special interests or political groups.

Conclusions

There are many challenges to bringing climate and energy literacy into the classroom. These include political and social pressure to not teach the science or teach "the controversy", the lack of coverage of these vital topics in standards or curricula as well as emotional challenges that students' may face when addressing a potentially distressing topic. Moreover, many teachers feel overwhelmed or ill-prepared to teach the complex sciences involved with both climate and energy, as the topics are highly inter-disciplinary. As a result of these many challenges, some teachers may choose to avoid engaging their students in climate and energy topics. This is inherently unfair to students, as it puts them at a disadvantage relative to their peers within the US where these issues are being more accurately addressed. Moreover, misinforming students about the science will stunt their ability to address challenges and choices as adults and future decision-makers.

The building blocks for greater literacy across the country already exist. The Next Generation Science Standards are an opportunity to address climate and energy literacy in public schools across the country. The Climate Literacy and Energy Awareness Network is a searchable database available for teachers to implement climate and energy literacy in their classrooms now under current state standards and in the future with NGSS. Meanwhile the Essential Principles of both Climate Literacy and Energy Literacy outline the fundamental ideas and language for talking about climate and energy literacy topics. Combined, the standards, lesson plans, information networks and fundamental principles create a foundation for teachers to encourage greater climate and energy literacy, and that in turn will better prepare young people for the climate and energy challenges of the 21st Century.

As tomorrow's policy-makers, students must be able to make scientifically informed, thoughtful decisions as to how they want to spend their resources and the associated costs with each choice. The scientific and educational community can support these efforts by working together to promote pedagogically sound and scientifically accurate material to the decision-makers of tomorrow.

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