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Assessing Multidimensional Energy Literacy of Secondary Students Using Contextualized Assessment

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Energy literacy is multidimensional, comprising broad content knowledge as well as affect and behavior. Our previous study has defined four core dimensions for the assessment framework, including energy concepts, reasoning on energy issues, low-carbon lifestyle, and civic responsibility for a sustainable society. The present study compiled a series of contextualized question items into a computer-based test (CBT) platform to examine students' energy literacy. Each test unit included a scenario, presented via multimedia materials (e.g., text, image, short video, and animation), that pertained to real-life situations. Various types of questions were employed (e.g., multiple true-false, multiple choice, and short-answer) that required students to construct responses and make judgments. A total of 1,711 secondary school students participated in this survey. The results indicate that the energy literacy level of Taiwanese secondary students is discouragingly low and inter-correlations between the dimensions of energy literacy reveal that energy knowledge and behavior are more closely correlated than affect and behavior. In addition, the scores on the attitudinal items were slightly higher for junior than senior students and the students in the southern region scored higher on energy literacy than those in other regions. These findings provide evidence for the future development of energy-related educational curricula and materials that can improve students' energy literacy and engagement in energy-related decisions.

Keywords: assessment, computer-based test, energy education, energy literacy

INTRODUCTION

Energy usage has a profound impact on our standard of living and every major

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sector of the economy. The recent issue of climate change mitigation demands attention on energy efficiency and reducing energy use in order to pursue sustainable economic growth (Chen, Huang, & Liu, 2013; Whitmarsh, Seyfang, & O'Neill, 2011). In addition, policy proposals relying on individuals' voluntary carbon reduction highlight the need for at least some level of public understanding of energy conservation. In this regard, education plays an important role in establishing modes of communication that can improve individuals' energy literacy so that energy can be utilized both rationally and efficiently (Dias, Mattos, & Jose, 2004; Liarakou, Garvrilakis, & Flouri, 2009; Zografakis, Menegaki, & Tsagarakis, 2008). In general, the objectives of energy education are to develop people's awareness about energy crises, to make them understand the energy-environment nexus, and subsequently to ensure environmental sustainability of every nation (Kandpal & Garg, 1999). The concepts of carbon reduction should also be incorporated into curricula and teaching activities in order to improve student awareness about energy conservation and related practices (Directorate-General for Energy and Transport, 2006). For example, since 2008, Taiwan's government has promoted its Sustainable Energy Policy in which the action plans include supporting environmental education for energy saving and carbon reduction as well as designing and implementing relevant teaching materials (Yeh & Chuang, 2009).

In recent years, environmental education has risen steadily with the goal of fostering environmentally literate citizens (Teksoz, Sahin, & Tekkaya-Oztekin, 2012; Spiropoulou, Antonakaki, Kontaxaki, & Bouras, 2007). Since energy literacy has been an important agenda for environmental education, energy education shares the same rationale with environmental education. In the 1990s, numerous studies were conducted to develop frameworks for defining the components of environmental literacy (Hungerford & Volk, 1990; Marcinkowski, 1990; Roth, 1992), which subsequently guided several national assessments of environmental literacy (McBeth, Hungerford, Marcinkowski, Volk, & Meyers, 2008; Negev, Sagy, Garb, Salzberg, & Tal, 2008; Shin et al., 2005). These frameworks measured the domains of knowledge, affect, cognitive skills, and behavior, which are commonly regarded as critical to environmental literacy (McBeth & Volk, 2009). By referring to these aforementioned frameworks developed in Western countries, the present article compiles its own framework for designing the assessment of energy literacy in Taiwan (Chen et al., 2013). Furthermore, it examines the design of a multi-dimensional assessment and analyzes the test results of a nationwide sample.

Defining Energy Literacy

Energy literacy is regarded as an educational effort that helps pave the way toward a more energy-secure future by empowering individuals to choose appropriate energy-related behaviors throughout their daily lives (DeWaters & Powers, 2011). The notion of energy literacy comprises broad content knowledge of affective and behavioral dimensions as well as the competency that people need to make wise choices and commit to energy conservation (DeWaters & Powers, 2011, 2012; DeWaters, Qaqish, Graham, & Powers, 2012; DoE, 2012; Lay, Khoo, Treagust, & Chandrasegaran, 2013).

In their survey of New York state, DeWaters and Powers (2011, 2012) developed an Energy Literacy Questionnaire to assess secondary students' energy literacy in three core dimensions: cognitive (knowledge), affective (attitudes, values), and behavior. Their findings also emphasized that energy literacy embodies not only content knowledge, but citizen engagement. Additional studies (Bodzin, Fu, Peffer, & Kulo, 2013; Lay et al., 2013) also utilized an Energy Literacy Questionnaire to investigate the levels of energy literacy among 8th grade students in Malaysia. Furthermore, it was shown that energy literacy not only strives for behavioral change, but also for enabling individuals to make thoughtful decisions based on science (DoE, 2012). These previous findings emphasized the importance of practical energy-related knowledge, decision-making skills, value judgments, and ethical and moral dimensions related to energy conservation. In order to develop a framework for energy education in Taiwan, the Chen and colleagues (2013) adopted the ideas of energy literacy and carbon capability. We also applied the Analytical Hierarchy Process (AHP) method with a panel of experts to determine the core dimensions (Table 1), which basically conform to the common constructs of environmental literacy (i.e., knowledge, attitude, behavior, and civic engagement). However, the present study placed greater emphasis on practical knowledge and high-level cognitive skills.

Table 1. Dimensions of environmental literacy and energy literacy (Chen et al., 2013)

Dimensions	Environmental Literacy	Energy Literacy
Knowledge	Knowledge	Knowledge Understandings Skills
Affective	Interest Sensitivity Locus of control	Sensitivity attitude Self-efficacy
Behavior	Responsibility	Intentions Involvement Action

Energy Education in Taiwan

Due to the lack of local energy resources, effective energy use has become one of the most important issues in Taiwan (Chuang & Ma, 2013; Huang & Wu, 2009). Moreover, the Taiwanese government has continually revised its energy policy in favor of sustainable energy use (Huang & Wu, 2009; Tsai, 2005). In November 1979, the Energy Commission was established by the Ministry of Economic Affairs (MOEA) to develop and implement a national energy policy (MOEA, 2012). In 2007, an action plan titled, "Energy Saving and Carbon Reduction," in accordance with the Sustainable Energy Policy Framework, was approved and promoted by the Executive Cabinet (Yeh & Chuang, 2009). The goal of this plan was to improve energy efficiency and conservation, and subsequently reduce carbon dioxide (CO_2) emissions. However, individual behavior change and public engagement are still key factors in promoting and implementing an energy-related policy.

Since 1979, energy education has been promoted in various countries such as the United Kingdom, the United States, and Australia (Hsu, Huang, Fu, & Teng, 2010). In line with the international trend, the Ministry of Education in Taiwan has funded 17 centers and established an energy education program targeted at elementary and lower secondary schools (Tsai, 2005). In addition, the National Science Council implemented a national-level project to invest human capital in the research and development of an effective energy education program. The success of an energy education program requires a comprehensive assessment to ensure that its educational objectives align with the criteria for energy literacy, which include not only cognitive aspects, but also affective and behavioral characteristics. Furthermore, since energy education programs must be tailored to local, regional, and international priorities and requirements, it is necessary to establish clear educational criteria for these programs. Therefore, our previous research aimed at developing a framework of energy literacy that targeted the ability to make informed judgments regarding energy use as well as take effective actions related to energy management (Chen et al., 2013). Our study also found that the dimensions of "civic responsibility for a sustainable society" and "low-carbon lifestyle" were considered as the most important energy education goals. Due to the local, regional, and international priorities and requirements for energy education, this study designed an assessment that can help improve energy education by understanding the energy literacy of secondary students.

Contextualized Assessment for Energy Literacy

In order to ensure that students attain the desired proficiency levels, a suitable assessment should be developed to evaluate the effectiveness of energy education programs. In real-life situations, students must use different cognitive processes to understand various components of an event, especially when the event is related to complex environmental problems. However, conventional instruments were limited to paper-and-pencil tests with single, closed items that measured students' knowledge and attitudes. According to Lee (2004), using a contextualized test makes it possible to measure examinees' understanding of the material from various perspectives. This format has been used to assess complex cognitive processes by the Organization for Economic Co-operation and Development (OECD) and by the International Association for the Evaluation of Educational Achievement (IEA) (Mullis et al., 2007; OECD, 2002). Routitsky and Turner (2003) also endorsed the importance of using various test item formats in order to accommodate the full range of student abilities typically sampled in the Program for International Student Assessment (PISA).

Substantial studies have been performed on energy literacy surveys, but there is still a critical lack of comprehensive tests for energy literacy. In addition, the availability of a suitable instrument that measures broad energy literacy has been limited or non-existent (DeWaters & Powers, 2011) since such literacy indicates having the required knowledge and skills as well as the ability to make informed decisions when participating in society (Harlen, 2001). We argue that the findings of these survey assessments do not represent energy literacy levels since they lack a context in which the respondents can solve energy-related problems in a holistic manner. Moreover, based on a non-curricular approach, the test format is coherent with the general theoretical framework of this study (OECD, 2003, 2006). Therefore, literacy-related assessment is conducted as a series of contextualized questions to evaluate, from various perspectives, the complex process of respondents' understanding of the material (Monseur, Baye, Lafontaine, & Quittre, 2011).

Information and communication technology (ICT) has become a crucial component in the education process (Alabi, Issa, & Oyekunle, 2012). The computer-based test (CBT) has been considered as a special type of ICT that has become increasingly important in various fields of competence assessment (Wirth, 2008). Complex problem solving is an essential skill for students when dealing with complex and dynamic systems (Frensch & Funke, 1995) and their performances can be measured by a CBT, even in large-scale assessments (Wirth & Klieme, 2003). A CBT can also be used to assess tacit knowledge regarding procedures/strategies that cannot be easily verbalized and difficult to assess through conventional pencil-paper tests (Buchner, Funke, & Berry, 1995). The framework of energy literacy, as described earlier, includes the following components that students are expected to possess: the ability to acquire energy-related knowledge; the ability to make informed judgments about energy saving; and the ability to take actions of energy management in complex situations. In order to assess students' energy literacy in a more comprehensive manner, the present study designed an assessment tool that requires students to answer a series of question items after comprehending the scenarios presented via multimedia materials (e.g., text, image, short video, and animation). For this assessment design, the CBT provided both accessibility and flexibility.

For a shift toward more energy conservation in society, it is necessary to understand the level of energy literacy among students as an indicator of the effectiveness of energy literacy efforts (Fah, Hoon, Munting, & Chong, 2012). In order to measure energy literacy among secondary students in Taiwan, we developed an instrument based on the test format adopted by the PISA. This instrument included multiple types of questions that pertained to real-life situations and required the students to construct responses and make judgments. The purpose of this study was to answer the following research questions:

1. How do Taiwanese students perform in regard to the four dimensions of energy literacy (i.e., energy concepts, reasoning on energy issues, low-carbon lifestyle, and civic responsibility for a sustainable society)?
2. Is there any correlation among individual variables, the four dimensions, and overall energy literacy?
3. Is there any relationship among individual variables and the students' performance on the energy literacy assessment?

The answers to these questions should provide evidence for the future development of energy-related educational curricula and materials that can improve students' energy literacy and engagement in energy-related decisions.

MATERIALS AND METHODS

Survey Instrument

Contextualized assessment may be viewed as the most appropriate approach for evaluating complex processes such as science comprehension (Monseur et al., 2011), which requires students to employ different cognitive processes to understand various components of the same text for a non-curricular approach. The OECD has applied this format for its PISA tests since 2000 (Monseur et al., 2011), and the IEA used it for its first reading comprehension test in 1971 (Elley, 1994; Mullis et al., 2007; Mullis et al., 2003). In consideration of the non-curricular approach and the various aspects of energy literacy, the present study compiled a series of contextualized question items into a CBT platform in order to explore energy literacy among Taiwanese secondary students. In the following sections, we provide a description of the energy literacy framework used for development and assessment, illustrate the test format and the process of item development, and present some samples of the items.

Assessment framework for energy literacy. Table 2 summarizes the dimensions and indicators defined in this study. The four core dimensions are described as follows:

1. Energy concepts: In order to actively participate in decision making for a low-carbon society, an energy-literate individual should possess energy concepts, which include a systematic understanding about sources, uses, and development of energy, and its costs and benefits,
2. Reasoning on energy issues: An energy-literate person should have the ability to evaluate the reliability of information sources that help ascertain how to use energy effectively, and make judgments on energy-related issues.
3. Low-carbon lifestyle: Individual behavior is important for government policy on carbon reduction and energy-related issues. For a sustainable society, individuals must choose to adapt their daily lifestyles to contribute to carbon reduction and energy conservation.
4. Civic responsibility for a sustainable society: Individuals' awareness about climate change leads to their engagement in energy conservation activities and a shift towards a sustainable society. In the energy literacy assessment, the essential qualities of energy literacy include the ability to make informed

judgments about the use of energy and take effective actions with regard to energy management.

Table 2. Dimensions and indicators of the energy literacy framework (Chen et al., 2013)

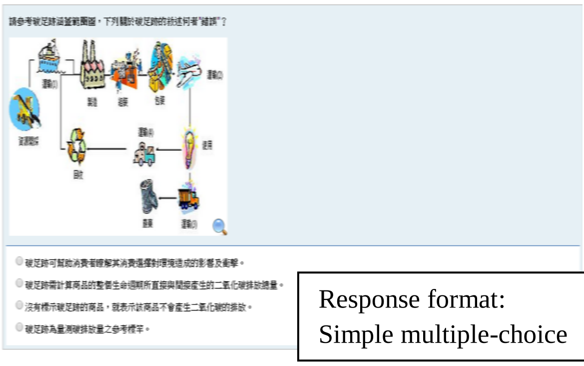
Dimension	Indicator	One should be able to:
1. Energy concepts	1-1 Awareness of sources, uses, and development of energy	Acknowledge issues related to energy sources and resources
	1-2 Possessing a systematic understanding about energy	Interpret the discovery, development, and use of energy resources
	1-3 Understanding energy costs and benefits	Recognize that the different sources of energy and the ways of using them have different costs, implications, risks, and benefits
2. Reasoning of energy issues	2-1 Exploring international and local energy issues	Assimilate the interpreted current events in an international or local context relevant to energy issues
	2-2 Judging and evaluating information about energy-related issues	Analyze and assess objective and reliable information relevant to energy issues
3. Low-carbon lifestyle	3-1 Identifying carbonless technology and action plans	Adapt appropriate lifestyles that contribute to solving global energy problems
	3-2 Carrying out sustainable (green) consumption	Consider the impact of energy consumption patterns
4. Civic responsibility for a sustainable society	4-1 Awareness and self-efficacy	Be aware of the impact of personal energy-related choices on the environment; believe that personal actions can lead to a change
	4-2 Civic engagement	Be acquainted with energy-saving and carbon-reducing activities and engaged in decision making on energy-related issues

Instrument format. The instrument included a student information survey and an energy literacy assessment. The survey consisted of items related to the students' backgrounds, such as gender, grade, school location, numbers of learning activities attended, and perceptions of energy conservation and carbon reduction. The items regarding perceptions were based on a five-point Likert scale (with one neutral response) ranging from 1 (strongly disagree) to 4 (strongly agree). The energy literacy assessment contained a series of contextualized test units with each unit dealing with a real-life problem or issue. Each test units began with a stimulus text taken from authentic sources such as newspapers, blogs, and books about energy issues. The students were then asked to answer a series of items related to the problem or issue. The items were arranged in groups of independently scored items based on a common stimulus, which enabled us to utilize contexts that realistically reflected the complexity of life situations as well as efficiently used the time allotted. Four types of item formats were used in the assessment and each item aligned with one of the indicators in the energy literacy framework. Approximately one-third of the items were selected-response (multiple-choice) items that required the selection of a single response out of four options, while another third included multiple true-false items and short-answer questions. The multiple true-false items required the respondents to answer multiple "yes/no" or "true/false" questions, while the short-answer questions required a written response that included short explanations and/or justifications. For the attitudinal items, another third of the questions were based on a four-point Likert-type. In this study, the terms "cognitive items" and "attitudinal items" are employed to distinguish between these two types of items where necessary.

Figure 1 presents a contextualized test unit titled, "Carbon Footprint," which includes a graph and diagram as well as various types of test questions. A commentary is also provided to explain how several items that test different processes and concepts can be presented in one unit. The stimulus material for this unit contained various factors that contribute to carbon footprints. The contextualized test unit required the respondents to use the given information to support a particular course of action and to recognize the carbon emission of the fuel and water purchased as well as their daily carbon footprint coverage. Two attitudinal items in this test unit assessed the respondents' disposition regarding how their energy consumption patterns impacted the environment and examined their attitudes toward engagement with carbon reduction in their daily lives. Figure 2 displays a contextualized test unit titled, "Cherish the Environmental Resources," which includes an animation as well as various types of test questions. The stimulus material for this unit used the animation to describe students' consumption behaviors for their breakfast and recycling behaviors. The contextualized test unit required the examinees to use the given information to recognize the choices of product packaging. Two attitudinal items in this test unit assessed students' disposition to saving energy with families and friends in their everyday lives.

Carbon Footprint

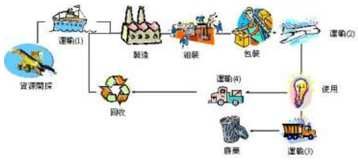
Mr. Wang noticed a statement on his fuel invoice that read, "The CO_2 emission of this fuel purchase is approximately 32 kg." This statement made him aware of the high level of CO_2 that his fuel was emitting! Additionally, his home electricity and water bills provided similar calculations of the carbon footprint, such as "The CO_2 emission calculated from your electricity usage in this statement is approximately 72 kg. Please save electricity to help reduce CO_2 emissions and the impact of global warming" and "The CO_2 emission calculated from your water usage in this statement is about 2 kg. Please conserve water ……" (as described on the invoice below). With such information on CO_2 emissions, users are reminded of the carbon emissions associated with their daily lives.



Response format:
Simple multiple-choice

Referring to the carbon footprint coverage chart below, which of the following statements regarding carbon footprints is <u>incorrect</u>?

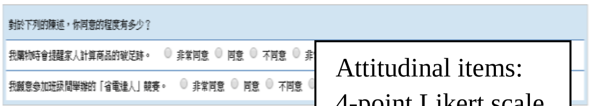
A. Carbon footprints can help consumers understand the effect and impact of their consumption choices on the environment.
B. It is necessary that the calculation of the carbon footprint includes direct and indirect CO_2 emission throughout the life cycle of the commodity.
C. If a commodity has no carbon footprint labeling, then it does not produce CO_2 emissions.
D. The carbon footprint is a referral benchmark for measuring carbon emissions.



Response format:
Order

Based on the product life cycle, please calculate the carbon footprint of the following actions and arrange them in descending order, from the action with the highest carbon footprint to the action with the lowest (e.g., A > B > C).

A. Dining in a restaurant and using self-prepared tableware.
B. Preparing your own meal at home and eating more vegetables and less meat.
C. Bringing fast-food meals home and using the plastic bags and disposable utensils provided by the store.



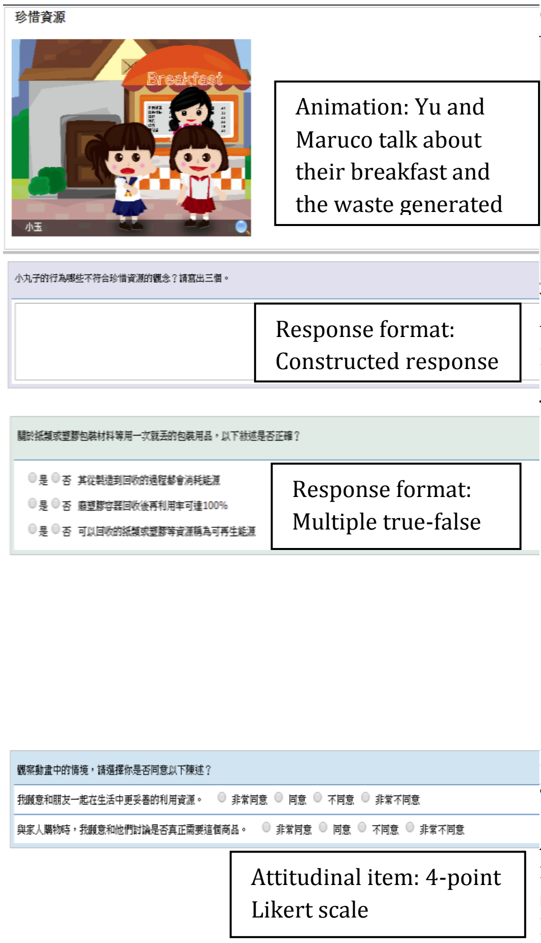
Attitudinal items:
4-point Likert scale

To what extent do you agree with the following statements?

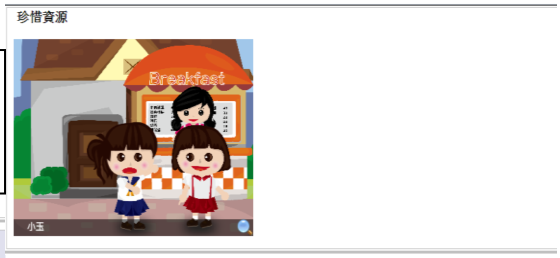
A) I will remind my family members to compare the carbon footprints of the products that they use.
□Strongly Agree □Agree □Disagree □Strongly Disagree
B) I will take part in the "Power Saving Guru" contest.

□Strongly Agree □Agree □Disagree □Strongly Disagree

Figure 1. A contextualized test unit—Carbon Footprint



Cherish the Environmental Resources



Which of Maruco's behaviors are improper in terms of cherishing environmental resources? Please list three.

TRUE	FALSE	Which statements about product and packaging materials (paper or plastic) are true?
○	○	The product recycling process does not consume energy.
○	○	The recycling rate for plastics can be up to 100%.
○	○	Recyclable resources, such as paper and plastic, can be called "renewable energy."

Referring to the animation, to what extent do you agree with the following statements?

A) I will persuade my friends to use resources more efficiently.
□Strongly Agree □Agree □Disagree □Strongly Disagree

B) When shopping with my family, I will discuss whether we need to purchase the products.
□Strongly Agree □Agree □Disagree □Strongly Disagree

Figure 2. A contextualized test unit-- Cherish the Environmental Resources

Item development. In the process of designing the test items, we involved experienced secondary school teachers to ensure that the context of the items were as close as possible to the students' real-life experiences and levels of energy literacy. A series of teacher workshops was held to accomplish the following steps: 1) introducing the assessment framework of energy literacy; 2) presenting the advantages of contextualized question items; 3) brainstorming possible scenarios for designing questions; and 4) developing contextualized test units through teamwork.

A total of 40 teachers from various subjects/areas were recruited to participate in the workshops after which they were asked to design at least one test unit. As a result, 20 units were submitted for consideration. The contextualized test units were separately presented for review to a panel of experts specializing in environmental education, science education or energy technology. Various criteria, such as the overall quality of the unit, the amount of revisions required, and indicators in framework coverage, were used to determine which units to retain. The six selected units (49 question items) were then modified into a paper-and-pencil test that was administered to 200 junior high school students. Following Wainer's (1990) suggestion, our pilot study first employed the classical test theory to analyze Cronbach's alpha values, and item difficulty and discrimination, and then adopted the item response theory (IRT) to identify and compare the fitness index (including deviance value, BIC, and λ^2) between the one-dimensional model and the multi-dimensional model in order to justify the validity and reliability of the question items. Each subscale appears to be internally consistent, as indicated by Cronbach's alpha values, which ranged from 0.70 to 0.82. The item difficulty values (from 0.21 to 0.84) and item discrimination values (from 0.24 to 0.53) indicate that the question items were appropriately designed for assessing students' knowledge and cognitive skill. Based on the item response theory (IRT), the results show that the fitness index of the one-dimensional model (deviance value = 7737.80; BIC = 7933.84; λ^2 = 2216.08) is slightly lower than that of the multi-dimensional model (deviance value = 7739.79; BIC = 7972.92; λ^2 = 2578.03). Multi-dimensionality not only improves the reliability of individual tests, but it also accurately estimates the correlation between dimensions since measurement error has been factored into the estimation process (Wang, 2004). The results from the pilot study supports that this multi-dimensional assessment is a valid and reliable quantitative measure for assessing high school students' energy literacy.

Sample

A total of 1,711 secondary school students were drawn from 18 junior high schools and 13 senior high schools in the central, north, south, and east regions of Taiwan. These schools were informed of the research objectives and the requirements of technical support after which they agreed to participate in this study. One or two classes of students (depending on the size of the school) were randomly selected as the sample and the selected students were gathered in the computer classroom at their school in order to complete the online test. The final data was gathered from 974 junior and 737 senior high school students. As shown in Table 3, 51.3% of the participants were male while 48.7% were female, and the majority were in the 10th grade (23.7%) with the remaining students distributed among the 8th grade (22.1%), the 7th grade (22.0%), and the 11th grade (18.2%). Finally, the students came from various regions with a broad range of socioeconomic backgrounds (north, 41.1%; central, 26.3%; south, 25.1%; and east, 7.5%).

Table 3. *Characteristics of participants*

Characteristic		%	Characteristic		%
Regional	North	34.07	Grade	7th	25.69
	Central	30.01		8th	19.63
	South	29.72		9th	11.20
	East	6.20		10th	23.56
Gender	Female	50.82		11th	15.22
	Male	49.18		12th	4.70

Reliability and Validity of the Instrument

To ensure the reliability and validity of the scale items, we used Cronbach's alpha to evaluate the internal consistency, which exceeded the recommended minimum of 0.7 (Nunnally, 1978). Confirmatory factor analysis, using structural equation modeling (SEM) software (LISREL 8.51), was performed to test the validity and reliability of the assessment. The factor loadings were statistically significant with values of 0.82 to 0.22. In addition, the composite reliability was 0.69 and the average extracted variance (AVE) was 0.40. These values, combined with acceptable Cronbach's alpha coefficients of 0.85, supported the reliability of the assessment (Hair, Anderson, Tatham, & Black, 1999). Finally, the discriminant validity among the dimensions of energy literacy was tested using Fornell and Larcker's (1981) criteria in which the square root of the AVE should be greater than the correlations between the construct for satisfactory discriminant validity. Thus, it was determined that all dimensions exhibited satisfactory discriminant validity.

As previously noted, instrument validity was supported through various methods such as drawing items from existing energy and environmental research, administering the instrument to a panel of experts in energy, environment, and science education. Moreover, the values from Cronbach's alpha as well as the results of SEM and the AVE have satisfied the criteria of reliability and validity. Consequently, it was determined that the instrument was reliable and valid for assessing secondary students' energy literacy

Data Analysis

The students' questionnaire responses were converted into numerical scores. The cognitive items were assigned one point for each correct answer and zero points for each incorrect or blank response. In addition, the attitudinal items were converted to numerical values according to a predetermined preferred direction of response in order to calculate the summated rating totals.

In order to examine the relationship between the dimensions of energy literacy and overall energy literacy, inter-correlations between the average student scores on the items and overall energy literacy were calculated with Pearson's correlation coefficients. The effects of students' gender, grade, and region on the dimensions of energy literacy and overall energy literacy were investigated using multiple regression analysis.

RESULTS AND DISCUSSION

Student Performance on the Four Dimensions of Energy Literacy

In order to answer the first research question, the performance summaries for the four dimensions of energy literacy are presented in Table 4. According to the passing grade for the tests (commonly set at 70%), the results in this study indicate that this sample of Taiwanese secondary students have a positive attitude towards energy conservation and carbon reduction. However, their performances were discouragingly low with regard to the dimensions of "low carbon lifestyle" and "reasoning on energy issues." It was also evidenced that two items had the lowest percentage of correct responses in the assessment: "judging and evaluating information about energy-related issues" and "reasoning on energy issues." For instance, the item of Test Unit 2 titled, "Fossil Fuel Energy," required students to use the given information to choose a correct description of the goal and situation of the 2012 COP16 in Cancun, Mexico (25% correct responses). The item of contextualized Test Unit 3 titled, "Geothermal Energy," required students to choose the correct information about the characteristics of geothermal energy (32% correct responses). The results of the test show that the students failed to identify the information about current events relevant to energy issues and that they lacked the ability to analyze and evaluate the energy-related issue information. Furthermore, the findings show that the students also required more understanding about energy resources.

The two items related to the indicator, “awareness of sources, uses, and development of energy,” under the dimension of “Energy Concepts,” also had fewer correct responses. For instance, the item of contextualized Test Unit 4 titled, “New Era—Biomass Energy,” asked students to choose the correct answer for biodiesel (38% correct responses). Moreover, the item of contextualized Test Unit 3 titled, “Geothermal Energy” asked students to determine the characteristics of air conditioning using geothermal energy (42% correct responses). It is noteworthy that the students lacked a systematic understanding about alternative energy and the ability to obtain new information about such energy. They also had limited ability to gather and analyze information about local and international energy-related issues. Evidently, a lack of knowledge is a common theme in participants’ understanding of energy conservation, which is similar to the findings of DeWaters and Powers (2011).

Table 4. Summaries for student performance on four dimensions of energy literacy by demographic backgrounds

	Dimension				
	1.Energy concepts	**2.Reasoning on energy issues**	**3.Low-carbon lifestyle**	**4.Civic responsibility**	**Overall energy literacy**
Gender					
Male	71.17	68.44	66.15	82.21	72.00
Female	70.91	68.56	66.23	82.13	71.96
Region					
North	70.52	68.11	65.69	82.05	71.59
Central	71.17	68.44	66.15	82.21	72.00
South	70.78	68.22	65.85	82.11	71.74
East	70.96	67.89	65.15	81.88	71.47
Grade					
7th	70.30	67.89	65.46	82.09	71.44
8th	70.70	68.22	65.77	82.11	71.70
9th	70.48	68.11	65.54	82.14	71.57
10th	70.96	68.44	66.00	82.11	71.88
11th	70.61	68.11	65.77	82.00	71.62
12th	70.39	68.11	66.15	81.71	71.59

Note: Each value in this table has been converted into a percentage of possible full score.

Relationships among Measured Variables

Table 5 presents the correlation coefficients among the dimensions of energy literacy and other surveyed variables. The result of the correlation analysis shows that the dimensions of energy literacy are positively correlated with one another and there is a relatively high relationship between “energy concepts” and “low carbon lifestyle,” with an obtained r as large as .62. It was also found that there are weak relationships between “civic responsibilities for a sustainable society” and the other dimensions of energy literacy. Conversely, “energy concepts” is most likely associated with the other dimensions of energy literacy, especially “low carbon lifestyle,” which is considered as a behavioral aspect that emphasizes personal choices of appropriate lifestyles and practices of carbon reduction. This finding is in accordance with earlier models of environmental behavior, which assumed the widely held position that knowledge leads to changes in attitudes and values, which, in turn, fosters action or behavior (Fah et al., 2012).

The results displayed in Table 5 indicate that the students’ perceptions on the importance of energy conservation and carbon reduction are positively correlated with all four dimensions of energy literacy. However, according to the values of the correlation coefficient, only the relationship between perceptions and attitudes ("civic responsibilities for a sustainable society") is significantly recognized (r = .54). This finding supports the assumption that students' perceptions of individual and collective efforts toward energy conservation may be revealed in their positive attitudes about environmental responsibility (Lawrenz & Dantchik, 1985). Another surveyed variable, the number of environmental learning activities students had experienced, unfortunately, shows no or weak correlations with all of the energy literacy dimensions. Based on our observations, most of the learning activities are provided by school curricula and they mainly focus on conceptual learning of energy technology and related knowledge, which may be insufficient for improving students' comprehensive understanding of energy issues. Nevertheless, we argue that the issue-based teaching approach can be incorporated into learning activities in order to formulate students' abilities to evaluate and assess information in regard to energy issues.

Table 5. Mean, standard deviations, and correlation coefficients of measured variables

Variables		1	2	3	4	5	6	7
Energy Literacy	1.Energy concepts	-						
	2.Reasoning on energy issues	.49**	-					
	3.Low-carbon lifestyle	.62**	.43**	-				
	4.Civic responsibility for a sustainable society	.16**	.14**	.18**	-			
	5.Overall energy literacy	.83**	.74**	.84**	.40**	-		
Perception	6.Students' perceptions of energy conservation and carbon reduction	.11**	.11**	.15**	.54**	.26**	-	
Experience	7.Number of learning activities attended	.02	.04	.07**	.14**	.08**	.09**	-

**Significant at the p < .01 level.

Regression Analysis for Estimating Predictors To Energy Literacy

A multiple regression analysis was conducted to test the relationships between individual variables and energy literacy. The categorical variables, such as gender, grade, area, and region, were dummy variables used to predict the dimensions of energy literacy. Since the number of learning activities attended did not correlate with energy concepts and reasoning on energy issues, it was excluded from Model A and Model B of Table 6. The results show statistically significant relationships between the respondents' characteristics and the dimensions of energy literacy. In each regression, the variance inflation factors (VIF) were considerably less than 5.0, thus indicating that multi-collinearity was not a problem (O'Brien, 2007). Table 6 shows the results of the multiple regression analysis that examined the relationships between respondents' characteristics and the dimensions of energy literacy. Model A indicates that the respondents' characteristics (including gender, region, grade, and perception of the need for energy conservation) are significant to "energy concepts." Model B shows that the variables of region, grade, and perception are the significant predictors for "reasoning on energy issues," while Model C indicates that all of the respondents' characteristics (except for gender) are significant to "low-carbon lifestyle." Finally, Model D shows that region, number of learning activities attended, and perception of the need for energy conservation are significant to "civic responsibility for a sustainable society," while Model E is similar to Model C in that the respondents' characteristics (excluding gender) are significant to overall energy literacy.

Table 6. Regression analysis for four dimensions and overall energy literacy

	Model A[b] β	Model B[b] β	Model C[b] β	Model D[b] β	Model E[b] β
Gender					
Female[a]					
Male	0.14*	-0.02	-0.04	-0.05	-0.02
Region					
North[a]					
Central	0.15*	0.16*	0.09*	0.13*	0.18*
South	0.30*	0.22*	0.19*	0.07*	0.29*
East	-0.02	0.05	-0.06*	0.03	-0.02
Grade					
7[a]					
8	0.11*	0.08*	0.10*	-0.02	0.11*
9	0.18*	0.09*	0.06*	-0.01	0.13*
10	0.42*	0.27*	0.38*	-0.03	0.41*
11	0.15*	0.13*	0.13*	-0.04	0.15*
12	0.15*	0.10*	0.15*	0.01	0.15*
Number of learning activities attended	--	--	0.09*	0.09*	0.10*
Students' perceptions of energy conservation and carbon reduction	0.11*	0.10*	0.13*	0.53*	0.24*
R^2 (Adjust R^2)	0.21(0.21)	0.11(0.10)	0.16(0.15)	0.32(0.31)	0.25(0.24)
F	46.35*	20.15*	29.13*	78.55*	54.89*

*Significant at $p < .05$ level.
[a] Reference group
[b] Dependent variables: Model A, "energy concepts"
Model B, "reasoning on energy issues"
Model C, "low-carbon lifestyle"
Model D, "civic responsibility for a sustainable society"
Model E, overall energy literacy

The results show that the respondents' characteristics are positively associated with energy literacy. The variable of gender is merely significant to energy concepts since the male students outperformed the female students in regard to such concepts. Region and students' perceptions are positively associated with "low-carbon lifestyle" and overall energy literacy. For example, students in the central and southern regions scored higher than those in the northern region. However, in regard to "low-carbon lifestyle," students in the northern region scored higher than those in the eastern region. Furthermore, students in the 7th grade performed worse on the knowledge and behavioral dimensions than those in grades 8–12, except for "civic responsibility for a sustainable society." There are positive relationships between the number of learning activities attended and the overall energy literacy and "low-carbon lifestyle" and "civic responsibility for a sustainable society."

A t-test was conducted to further understand the differences between grades and the performance of the dimensions and overall energy literacy. Based on the structure of the education system in Taiwan, the students are divided into two groups in terms of their stage of school education: grades 7–9 (junior high students) and grades 8–12 (senior high students). The result of the t-test also indicates that the senior high students (n = 899) show significantly greater performance on the knowledge (energy concept: t = -14.38, p < .001; reasoning on energy issues: t = -9.339, p < .001) and behavioral dimensions (low-carbon lifestyle: t = -13.18, p <

.001) and overall energy literacy (t = -11.09, p < .001) compared to the junior high students (n = 1167). This result may be used to interpret the goal of energy education, which familiarizes students with energy conservation and carbon reduction in order to improve their cognition of energy conservation and related practices (Zografakis et al., 2008). In this case, senior high students might possess more advanced energy-related knowledge since they have been engaged in energy-conservation concepts through each stage of energy education. This finding is in accordance with the result that "energy concepts" and "low carbon lifestyle" were strongly positively correlated.

For "civic responsibility for a sustainable society," there was no statistical difference between junior and senior high students, despite the fact that the scores on the attitudinal items are slightly higher for junior students than those of senior high students (t = -1.073, *n. s.*). Similar to the findings from earlier studies (e.g., DeWaters & Powers, 2011; Whitmarsh, Seyfang, & O'Neill, 2011), there appears to be a value-action gap among students' cognitive, affect, and actions. Although senior high students were concerned about the energy problems of society, they apparently lacked the actions of engaging in energy-conservation behaviors in their daily lives. DeWaters and Powers (2011) clarified that as adolescents become young adults, they are less willing to change their habits that consume more energy. In addition, the students in higher grades have lower levels of environmentally friendly behaviors because the current provision systems are not conducive to such practices (Whitmarsh et al., 2011).

Male students had significantly higher energy-related knowledge than the female students, yet there was no correlation in their attitude scores, which is in line with the study by Lusardi and Mitchell (2007). Like several other studies (e.g., Barrow & Morrisey, 1989; Gambro & Switzky, 1999; Lay et al., 2013), gender disparities were found in energy and environmentally related knowledge. Other studies also showed general trends of gender differentiation in science achievement and increased differentiation as students progressed through school (Clewell & Campbell, 2002; Haertel, Walberg, Junker, & Pascarella, 1981). The finding in the present study that male students outperformed the female students only on "energy-related knowledge" may be similar to the gender difference in science learning achievement.

It is interesting to note that students in the southern region scored higher on energy literacy than those in the other regions, including the northern region, which mostly contains Taiwan's metropolitan and urban areas. This result differs from other studies in that respondents from urban schools performed better on the cognitive skills and attitudes toward energy conservation than their rural counterparts (Fah et al., 2012; Lay et al., 2013).

Personal experiences of the surroundings could raise people's demands for environmentally friendly practices, and foster their long-term environmental concerns (Chawla, 1999). The study by Davidson, Yantis, Norwood, and Montano (1985) also found that the prediction of behavior is associated with personal experience. For example, natural disasters, such as typhoons and floods, occur frequently in Taiwan and they cause serious damage to properties and the quality of life, especially for those in southern region. Thus, the impact of natural disasters can be used as teaching cases in school since students might possess awareness of environmental issues and then develop their energy literacy in their respective environments. Compared to the southern region, the infrastructure in the northern region of Taiwan is more advanced. As a result, the students from the northern region may not directly suffer from environmental disasters, and for this reason, they are more likely to have lower levels of energy conservation-related attitudes and practices. Raising awareness of the urgency of energy problems and the need for energy education programs might foster actual behaviors in energy conservation and carbon reduction (DeWaters & Powers, 2011).

CONCLUSION AND RECOMMENDATION

Educational efforts may help transform people's behaviors toward rational use of energy and increase their energy literacy (Dias, Mattos, & Balestieri, 2004; Zografakis et al., 2008). The government sectors in Taiwan, such as the Ministry of Education (MOE) and the Ministry of Science and Technology (MOST), have promoted energy education programs targeted at each stage of school education as well as developed various educational programs and evaluation methods for energy education through national projects. However, the success of an energy education program is in need of an adequate and comprehensive assessment (DeWaters & Powers, 2011). Therefore, this study comprehensively evaluated the energy literacy levels of secondary students in Taiwan in order to understand the effectiveness of the energy education policy. The instrument in this study consisted of contextualized test units with various test items to accommodate students' comprehensive energy literacy, which included cognitive, affective, and behavioral aspects.

Based on the assessment results, the energy literacy level of Taiwanese secondary students is unsatisfactory. Students had limited abilities to evaluate information about global energy issues and they lacked knowledge regarding new energy resources. Students in grades 8–12 outperformed those in the 7th grade on the knowledge and behavioral dimensions of energy literacy. Furthermore, the results of the correlational analyses show that the behavioral dimension is more closely correlated with energy knowledge than the affective dimension. It is suggested that effective educational programs should target students' abilities to possess a basic understanding of energy concepts as well as evaluate and assess information in order to actively participate in decision making for a low-carbon society. The energy curricula should also incorporate active pedagogical techniques, such as the issue-based teaching approach, to increase the diversity of activities for engaging students and ultimately improve their civic knowledge, skills, and participation (Papadimitriou, 2004).

Energy education programs should be tailored to local and regional concerns and priorities in order to be relevant to learners' living experiences and interests. The results indicated that students in the southern region scored higher on energy literacy than those in the other regions, thus suggesting that local issues, such as impact of natural disasters, can be applied as teaching cases to raise awareness of the urgency of energy problems and the impact of decisions regarding energy use. Moreover, such issues can foster actual behaviors in energy conservation and carbon reduction (DeWaters & Powers, 2011).

The instrument designed in the present study adopted the recommendation by Monseur et al. (2011) in which a format of contextualized items might be suitable for assessing complex processes such as scientific literacy. We agreed with the idea that a literacy-related assessment should be conducted using a series of contextualized questions that examine students' understanding of complex materials and processes from various perspectives. More specifically, the instrument used in this study contained contextualized test units with various test items, and empirical analysis demonstrated its suitability to accommodate the full range of student abilities as well as broadly encompass the cognitive, affective, and behavioral characteristics of energy literacy. Incorporating the CBT platform also allowed the contextualized assessment to be more accessible and interesting to the students since students of this generation are generally comfortable with using computers and most schools are equipped with sufficient ICT environments. Finally, it is suggested that the CBT for energy literacy assessment be conducted in a nationwide follow-up study containing longitudinal and multidimensional features of energy literacy for a wider population (e.g., students, teachers, and parents) in order to improve our understanding of the factors that influence energy conservation behaviors and evaluate the effectiveness of energy education as a whole.

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REFERENCES

Alabi, A. T., Issa, A. O., & Oyekunle, R. A. (2012). The use of computer based testing method for the conduct of examinations at the university of ilorin. *International Journal of Learning & Development, 2*(3), 68-80.

Barrow, L. H., & Morrisey, J. T. (1989). Energy literacy of ninth-grade students: a comparison between Maine and New Brunswick. *Journal of Environmental Education, 18*, 15-21.

Bodzin, A. M., Fu, Q., Peffer, T. E., & Kulo, V. (2013). Developing energy literacy in US middle-level ltudents using the geospatial curriculum approach. *International Journal of Science Education, 35*(9), 1561-1589.

Buchner, A., Funke, J., & Berry, D. C. (1995). Negative correlations between control performance and verbalizable knowledge: Indicators for implicit learning in process control tasks?. *The Quarterly Journal of Experimental Psychology, 48*(1), 166-187.

Chawla, L. (1999). Life paths into effective environmental action. *Journal of Environmental Education, 31*(1), 15-26.

Chedid, L. G. (2005). Energy, society, and education, with emphasis on educational technology policy for K-12. *Journal of Science Education and Technology, 14*(1), 75-85.

Chen, K.-L., Huang, S.-H., & Liu, S.-Y. (2013). Devising a framework for energy education in Taiwan using the analytic hierarchy process. *Energy Policy, 55*, 396-403.

Chuang, M.-C., & Ma, H.-W. (2013). An assessment of Taiwan's energy policy using multi-dimensional energy security indicators. *Renewable and Sustainable Energy Reviews, 17*, 301-311.

Clewell, B. C., & Campbell, P. B. (2002). Taking stock: Where we've been, where we are, where we're gone. *Journal of Women and Minorities in Science and Engineer, 8*, 255-284.

Davidson, A. R., Yantis, S., Norwood, M., & Montano, D. E. (1985). Amount of information about the attitude object and attitude–behavior consistency. *Journal of personality and social psychology*, *49*(5), 1184-1198.

DeWaters, J. E., & Powers, S. E. (2008, October). Energy literacy among middle and high school youth. In *Proceedings of the 38th ASEE/IEE Frontiers in Education Conference*.

DeWaters, J., & Powers, S. (2011). Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. *Energy Policy, 39*(3), 1699-1710.

DeWaters, J., & Powers, S. (2012). Establishing measurement criteria for an energy literacy questionnaire. *Journal of Environmental Education, 44*(1), 38-55.

DeWaters, J., Qaqish, B., Graham, M., & Powers, S. (2012). Designing an energy literacy questionnaire for middle and high school youth. *The Journal of Environmental Education, 44*(1), 56-78.

Dias, R. A., Mattos, C. R., & Balestieri, J. A. (2004). Energy education: breaking up the rational energy use barriers. *Energy policy*, *32*(11), 1339-1347.

Directorate-General for Energy and Transport. (2006). *Education on energy-teaching tomorrow's energy consumers.* Retrieved August 22, 2013, from http://www.managenergy.net/dowload/education2005/05-0001-EN.pdf

Elley, W. (Ed.). (1994). *The IEA study of reading literacy: Achievement and instruction in thirty-two school systems.* Oxford, Eng.: Pergamon Press.

Fah, L. Y., Hoon, K. C., Munting, E. T., & Chong, C. A. (2012). Secondary school students' energy literacy: effect of gender and school location. *OIDA International Journal of Sustainable Development, 3*(7), 75-85.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*, 39-50.

Frensch, P. A., & Funke, J. (Eds.). (1995). *Complex problem solving: The European perspective*. Psychology Press.

Gambro, J. S., & Switzky, H. N. (1999). Variables associated with American high school students' knowledge of environmental issues related to energy and pollution. *Journal of Environmental Education, 30*(2), 15-22.

Haertel, G. D., Walberg, H. J., Junker, L., & Pascarella, E. T. (1981). Early adolescent sex differences in science learning: Evidence from the National Assessment of Educational Progress. *American Educational Research Journal*,*18*(3), 329-341.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1999). *Multivariate data analysis*. Englewood Cliffs, NJ: Prentice Hall.

Harlen, W. (2001). The assessment of scientific literacy in the OECD/PISA project. *Studies in Science Education, 36*(1), 79-103.

Hsu, H. G., Huang, W. H., Fu, H. Y., & Teng, T. P. (2010). *Establishing an energy education experience course program in Taiwan.* Paper presented at the 2010 IEEE International Conference on Industrial Engineering and Engineering Management, Macao.

Huang, Y.-H., & Wu, J.-H. (2009). Energy policy in Taiwan: Histroical developments, currents status and potential improvements. *Energies, 2*, 623-645.

Hungerford, H. R., & Volk, T. (1990). Changing learner behavior through environmental education. *Journal of Environmental Education, 21*(3), 8-21.

Kandpal, T. C., & Garg, H. P. (1999). Energy education. *Applied energy*, *64*(1), 71-78.

Keser, O. F., Ozmen, H., & Akdeniz, F. (2003). Energy, environment, and education relationship in developing countries' policies: A case study for Turkey. *Energy Sources, 25*, 123-133.

Lawrenz, F., & Dantchik, A. (1985). Attitudes toward energy among students in grades 4, 7 and high school. *School Science and Mathematics, 85*, 189-202.

Lay, Y.-F., Khoo, C.-H., Tregust, D. F., & Chandrasegaran, A. L. (2013). Assessing secondary school students' understanding of the relevance of energy in their daily lives. *International Journal of Environmental & Science Education, 8*(1), 199-215.

Lee, Y.-W. (2004). Examining passage-related local item dependence (LID) and measurement construct using Q3 statistics in an EFL reading comprehension test. *Language Testing, 21*, 74-100.

Lusardi, A., & Mitchell, O. S. (2007). Baby boomer retirement security: The roles of planning, financial literacy, and housing wealth. *Journal of Monetary Economics*,*54*(1), 205-224.

Marcinkowski, T. J. (1990). The national environmental education act: A renewal of commitment. *Journal of Environmental Education, 22*(2), 7-10.

McBeth, W., Hungerford, H. R., Marcinkowski, T., Volk, T., & Meyers, R. (2008). *National Environmental Literacy Assessment Project: Year 1: National baseline study of middle grades students*, Retrieved August 20, 2013, from http://www.oesd.noaa.gov/NAEE_Report/Final_NELAminusMSELS_8-12-08.pdf

McBeth, W., & Volk, T. L. (2009). The national environmental literacy project: a baseline study of middle grade students in the united states. *The Journal of Environmental Education, 41*(1), 55-67.

MOEA (Ministry of Economic Affiar). (2012). Taiwan's energy policy and supply-demand situation, Retrieved August 20, 2013, from http://web3.moeaboe.gov.tw/ECW_WEBPAGE/webpage/book_en3/index.htm

Monseur, C., Baye, A., Lafontaine, D., & Quittre, V. (2011). PISA test format assessment and the local independence assumption. *Ieri Monographs Series. Issues and Methodologies in Large-Scale Assessments, 4*, 131-155.

Mullis, I. V. S., Martin, M. O., Ruddock, G. J., O'Sullivan, C. Y., Arora, A., & Erberber, E. (2007). *TIMSS 2007 assessment frameworks*. Chestnut Hill, MA: Boston College.

Mullis, I. V. S., Martin, M. O., Smith, T. A., Garden, R. A., Gregory, K. D., Gonzalez, E. J., & O'Connor, K. M. (2003). *TIMSS assessment frameworks and specificantions 2003*. Chestnut Hill, MA: Boston College.

Negev, M., Sagy, G., Garb, Y., Salzberg, A., & Tal, A. (2008). Evaluating the environmental literacy of Israeli elementary and high school students. *Journal of Environmental Education 39*(2), 3-20.

North American Association for Environmental Education (NAAEE). (2011). *Developing a framework for environmental literacy.* Washington, DC: Author.

Nunnally, J. (1978). *Psychometric theory*. New York: McGraw-Hill.

O'Brien, R. M. (2007). A caution regarding rule of thumb for variance inflation factors. *Quality and Quantity, 41*, 679-690.

Organisation for Economic Co-operation and Development (OECD). (2002). *PISA 2000 technical report.* Paris, France: Author.

Organisation for Economic Co-operation and Development (OECD). (2003). *Assessing scientific, reading and mathematical literacy: A framework for PISA 2006*. Paris, France: Author.

Organisation for Economic Co-operation and Development (OECD). (2006). *Assessing scientific, reading and mathematical literacy: A framework for PISA 2006*. Paris, France: Author.

Papadimitriou, V. (2004). Prospective primary teachers' understanding of climate change, greenhouse effect, and ozone layer depletion. *Journal of Science Education and Technology, 13*(2), 299-307.

Roth, C. E. (1992). *Environmental literacy: Its roots, evolution and directions in the 1990s.* Columbus, OH: ERIC: Clearninghouse for Science, Mathematics, and Environmental Education.

Routitsky, A. & Turner, R. (2003) Item format types and their influences on cross-national comparisons of student performance. Paper presented at the *Annual Meeting of the American Educational Research Association*, Chicago.

Shin, D., Chu, H., Lee, E., Ko, H., Lee, M., Kang, K., & Park, J. (2005). An assessment of Korean students' environmental literacy. *Journal of the Korean Earth Science Society, 26*(4), 358-423.

Spiropoulou, D., Antonakaki, T., Kontaxaki, S., & Bouras, S. (2007). Primary teachers' literacy and attitudes on education for sustainable development. *Journal of Science Education and Technology, 16*(5), 443-450

Teksoz, G., Sahin, E., & Tekkaya-Oztekin, C. (2012). Modeling environmental literacy of university students. *Journal of Science Education and Technology,21*(1), 157-166.

Tsai, W.-T. (2005). Current status and development policies on renewable energy technology research in Taiwan. *Renewable and Sustainable Energy Reviews, 9*, 237-253.

Wainer, H. (1990). *Computerized adaptive testing: A primer*. Hillsdale: Lawrence Erlbaum Associates

Wang, W.-C. (2004). Direct estimation of correlation as a measure of association strength using multidimensional item response models. *Educational and Psychological Measurement,64*, 937-955.

Whitmarsh, L., Seyfang, G., & O'Neill, S. (2011). Public engagement with carbon and climate change: To what extent is the public 'carbon capable'? *Global Environmental Change, 21*, 56-65.

Wirth, J. (2008). Computer-based tests: Alternatives for test and item design.*Assessment of competencies in educational contexts*, 235-252.

Wirth, J., & Klieme, E. (2003). Computer-based assessment of problem solving competence. *Assessment in Education: Principles, Policy & Practice, 10*(3) 329-345.

Yeh, H.-C., & Chuang, M.-C. (2009). Taiwan's sustainable energy policy and national energy conference 2009. *Sci-Tech, 7*, 3-16.

Zografakis, N., Menegaki, A. N., & Tsagarakis, K. P. (2008). Effective education for energy efficiency. *Energy Policy, 36*, 3226-3232.

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