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Devising a framework for energy education in Taiwan using the analytic hierarchy process

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HIGHLIGHTS

- We propose a comprehensive framework for energy education that captures the concepts of "energy saving & carbon reduction".
- We determine the conceptual indicators and their priority and weights.
- Civic responsibility for a sustainable society is the most important dimension as an education goal in the framework.
- Awareness and self-efficacy is the most important indicator as a curriculum objective.

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ABSTRACT

Research has indicated that incorporating carbon reduction in the curriculum could improve awareness about energy conservation and related practices. Much research has been conducted on curriculum design and evaluation methods for energy education. However, a comprehensive view of the educational objectives for improving energy literacy is still lacking in these efforts. In this study, we propose a framework for energy education that clearly captures the concept of energy saving and carbon reduction by reviewing related literature and consulting an ad hoc panel of experts on energy and education. We then apply the analytic hierarchy process (AHP) to determine the indicators of the framework and their priority or weights. The results show that the dimensions of "civic responsibility for a sustainable society" and "low-carbon lifestyle" are considered most important as an energy educational goal. Among the indicators, "awareness and self-efficacy" and "identifying carbon-less technology and action plans" are ranked first and second. Application of this framework in K-12 curriculum and relevant educational issues are recommended.

1. Introduction

Climate change has been a pressing issue in recent decades (Mohanty and Mohanty, 2009; Whitmarsh, Seyfang, and O'Neill, 2011), and its causes and implications have been confirmed through empirical evidence (Intergovernmental Panel on Climate Change (IPCC), 2007). Even though the trend of global warming has been debated, the scientific community has generally accepted that the climate change phenomenon in recent years is mostly an anthropogenic one (Doran and Zimmerman, 2009). The use of fossil fuels as an energy source is the primary cause of greenhouse gas emissions induced by human activity. Because energy consumption has implications for various aspects of human development (Dias et al., 2004; Kandpal and Garg, 1999), education about the energy crises has become an important part of the agenda in all developed and developing countries (Keser, Özmen, and Akdeniz, 2003).

The Taiwanese government has been continually revising its energy policy in favor of sustainable energy use (Huang and Wu, 2009; Tsai, 2005). The Energy Commission was established by the Ministry of Economic Affairs (MOEA) in November 1979 to formulate and implement a national energy policy (MOEA, 2012). To induce Taiwanese citizens to conserve energy and reduce carbon emissions, the Environmental Protection Administration (EPA) implemented the Eco Life policy and started a website to encourage environmental protection practices in everyday life (Chen and Hou, 2009).

To reinforce effective energy use and encourage research and technology on renewable energy use toward a low-carbon society, an action plan in accordance with Sustainable Energy Policy Framework (Yeh and Chuang, 2009), titled "Energy Saving and Carbon Reduction," was approved and promoted by the Executive Yuan (Cabinet) in 2007 (Chen and Hou, 2009). The goal

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of this plan is to promote energy efficiency and conservation, and reduce carbon emissions. However, the slogan of "Energy Saving and Carbon Reduction" refers to a complex concept encompassing not only content knowledge but also attitudes, values, and behaviors. The action plan aims to (1) augment the energy-related knowledge and increase awareness regarding the impact of energy production and consumption on the environment, and (2) transform the energy-related comprehension into low-carbon and energy saving attitudes for citizens. Attitudes can express values (Maio and Olson, 1995) leading to the adoption of a new lifestyle which entails environmental responsibility, green production, and low-carbon living (Chen, 2011). Values are behavioral guides (Verplanken and Holland, 2002) which motivate action and affect behavior, which can assist in achieving a sustainable society (DeWaters and Powers, 2011). Therefore, clarifying the concepts behind the term "Energy Saving and Carbon Reduction" can significantly assist individuals, institutes, and governments in facilitating a shift toward a low-carbon society.

An energy policy inclusive of necessary evaluations is an effective manner for understanding plasticity (Dietz et al., 2009). Research has indicated that incorporating the concepts of carbon reduction into curriculum and teaching activities can improve student awareness of energy conservation and related practices (Directorate-General for Energy and Transport, 2006). Energy education has been promoted in many countries since 1979 (Hsu et al., 2010). For example, in the USA, the National Energy Education Development (NEED) project incorporated energy education into the curriculum in 1980, and the Center for Sustainable Energy (CSE) in the UK developed a series of energy education programs. Similarly, Energy Education Australia Inc. was founded in 2006. Meanwhile, in Japan, 179 schools were chosen to participate in an energy education initiative in 2005. Thus, many curricula were devised and institutes founded to promote energy education in K-12 schools.

In line with the international trend, the Ministry of Education (MOE) in Taiwan has funded 17 centers since 2007 and established an energy education program targeted at elementary and junior high school students (Tsai, 2005). Additionally, the National Science Council (NSC) implemented a national-level project to train personnel for the "National Science and Technology Program." As part of this project, much research has been conducted on curriculum design and evaluation methods for energy education. However, a comprehensive view of the educational objectives for improving energy literacy is still lacking in these efforts.

In this study, we will propose a framework for energy education that clearly captures the concept of energy saving and carbon reduction. This concept combines the notions of energy, carbon, and environment. The framework begins with a review of the theoretical context pertaining to environmental literacy (North American Association for Environmental Education (NAAEE), 2011), energy literacy (DeWaters and Powers, 2011), and carbon capability (Whitmarsh et al., 2011). We expand on the aforementioned concept by consulting an ad hoc panel of experts on energy and education. We then apply the analytic hierarchy process (AHP) to determine the indicators of the framework and their priority or weights. AHP is generally applied to analyze and organize complex problems, using different pairwise comparison scales to measure the relative importance of factors at different levels (Sipahi and Timor, 2010; Vaidya and Kumar, 2006; Wang et al., 2010) for identifying the priority of various dimensions and indicators (Kamal, 2001; Lipovetsky and Michael, 2002; Mohammed, 2002; Sipahi and Timor, 2010). The elements of this framework may be important in developing a suitable curriculum for promoting energy education.

2. Related literature

2.1. Energy education

Education could play a pivotal role in teaching energy thrift and instilling energy conservation behavior and attitudes in society (Zografakis et al., 2008). It is important to establish more efficient mechanisms of communication to improve people's attitudes so that they know how to use energy rationally and efficiently (Dias et al., 2004).

Educational activities and projects dealing with energy issues have been implemented in the context of other European programs through the multiple pathways of school education, adult education and informal education; moreover, related information and communication technologies have been developed for such educational programs (Zografakis et al., 2008). These countries have recognized the importance of formal and informal energy and environmental education and worked toward increasing their citizens' awareness of environmental problems (Keser et al., 2003).

As mentioned above, the objectives of energy education are to develop students' awareness of energy crises; make students understand the energy-environment nexus, thus enabling them to evolve holistic solutions; and ensure environmental sustainability (Kandpal and Garg, 1999). However, to be effective and accepted by target learners, energy education programs must be tailored to local, regional, and international priorities and requirements. Therefore, as suggested by Dias et al., 2004, it is necessary to establish clear educational criteria about these programs, and then to suggest modifications for them.

2.2. Environmental literacy and energy literacy

In the 1990s, much research was conducted in the field of environmental education to develop a framework for defining components of environmental literacy (e.g., Hungerford and Volk (1990); Roth, 1992; Simmons, 1995; Wilke, 1995). In the 21st century, these frameworks guided several national assessments of environmental literacy (e.g., McBeth et al., 2008; Negev et al., 2008; Shin et al., 2005).

Environmental literacy enables individuals with appropriate knowledge, attitudes, motivations, commitments, and skills to work individually or collectively to solve current environmental problems and prevent new ones from developing (Orr, 1992; Roth, 1992). Environmental literacy is a basic educational goal that empowers individuals with the motivation and fundamental knowledge, and skills to cope with environmental needs and encourages them to contribute to sustainable development (Marcinkowski (1990)). Roth (1992) provided a theoretical framework of environmental literacy with cognitive, affective, and behavioral dimensions. His definition of environmental literacy slightly modifies these dimensions to create four strands that he recommends should be addressed in education for environmental literacy: knowledge, skill, affect, and behavior. Therefore, environmental education not only focuses on providing environmental knowledge but also strives to instill values, cultivate attitudes, and encourage actions that are appropriate (UNESCO-UNEP, 1976).

The NAAEE (North American Association for Environmental Education) (2011), with the aim of developing an international assessment framework for environmental literacy, defined environmental literacy as "the knowledge, abilities, dispositions, and behaviors of students that enable students to make decisions and act to address environmental issues. (p.15–16)" This definition covers environmental knowledge, attitudes towards the environment, and knowledge of effective citizen action strategies.