Energy Challenges and the Role of Education

Pam Wagner
University of Illinois at Chicago, Chicago, IL

Introduction

In the United States, public knowledge of energy and energy use is not exceptional. Twenty seven percent of adults in the United States report that the majority of our energy comes from fossil fuel sources. According to the United States Energy Information Administration, petroleum, coal, and natural gas account for 35%, 18%, 28% of energy consumption, respectively. Four out of ten Americans believe that hydroelectric power is the top energy source in the United States while in reality 2.6% comes from hydroelectric power sources. Ten percent comes from all renewables. The majority of Americans will agree global warming is happening and an increasing number of Americans have agreed with that statement in recent years. However, only about half of Americans believe global warming is related to human behavior while human behavior is accepted as a global warming factor in scientific research.

Knowledge that we need to do something does not always correlate positively with human actions. According to a PEW research poll, 75% report concern for the environment. From this same survey (The Politics of Climate, PEW Research Center), 20% say they make an effort to act on this concern all the time. Of this 20% who make an effort to act, 57% see climate change issues as a great deal. 46% of United States adults contribute climate change to human activity. Knowledge of energy does not seem to positively affect consumption behavior, as high school students show a decrease in energy-conserving behaviors when compared to their middle school counterparts. It is quite possible there are other factors involved. For example, as a person grows they may be using more electrical energy because of behavioral changes. However, part of this paper is to look at ways in which education could affect behavior choices.

Policy and technology have had several effects on energy consumption. Looking at residential use on a broad scale, one can see energy consumption has remained stagnant. This could be a result many factors. For example, we may be using more technology that requires energy but increasing the efficiency of some technologies. Although energy efficiency technology has been developed over the past 15 years and decreased energy consumption used for space heating, other areas have increased.

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Energy sustainability and climate sustainability are issues we must face in the near future. This paper will define energy literacy, discuss the recent developments in K-12 science standards (Next Generation Science Standards), and summarize energy related curriculum research in order to find connections and deficiencies amongst the three.

Attributes of Energy Literacy

Energy literacy refers to not only content knowledge involving energy concepts in the K-12 curriculum, but also what are referred to as affective and behavioral changes. However, part of this paper is to look at ways in which education could affect behavior choices.

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attributes. Figure 3 shows an example of how each attribute may be measured in several benchmarks.

According to DeWaters and Powers (2011), an energy literate person would meet the following criteria:

- Understand conceptual knowledge related to energy
- Understand how energy is used in everyday life
- Understand the relationship between energy production, consumption, environment, and society
- Recognize the impact on the environment of individual decisions and actions that are energy related
- Makes choices (or strives to make choices) that reflect energy conservation and energy resource development

Deficiencies in energy literacy have been found in many studies. New York high school students have shown limited ability to connect energy consumption to heating and cooling appliances in their households; this is true even when they understand basic energy concepts via the cognitive attribute. Other areas are recognized as problem areas in energy literacy. For example, many people cannot estimate energy use saved or required for certain behaviors (Figure 4).

The attributes involved in energy literacy do not always show a positive correlation. While high school students have developed more cognitive energy knowledge than middle schools in their same state, they show a very small increase in energy attitudes. In fact, their energy related behavior attributes have been shown to decrease, even when cognitive aspects may have increased from middle school to high school. This suggests that energy curriculum needs both an affective and behavior component in order to be effective.

Science Standards

In many state science standards, energy literacy is not prevalent or is unclear. For example, the Illinois state science standards included a brief description of what energy is:

- Understand that energy, defined somewhat circularly, is the ability to change matter, or the ability to do work. Understand that energy is defined by the way it is measured or quantified. Understand the difference between potential and kinetic energy.

This definition does not get at the affective or behavioral components of energy literacy. Figure 5 shows how energy is emphasized at different stages of K–12 curriculum.

While there are several instances where content is described (identify sources, explain interactions of energy), there is no connection back to affective or behavioral attributes when it comes to energy literacy. The attribute is included only once at one level in the curriculum (middle/junior high school level). Energy consumption appears as an example in standards 13.B.3f, which states: Apply classroom-developed criteria to determine the effects of policies on local science and technology issues. This lacks specifics and does not engage students in behavior or affective components as described above. The places where energy literacy appears (or is lacking) are quite unclear in the Illinois science teaching standards and could be misinterpreted or ignored. This is not only true for Illinois. Many states are rated very low when it
comes to clarity of standards. Lack of clarity has been shown to affect students conceptual understandings and attitude toward energy conservation in six different major curriculum based textbooks.

In 2012, the National Academy of Sciences pushed for an increase in energy literacy in K-12 education. The framework included an emphasis on some foundational energy literacy issues. Included were the ideas that students should understand generating enough energy and addressing climate change as major societal issues. Energy appears as a central idea, called a cross cutting concept in this new framework. Energy is an important aspect of many science concepts and is emphasized across content and grade level. Energy is also related back to human behavior around energy consumption in the disciplinary core ideas within the K-12 curriculum. Students are also asked to design and evaluate solutions around energy use scenarios with an energy sustainability and human impact perspective. In recent Next Generation Science Standards, energy concepts appear with much more clarity than in previous Illinois standards and have the potential to relate back to areas of energy literacy more than previous standards. This is a step in the right direction, but requires a deeper look.

In the new science standards adopted by Illinois (Next Generation Science Standards) energy concepts appear much more frequently than in the old Illinois standards. However, when looking at benchmarks and energy literacy, one finds more cognitive benchmarks than the other two domains. Evidence statements, which are created to be measurable like the benchmarks of energy literacy, tend to be more related to the cognitive domain of energy literacy than the affective and behavioral benchmarks. Figure 6 gives and example from a fourth grade energy standard.

Energy Consumption and the Role of Education

There are many factors that affect how we use energy in the residential sector. A study by Haas has also been shown that residential energy consumption can vary significantly depending on things such as structures, attitude, behavior, and technical efficiency. While these factors influence energy consumption, their specific role should be studied. Many of these factors related to policy and technological innovation, which are important factors in todays energy challenges. For example, improving electric car batteries and residential appliances is one way to improve technical efficiency and thus affect energy use. These relationships can be studied to look for ways to change behavior around energy.

However, little information existed around what affects behaviors and attitudes in the Haas study. Behavior is linked to prices of energy and technology. Attitude does not have a causal factor. Dias et al look for connections between attitude and behavior through several different initiatives in Brazil. According to their findings, education is not only the top three factors in energy consumption reductions but is also the least expensive when you look at it compared to amount of energy saved. With these findings, Dias et al add an educational component to Haass energy consumption web (Figure 7).

![FIG. 6: 4th grade Next Generation Science Standard 4-PS3-4 and related evidence statements. Evidence statements are cognitive rather than behavioral and affective.](image)

![FIG. 7: Haass original web is on the left. R. A. Dias et al added education into the web after their research showed education played a role.](image)
Curriculum

Attitude and behavior of the public can be affected through education. This section will look at several successful curricula presented in recent studies. One commonality in these curricula examples is the incorporation of all three domains of energy literacy: cognitive, affective and behavioral.

1. 5th and 6th grade environmental inquiry

Curriculum included problem solving and critical thinking using data from the community on environmental issues. Students showed an increased ability to practice environmental positive behaviors as well as an increased cognitive knowledge of skills.21

2. 3rd Grade electrical energy unit

Students learned basic electrical energy concepts in the classroom as well as defined energy. The participating students then choose a related project to complete in their school in terms of energy consumption. Students were actively part of the project in the design, implementation, and teaching of other students in the school. Students increased their content knowledge electricity use. The school also decreased their energy consumption (electricity) by 30%. Student homes decreased their energy consumption by 15%.22

Both curricula reviewed above included cognitive, attitude, and behavioral components. This supports earlier discussion on how increase in energy knowledge does not always correlate with behavioral and attitude components.9 Attitude and behavior have a correlation while cognitive benchmarks do not.9 When incorporating energy literacy into curriculum, it is important to factor in attitude and behavior benchmarks as well.

Conclusion

Without a basic understanding of energy, energy sources, generation, use, and conservation strategies, individuals and communities cannot make informed decisions on topics ranging from smart energy use at home and consumer choices to national and international energy policy. Current national and global issues such as the fossil fuel supply and climate change highlight the need for energy education.23

The U.S. department of energy states the above to prioritize the need for energy literacy. Public knowledge, behavior, and attitudes to not always reflect the issues, goals, and challenges related to energy and society. Educational standards do not always make a clear connection to all aspects of energy literacy. This disconnect can lead to unequal educational practices. When these ideas are aligned to curriculum, positive affects can be seen in student behavior and attitudes. While the Next Generation Science Standards open up the need for learning about energy, they still lack components of energy literacy. The standards provide the space for learning but do not explicitly state energy literacy benchmarks in the evidence statements.

As curriculum is developed around these new standards, energy literacy needs to be an emphasized factor in development of activities, inquiry, and assessments. Energy literacy, done correctly, can lead to larger affects in individuals lives and communities. It is not something that comes without thoughtful implementation of energy literacy standards.

1 K. Coyle, National Environmental Education & Training Foundation (2005).