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The impact of curriculum-based learning on environmental literacy and energy consumption with implications for policy

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ABSTRACT

Policy related to energy efficiency programs implemented by utility companies should be informed by an understanding of building occupant behavior change. This case study utilized a longitudinal design and mixed methodology to assess the effect of curriculum-based experiential learning on elementary school students' environmental literacy and energy-saving behaviors. We found that the students significantly improved their environmental literacy. Normalizing kWh consumption for weather, we observed a decrease in energy consumption of more than 15% in student homes and more than 30% at the focal school.

1. Introduction

There are serious utility policy implications for how taxpayer and ratepayer dollars are allocated to support energy-efficiency and clean-energy projects. Programs have focused on providing funds to offset the expense of cost-effective upgrades (Foster et al., 2012). With improved tracking mechanisms, more funding is being directed toward behavioral programs within utility efficiency portfolios (Gilleo et al., 2014). The potential exists to increase energy savings by engaging building occupants around efficiency upgrades. The current study focuses primarily on the potential effectiveness of environmental literacy-driven behavior change initiatives in schools, how these initiatives can result in decreased energy consumption at school and in student homes, and the need for policy-makers to consider the energy savings and student learning implications of such initiatives when allocating taxpayer and ratepayer dollars toward these programs. Studies that investigate energy use related to environmental literacy and behavioral change efforts are critically important as public K-12 schools and community residents face financial challenges related to rising energy prices and, in some areas of the U.S., variable supply.

Public schools face a growing need to become more energy efficient due to budgetary constraints and projected energy-cost increases. According to the National Center for Educational Statistics (NCES), budgetary constraints in elementary schools were a contributing factor to an increase in closures from 487 in 1995 to 1073 in 2011 (United States Department of Education, 2013b). The NCES also reports that facility-related operating costs are second only to instruction-related costs in public schools (with instructional costs over six-times larger than operational costs). As of the 2013–2014 school year, at least 35 states received less funding per student than prior to the 2008 recession (Leachman and Mai, 2014). Due in part to inefficiencies associated with aging infrastructures, it is estimated that schools have the potential to reduce energy consumption by 20%–30% and save approximately $2 billion through available energy efficiency measures and efficient behaviors (Schelly et al., 2012; United States Environmental Protection Agency (EPA), 2011).

Investor-owned and other energy utilities, as well as federal, state, and local governmental entities, provide incentives to help businesses, schools, and residents obtain energy savings (Craig and Allen, 2014). For instance, the California Clean Energy Jobs Act (Proposition 39) appropriated more than $400 million to help local

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schools and community colleges implement energy efficiency and clean-energy projects (California Energy Commission, 2013). Based on an analysis of annual utility documents filed with the focal state, the funding allocation to schools is nominal compared to allocations for businesses and residents. Furthermore, school projects can be complicated by the need for school board approval for large capital outlays.

Some state governments have enacted policies related to behavioral change programs; however, funding in this area is minimal compared to the more than $7 billion yearly offered by investor-owned utilities to upgrade facilities (Gilleo et al., 2014). Energy utilities have programs that provide incentives for investing in energy efficiency technologies. Funded efficiency efforts are policy driven and implemented by regulated utility companies (Craig and Allen, 2014). Most programs, however, tend to overlook the potential of behavioral change initiatives that focus on how building occupants (i.e., students and teachers) can positively impact energy savings. For example, as of 2011, only 10% of utility bills included messages designed to promote energy savings (Foster and Alschuler, 2011; Mazur-Stommen and Farley, 2013). This study recommends consideration of holistic behavioral-based programs, such as experiential learning and curriculum deployment, as a means of improving the effectiveness of energy-efficiency programs in schools and student homes.

Research has demonstrated that students can influence adults and help schools drive energy savings (e.g., Cross et al., 2010), with efficiencies achieved often greater than those associated with utility-directed efficiency programs. Students can be social change agents, and can normatively influence or “nudge” adults and their peers to participate in socially conscious activities such as energy conservation (Cialdini, 2003; Thaler and Sunstein, 2008). Although there are notable exceptions (e.g., Alliance to Save Energy's Green Schools program, a national environmental initiative among 5000 K-12 schools) (Bulman and Ehrendreich, 2010), many school programs do little to promote environmental literacy and behavioral changes in students. For example, a review of first-round Proposition 39 Request for Proposals (RFPs) from California schools found that opportunities for learning and behavior change of school occupants (i.e., students, teachers, and administrators) were largely overlooked in favor of equipment and facilities. In general, efficiency programs do little to target occupant awareness, learning, or pro-environmental behaviors (Craig and Allen, 2014; Foster et al., 2012).

In a longitudinal study, Alcott and Rogers (2014) demonstrated that the cost-effectiveness of some behavioral programs has been understated because of overly conservative assumptions about energy savings. Darby (2006) found that direct feedback, such as that provided by smart meters, produced savings of between 5% and 15% absent any other documented upgrades. A meta-analysis of energy conservation studies between 1975 and 2012 indicated that implementing energy efficiency measures without behavioral-change (feedback) mechanisms actually led to an increase in energy consumption over time because consumers become less concerned about the need to conserve (Delmas et al., 2013). “Programs can achieve greater impact and deeper savings by incorporating insights from social and behavioral sciences” (Mazur-Stommen and Farley, 2013, p. v). To achieve the goals of utility efficiency programs, the inclusion of learning and pro-environmental behavioral change for energy consumers is important.

Improving environmental literacy in schools not only has an impact on student learning and school energy consumption, but it can also have a positive impact on student homes and surrounding communities in terms of spreading awareness and encouraging behavioral changes. Young people generally are open to environmental topics and often hold pro-environmental beliefs more strongly than do their parents (Allen et al., 2013; Coffey and Joseph, 2013; Craig and Allen, 2014). Similar to seat-belt, anti-smoking, and anti-bullying campaigns deployed in schools (e.g., Ad Council, 2013; National Highway Traffic Safety Administration, 2008; Stuart-Cassell et al., 2011), students are capable of disseminating environmental knowledge and discussing related topics at home. With knowledge, experience, and tools, students may be able to influence energy usage by their parents and other household members. Recognizing this potential, some educational programs have focused on reaching student homes through the school (e.g., National Energy Foundation's Think!Energy Program and the Resource Action Program's Living Wise) as well as on saving energy in the school (e.g., ASE's Green Schools program).

The purpose of this case study is to longitudinally track the effects of behavioral change intervention in one K-3 elementary school in terms of increased student knowledge and reduced energy consumption at school and in student homes. The focal school participated in a statewide “green” competition among K-12 schools in a rural south-central US state. Participating schools chose their own projects. The focal school elected to focus on energy efficiency, although the statewide competition was not energy or efficiency specific. Environmental competitions among schools can be effective at encouraging conservation behaviors, including energy conservation (Bulman and Ehrendreich, 2010). Competitions that promote community-level energy conservation can also help households' lower energy bills and reduce carbon emissions (Melillo et al., 2014).

Understanding the linkages among energy use, emissions, and climate variability is challenging for schools, parents, and students. Interventions associated with learning about energy consumption using systems-level thinking (Forrester, 2009) have the potential to show students how efficiencies can be used to make positive change. A systems-level approach includes identifying a concept or problem, engaging in an action relative to the concept or problem, and observing the result in order to guide future decisions, all set within a temporal context of feedback networks (Forrester, 2009). In this case study, students engaged in system-levels thinking at school through the implementation of curriculum-based learning that: (1) introduced what energy is, how it is produced, and how it is measured (i.e., the concept), (2) provided knowledge and skills as to the actions students could take to be more efficient by reducing energy consumed (i.e., action), and (3) reported energy savings and directly linked these savings to reducing CO_2 emissions (i.e., results).

The outcomes of interest in this case study were (1) increased student knowledge in terms of environmental literacy as related to energy, and (2) decreased energy use in students' homes and in their school. The goal of the intervention was to create a learning environment that followed STEM (science, technology, engineering, and math) guidelines to help students gain knowledge and skills related to energy consumption, and apply the newly acquired knowledge and skills to measurably reduce energy usage. The study used a longitudinal design to examine student energy knowledge, energy usage at student homes, and school energy usage.

1.1. Knowledge acquisition and environmental literacy

Student knowledge about energy, energy alternatives, carbon emissions, and energy use has the potential to influence future generations in terms of resource and climate issues. Students gain knowledge from a variety of interpersonal sources including peers,