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# Assessing secondary school students' understanding of the relevance of energy in their daily lives

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The purpose of this study was to investigate the levels of energy literacy among 276 Form 2 (Grade 8) Malaysian students as no similar study has been previously conducted in the country, as well as the contribution of students' energy-related knowledge and attitudes on their energy-related behaviors. This was a non-experimental quantitative research using the sample survey method to collect data by using the 'Energy Literacy Questionnaire' (ELQ). Independent samples t-test, Pearson product-moment correlation, and multiple linear regressions were used to analyse the data. The study found that levels of energy literacy were relatively low suggesting that the implemented curriculum had failed to meet the specifications of the intended curriculum that emphasises the relevance of energy-related issues to students' everyday life experiences. The authors suggest that there is a need to emphasise the importance of a context-based curriculum specifying criteria that embrace broad energy literacy with benchmarks related not just to science-related energy content but also recognizing the importance of practical energy-related knowledge, decision making skills, value judgments, ethical and moral dimensions, and issues of personal responsibility related to energy resource development and consumption in Malaysia.

**Keywords:** energy-related attitudes; energy-related behaviors; energy-related knowledge; energy concepts; secondary school students

## Introduction

Our reliance on energy-rich sources of fossil fuels has created the underpinnings of modern society enabling mobility, industrial growth, domestic comfort, unprecedented lavish food supply, and economic prosperity. As we move into a future with limited fossil fuels resources and worsening environmental conditions, societies in the developed world are faced with defining new options with respect to energy consumption, energy resources, and a shift toward energy independence (DeWaters & Powers, 2011). The decisions on the choice of options will therefore be determined not just by professionals and politicians, but by every citizen in society who depends on the use of energy in their daily lives and hence needs to be sufficiently well-informed (or energy literate) about energy issues in their daily lives. In the Malaysian context, students should develop an awareness and understanding of the importance of the energy-related issues and the effects of human activities on the depletion of energy sources. This expectation raises the question: How proficient are Malaysian students in translating their understanding of the contents

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of the school science energy curriculum to the everyday issues of energy consumption in their daily lives?

## Theoretical Background

Teaching science in context is generally accepted as relating the science that is learned in school to students' everyday life experiences as a means of developing scientific understanding. This trend has been observed over the last two decades or so in the science curriculum development in several countries (Bennett, Lubben & Hogarth, 2007). In conjunction with this context-based approach, often the idea of *scientific literacy* has also received greater attention. Bennett, Lubben and Hogarth (2007) consider scientific literacy as encompassing the "knowledge, understanding and skills young people need to develop in order to think and act appropriately on scientific matters that may affect their lives and the lives of other members of the local, national, and global communities of which they are a part" (p. 348). In a study comparing the scientific literacy among students in Germany and in the US by Preczewksi, Mittler and Tillotson (2009), the authors specifically suggest the need for teachers to deemphasize classic science content "when attempting to teach towards the enhancement of individuals' scientific literacy; instead the process and interaction with science in natural-world and individualized methods should be the focus" (p. 256).

So, the teaching of energy concepts in context must embody more than just content knowledge for a student to be energy literate. De Waters and Powers (2007) suggest that being energy literate also includes understanding about energy that encompasses affective and behavioral aspects. An energy literate individual is one who has a sound conceptual knowledge base as well as a thorough understanding of how energy is used in everyday life, understands the impact that energy production and consumption have on all spheres of our environment and society, is sympathetic to the need for energy conservation and the need to develop alternatives to fossil fuel-based resources, is cognizant of the impact that personal energy-related decisions and actions have on the global community, and most importantly, strives to make choices and exhibit behaviors that reflect these attitudes with respect to energy resource development and energy consumption. An informed, energy-literate public is more likely to be engaged in the decision-making process, and will be better equipped to make thoughtful, responsible energy-related decisions, choices, and actions. Energy literacy, which encompasses broad content knowledge as well as affective and behavioral characteristics, will empower people to make appropriate energy-related choices and embrace changes in the way they harness and consume energy. Hence, energy literacy is now more than ever an important life skill with which to empower today's students so that they will be better prepared to make appropriate decisions relating to energy sources and consumption in their adult lives.

A number of studies have shown that energy-related knowledge in the US for example, is disparagingly low (e.g., DeWaters & Powers, 2011; Farhar, 1996; Gambro & Switzky, 1999). In their study to measure the understanding of energy concepts of secondary students in New York State, DeWaters and Powers (2011) administered a written questionnaire to 2,708 students. Results indicated that the students were concerned about energy problems (affective dimension mean was 73% of the maximum attainable score), yet relatively low cognitive (42% correct) and behavioral (65% of the maximum attainable scores) suggested that students may lack the knowledge and skills they needed to effectively contribute toward solutions of energy-related issues. In order to address this issue concerning energy problems, Osbaldiston and Schmitz (2011) incorporated a simple program (*Energy Challenge*) in the curriculum aimed at engendering meaningful change in the attitudes, motives, and behaviors of Grade 9 students about home energy usage and conservation. Pretest-posttest mail surveys indicated that the program had a positive effect in improving the students' knowledge, motivation, and behavior related to home energy usage and conservation.

## Rationale and Objectives of the Study

There is extensive mention in the science syllabus issued by the Ministry of Education Malaysia (2003) albeit indirectly, to suggest the relevance of energy concepts in students' everyday lives. In the introduction to the syllabus it is mentioned that "society should … have the capability to manage the environment and its resources in a responsible manner" (p. 1). Following on from this, the introduction continues: "As a discipline of knowledge, science provides a conceptual framework that enables students to understand the world around them. The core science subjects for the primary and lower secondary levels are designed to provide students with basic science knowledge, prepare students to be literate in science," (p. 2), and "Environmental issues and the depletion of natural fuel are highlighted to create an awareness among students that human being has the responsibility to manage the environment wisely and in a sustainable way" (p. 7).

Organised in themes, the syllabus refers to various forms of energy including electrical energy, heat energy and nuclear energy. The theme *Energy for Life,* states: "This theme aims to provide understanding of various forms of energy, its conservation and its importance in life" (p. 11). The theme also covers issues such as (1) sources and forms of energy, (2) depleted sources of energy, (3) alternative and renewable energy, and (4) conservation of energy. Another theme, *Balance and Management of the Environment* "aims to provide understanding on the balance of nature and the interdependence among living things and the environment, the natural cycles in nature and the effects of unsystematic management of the environment. The theme also develops awareness that human beings play an important role in the conservation and preservation of nature and have the responsibility to manage nature wisely." (p. 13).

Although societal interest and investment in energy literacy is substantial and likely to increase, no researchers have comprehensively assessed energy literacy among Malaysian secondary school students. Hence, this study is crucial as it addresses the extent to which students are able to apply their knowledge about energy concepts learned in school science to energy issues that affect their daily lives. This study involving Form 2 (Grade 8) secondary school students was conducted with the view to address the following research questions (RQs):

> RQ 1: To what extent does the Malaysian secondary science curriculum facilitate Form 2 students in displaying their knowledge, concern and behavior about energy-related issues in their daily lives?
>
> RQ 2: What is the difference, if any, in the students' proficiency in displaying their knowledge, concern and behavior about energy-related issues in their daily lives based on gender?
>
> RQ 3: What is the difference, if any, in the students' proficiency in displaying their knowledge, concern and behavior about energy-related issues in their daily lives based on school location?

## Methodology

### *Research Design*

The study involved a non-experimental quantitative research method. Non-experimental research is a systematic empirical inquiry in which the researcher does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulable. Hence, inferences about relations among variables are made, without direct intervention, from concomitant variation of independent and dependent variables (Johnson & Christensen, 2000). The sample survey method was used to collect data using a modified version of the *Energy Literacy Questionnaire* (*ELQ*) to measure Form 2 students' energy literacy in terms of cognitive, affective, and behavioral dimensions (DeWaters & Powers, 2008).

*Research Samples*

The participants in this study were 276 Form 2 students, randomly selected by the cluster random sampling technique, from rural and urban secondary schools in the state of Sabah in Malaysia. The distribution of Form 2 students according to gender and school location is summarised in Table 1 below:

Table 1. Distribution of Form 2 Students according to Gender and School Location

| | Gender | | School location | |
|---|---|---|---|---|
| | Male | Female | Urban | Rural |
| No. of students | 119 | 157 | 127 | 149 |
| Percentage | 43.1 | 56.9 | 46.0 | 54.0 |

*Instrumentation*

A modified version of the *Energy Literacy Questionnaire (ELQ)* that was developed by DeWaters and Powers (2008) was administered to the 276 Form 2 students who were involved in this study. The *ELQ* is designed for classroom administration and is closely aligned with criteria that describe energy literacy in terms of students' broad energy-related knowledge and cognitive skills, affective aspects such attitudes and values, and behaviors.

The 56-item *ELQ* contains three subscales to encompass energy-related affective (17 items), behavioral (10 items), and cognitive (29 items) aspects. The affective subscale used a 5-point Likert-type scale ranging from 1 to 5 for the responses 'Strongly disagree, Disagree, Not sure, Agree and Strongly agree'. Similarly, the behavioral subscales also used a 5-point Likert-type scale ranging from 1 to 5 for the responses 'Hardly ever or Never, Not very often, Sometimes, Quite frequently and Almost always'. The cognitive subscales used 5-option multiple-choice questions to cover eight main topic areas that encompass basic energy science concepts as well as the *citizenship knowledge* of energy that is crucial to everyday life, in addition to cognitive skills such as critical thinking and analysis. The topic areas include: (1) saving energy; (2) energy forms, conversions, and units; (3) home energy use; (4) basic energy concepts; (5) energy resources; (6) critical analysis about renewable resources; (7) environmental impacts; and (8) energy-related societal issues. The 30 multiple-choice items in the cognitive subscale are found in Table 4. The original version of the *ELQ* was developed according to established psychometric principles and methodologies in the sociological and educational sciences (e.g., DeVellis, 2003; Qaqish, 2006). The internal consistency reliability of each subscale, as measured by Cronbach's alpha reliability coefficient, was 0.79 (cognitive subscale), 0.83 (affective subscale), and 0.78 (behavioral subscale), all satisfying generally accepted criteria for internal consistency.

*Data Collection Procedures*

Before administering the *ELQ*, formal permission from the related authorities was sought and obtained. The *ELQ* was concurrently administered to the 276 students by the first two authors.

The students were briefed about the nature of the questionnaire and how the items were to be answered. It took the students about 50 minutes to complete the *ELQ*.

*Data Analysis Procedures*

The data were converted to numeral scores ranging from 1 to 5 for the items in the affective and behavioral domains based on students'responses as mentioned previously. Blank responses in these two subscales were omitted case-wise from the analysis. Items in the cognitive domain were scored '1' if correct and '0' if incorrect. In order to ensure that all the quantitative data were drawn from a normally distributed population, graphical measures such as histogram, stem-and-leaf plot, normal Q-Q plot, and detrended normal Q-Q plot were plotted for each of the variables studied. Furthermore, numerical measures such as skewness and kurtosis were used to identify any deviations from normal distributions (Hair, Anderson, Tatham, & Black, 1998; Miles & Shevlin, 2001). The data were then analysed using the SPSS software package (version 16).

Responses to each of the three subscales were analyzed separately: Student scores were summed across each subscale, with maximum scores of 29 on the cognitive, 85 on the affective, and 50 on the behavioral subscales. Item mean responses (ranging from 1 to 5) were calculated for the Likert-type affective and behavioral subscales. The percentage of correct responses to the items in the cognitive dimension was also computed.

Independent samples *t*-test analyses were used to determine if there was significant difference in the students' energy literacy based on gender and school location at a predetermined significance level of 0.05. Pearson's product-moment correlation coefficients (*r*) were computed to identify any significant linear relationships between the cognitive, affective, and behavioral domains of energy literacy.

A multiple regresssion analysis was next performed to investigate the contribution of the cognitive and affective domains to the behavioral domain of energy literacy when all other independent variables were held constant. Stepwise variables selection method was used in order to get a parsimonious model which could explain most of the variance in the dependent variable by using the least number of independent variables. Assumptions namely normality, homoscedasticity, linearity, and independence were met prior to the multiple regression analysis. Besides that, distance statistics (leverage measure and Cook's distance) and influence statistics (DfBeta and DfFit) were used to identify any outliers and influential observations in the data. To detect multicollinearity among the independent variables used in this study, correlation matrices, Tolerance (T) and Variance Inflation Factor (VIF) were used (Hair *et al*., 1998).

## Results and Discussion

*Validity and Reliability of the Energy Literacy Questionnaire (ELQ)*

The original version of the *ELQ* (DeWaters & Powers, 2008) was shown to be a valid and reliable quantitative measure of the cognitive, affective and behavioral dimensions of energy literacy with acceptable Cronbach's alpha coefficient values mentioned previously. The Cronbach's alpha reliabilities obtained for the *ELQ* in this study are summarised in Table 2.

*Form 2 Students' Understanding of Energy Concepts*

The maximum percentage scores achieved by the students on the *ELQ* in descending order were as follows: Affective domain (72.71%), behavioral domain (71.24%), and cognitive domain (32.66%). The results indicate that, overall, the students' understanding of the energy concepts was discouragingly low, particularly with respect to their performance on the cognitive questions.

Table 2. Cronbach's Alpha Reliability Coefficients of the Energy Literacy Questionnaire (ELQ)

| Subscales | Item Nos. | Cronbach's Alpha Reliability |
|---|---|---|
| Knowledge dimension (cognitive) | C1 to C29 | 0.50 |
| Attitudes dimension (Affective) | A1 to A17 | 0.85 |
| Behavior dimension (Behavioral) | B1 to B10 | 0.78 |
| Overall | | 0.86 |

Table 3. Means and Standard Deviations of Students' Energy Literacy

| Dimensions | Number of items | Maximum attainable scores | % of the maximum attainable scores | Dimension m | Dimension sd |
|---|---|---|---|---|---|
| Cognitive | 29 | 29 | 32.66 | 9.47 | 3.34 |
| Affective | 17 | 85 | 72.71 | 61.80 | 12.01 |
| Behavioral | 10 | 50 | 71.24 | 35.62 | 7.82 |
| Overall *ELQ* | 57 | 164 | 64.78 | 106.88 | 18.73 |

In general, the overall student performance on each dimension, with students scoring lowest on the cognitive dimension and highest on the affective dimension, is consistent with earlier findings from the study of DeWaters and Powers (2011). DeWaters and Powers (2011) found that students were concerned about energy problems (affective dimension mean 73% of the maximum attainable score), yet displayed relatively low cognitive (42% correct) and behavioral (65% of the maximum scores) understanding suggesting that the students may have lacked the knowledge and skills needed to effectively contribute toward energy solutions in the environment. Table 4, 5, and 6 summarise the Form 2 students' responses on the energy-related knowledge, attitudes and behaviors items.

On average the Form 2 students' scores on the affective dimension, while not particularly high, are much better than cognitive or behavioral scores. The students generally acknowledge the existence of an energy problem and accept the need to conserve energy and increase the use of renewable resources. Students' generally positive attitudes and values regarding energy are apparent. Most students agreed that saving energy is important (83.3%) that Malaysians should conserve more energy (74.6%) and that more of our electricity should come from renewable energy sources (63.0%). However, their agreement drops substantially if an increase in cost is involved (44.6%). Students also expressed a willingness to be part of the solution: 77.9% agreed that they would do more to save energy if they knew how, they believed that they could contribute to solving the energy problems by making appropriate energy-related choices and actions (67.5%), and they believed that they could contribute to solving energy problems by working with others (70.3%).

Although students indicated they would do more, their responses on the behavioral dimension did not generally reflect their positive attitudes (Table 6). Similar to findings from earlier studies among American consumers (e.g., Bang *et al*., 2000; Costanzo *et al*., 1986; Farhar,

Table 4. Form 2 Students' Responses to the Energy-Related Knowledge Items

| Items | Energy-related knowledge items | Correct responses (%) |
|---|---|---|
| C1 | Each and every action on Earth involves ____________ .<br>Answer: *energy* | 69.9 |
| C2 | The original source of energy for almost all living things on Earth is _______ .<br>Answer: *Sun* | 50.4 |
| C3 | Which of the following statements best defines energy?<br>Answer: *The ability to do work.* | **35.5** |
| C4 | How do you know that a piece of wood has stored chemical potential energy?<br>Answer: *It releases heat when burned.* | **31.5** |
| C5 | All of the following are forms of energy except ________ .<br>Answer: *coal* | **30.1** |
| C6 | The amount of electrical energy (electricity) we use is measured in units called _________ .<br>Answer: *Kilowatt-hours (kWh)* | **13.0** |
| C7 | Which two things determine the amount of electrical energy (electricity) an electrical appliance will consume?<br>Answer: *The power rating of the appliance (watts or kilowatts), and the length of time it is turned on.* | **37.3** |
| C8 | When you turn on an incandescent light bulb, some of the energy is converted into light and the rest is converted into ________ .<br>Answer: *Heat* | 59.8 |
| C9 | What does it mean if an electric power plant is 35% efficient?<br>Answer: *For every 100 units of energy that go into the plant, 35 units are converted into electrical energy.* | **21.0** |
| C10 | It is impossible to _____________________________ .<br>Answer: *build a machine that produces more energy than it uses* | **13.8** |
| C11 | The term "renewable energy resources" means _________ .<br>Answer: *resources that can be replenished by nature in a short period of time* | **8.7** |
| C12 | Which of the following energy resource is not renewable?<br>Answer: *Coal* | **35.9** |
| C13 | Which resource provides about 85% of the energy used in developed countries like Malaysia and Europe?<br>Answer: *Fossil fuel* | **12.3** |
| C14 | Most of the renewable energy used in Malaysia comes from ________ .<br>Answer: *water (hydro) power* | **34.4** |
| C15 | Over the last 10 years, petroleum imports to Malaysia from other countries have _________ .<br>A. steadily increased<br>C. become more expensive<br>Answer: *Both A and C* | **21.7** |
| C16 | Scientists say the single fastest and most cost-effective way to address our energy needs is to ______________________________ .<br>Answer: *promote energy conservation* | **33.3** |
| C17 | Which is the most abundant fossil fuel found in Malaysia?<br>Answer: *Coal* | **36.6** |
| C18 | Some people think that if we run out of fossil fuels, we can just switch over to electric cars. What is wrong with this idea?<br>Answer: *Most electricity is currently produced from fossil fuels (coal, oil, natural gas)* | **21.7** |
| C19 | If a person travelled alone to work 30 miles every day and wanted to save gasoline, | **47.5** |

| | | |
|---|---|---|
| | which one of the following options would save the most gasoline?<br>Answer: *Carpooling to and from work with one other person.* | |
| C20 | Which of the following choices always saves energy?<br>Answer: *Turning off the care engine when the car is stopped for 15 seconds or more.* | **47.5** |
| C21 | Which uses the most energy in the average Malaysian home in one year?<br>Answer: *Heating and cooling rooms* | **22.8** |
| C22 | Which uses the least energy in the average Malaysian home in one year?<br>Answer: *Lighting the home* | **19.2** |
| C23 | Which of the following items uses the most electricity in the average Malaysian home in one year?<br>Answer: *Refrigerator* | **38.8** |
| C24 | Which resource provides most of the energy used in Malaysia each year?<br>Answer: *Petroleum* | **39.9** |
| C25 | Most of the electricity produced in Malaysia comes from ______________ .<br>Answer: *burning coal* | **34.1** |
| C26 | One advantage to using nuclear power instead of coal or petroleum for energy is that ________________________________ .<br>Answer: *there is less air pollution* | **23.2** |
| C27 | Many scientists say the Earth's average temperature is increasing. They say that one important cause of this change is<br>Answer: *increasing carbon dioxide concentration from burning fossil fuels* | 53.3 |
| C28 | Which of the following energy-related activities is least harmful to human health and the environment?<br>Answer: *Generating electricity with photovoltaic (solar) cells* | **30.1** |
| C29 | Which of the following choices is not a biofuel?<br>Answwre: *Gasoline* | **23.6** |

1996; Murphy, 2002), there appears to be a discrepancy between students' attitudes and their actions. For example, survey research by Costanzo *et al*. (1986) found that consumers who indicated conservation as the single most important strategy for improving our energy future were no more likely than others to engage in energy-conservation behaviors. An older study by Milstein (1977) found that, while the majority of the American public was aware of the nation's energy problems, and most indicated that they preferred to save fuel by carpooling, using public transport, or reducing highway speed, few actually reported doing these things. Like the subjects of these earlier studies, the Form 2 students who participated in this study seemed to be concerned about the energy problems faced by their society, yet they apparently lacked the knowledge and skills to work effectively toward a solution.

*The relationship between the cognitive, affective, and behavioral dimensions of energy concepts*

Correlation analysis results in Table 7 showed that there was low but significant, positive correlations among the cognitive, affective, and behavioral dimensions of energy literacy and overall energy literacy. On the other hand, all the three dimensions of energy literacy were positively and significantly correlated with Form 2 students' overall energy literacy.

These findings support the complex interactions between the several factors that influence energy-related behaviors and emphasize the importance of taking a broad educational approach that targets not just content knowledge but students' attitudes, values, and behaviors as well in order to improve students' overall energy literacy. According to DeWaters and Powers (2011), intercorrelations between groups of questions indicate energy-related behaviors are more strongly related to affect than to knowledge. These findings underscore the need for education that improves energy literacy by impacting student attitudes, values and behaviors, as well as broad content knowledge. They suggest that affect and behavior are more closely correlated than knowledge and behavior.

Table 5. Form 2 Students' Responses on the Energy-Related Attitudes Items

| Items | Energy-related attitudes items | Responses | | | | |
|---|---|---|---|---|---|---|
| | | SD (%) | D (%) | N (%) | A (%) | SA (%) |
| A1 | Energy education should be an important part of every school's curriculum. | 6.5 | 13.8 | 8.0 | **38.4** | 33.3 |
| A2 | I would do more to save energy if I knew how. | 8.0 | 6.9 | 7.2 | 32.2 | **45.7** |
| A3 | Saving energy is important. | 11.6 | 1.8 | 3.3 | 9.4 | **73.9** |
| A4* | The way I personally use energy does not really make a difference to the energy problems that face our nation. | **32.3** | 19.2 | 24.6 | 15.6 | 8.3 |
| A5* | I don't need to worry about turning the lights or computers off in the classroom, because the school pays for the electricity. | **63.4** | 8.0 | 9.4 | 5.1 | 14.1 |
| A6 | Malaysians should conserve more energy. | 9.4 | 9.1 | 6.9 | 20.3 | **54.3** |
| A7* | We don't have to worry about conserving energy, because new technologies will be developed to solve the energy problems for future generations. | **38.0** | 21.7 | 15.9 | 15.2 | 9.1 |
| A8 | All electrical appliances should have a label that shows the resources used in making them, their energy requirements, and operating costs. | 8.7 | 8.0 | 14.9 | 30.1 | **38.4** |
| A9 | The government should have stronger restrictions about the gas mileage of new cars. | 13.8 | 17.8 | 27.5 | **27.9** | 13.0 |
| A10 | We should make more of our electricity from renewable resources. | 8.3 | 11.6 | 17.0 | **33.3** | 29.7 |
| A11 | Malaysia should develop more ways of using renewable energy, even if it means that energy will cost more. | 12.3 | 19.9 | 23.2 | **31.2** | 13.4 |
| A12 | Efforts to develop renewable energy technologies are more important than efforts to find and develop new sources of fossil fuels. | 8.0 | 18.5 | 23.2 | **29.3** | 21.0 |
| A13* | Laws protecting the natural environment should be made less strict in order to allow more energy to be produced. | **41.3** | 18.1 | 10.9 | 12.7 | 17.0 |
| A14 | More wind farms should be built to generate electricity, even if the wind farms are located in scenic valleys, farmlands, and wildlife areas. | 14.5 | 19.6 | 17.8 | **31.2** | 17.0 |
| A15* | More oil fields should be developed as they are discovered, even if they are located in areas protected by environmental laws. | **23.9** | 18.8 | 23.6 | 18.8 | 14.9 |
| A16 | I believe that I can contribute to solving the energy problems by making appropriate energy-related choices and actions. | 5.8 | 12.3 | 14.5 | **35.6** | 31.9 |
| A17 | I believe that I can contribute to solving energy problems by working with others. | 8.3 | 12.7 | 8.7 | 30.1 | **40.2** |

*negatively-phrased items

Early models of environmental behavior assumed, in the simplest sense, the widely held position that education and knowledge lead to changes in attitudes and values, which in turn foster action or behavior. In fact, a handful of studies provide evidence that support the relationship between knowledge of and attitudes toward environmental issues (e.g., Costanzo *et al*., 1986; Murphy, 2002). Furthermore, early behavior models developed by Fishbein and Ajzen (1975) and modified by Ajzen (1991) hypothesised that behavior is predicted by a person's beliefs, attitudes, subjective norm, and perceived behavioral control, or feelings of self-efficacy. However, the majority of research in environmental behavior has not supported the quasi-linear cause-and-effect models that link knowledge and attitude to behavior. Most findings indicate that the relationship is complex, not necessarily one-directional, and is influenced by other factors such as positive/negative feedback, social norms, economic situations, values, and beliefs (e.g., Hungerford & Volk, 1990; Newhouse, 1990; Stern, 2000; Owen & Driffill, 2008).

Table 6. Form 2 Students' Responses on the Energy-Related Behaviors Items

| Items | Energy-related behaviors items | Responses | | | | |
|---|---|---|---|---|---|---|
| | | Hardly ever or Never (%) | Not very often (%) | Sometimes(%) | Quite Frequently (%) | Almost always or always (%) |
| B1 | I try to save water. | 6.2 | 8.0 | 22.8 | 31.9 | 31.2 |
| B2 | I walk or bike to go short distances, instead of asking for a ride in the car. | 19.2 | 11.6 | 15.2 | 15.6 | 38.4 |
| B3 | When I leave a room, I turn off the lights. | 12.0 | 6.9 | 17.4 | 21.7 | 42.0 |
| B4 | I turn off the computer when it is not being used. | 11.6 | 6.9 | 13.0 | 15.6 | 52.9 |
| B5 | Many of my everyday decisions are affected by my thoughts on energy use. | 6.5 | 17.0 | 41.7 | 21.4 | 13.4 |
| B6 | My family turns the heat down at night or the air conditioner temperature up when we are not home to save energy. | 13.4 | 6.5 | 5.8 | 9.1 | 65.2 |
| B7 | I am willing to encourage my family to turn the heat down or the air conditioner temperature up when wee're not home to save energy. | 14.1 | 7.6 | 9.8 | 20.3 | 48.2 |
| B8 | My family buys energy efficient compact fluo-rescent light bulbs. | 14.5 | 16.7 | 18.8 | 24.6 | 25.4 |
| B9 | I am willing to encourage my family to buy en-ergy efficient compact fluorescent light bulbs. | 15.2 | 12.7 | 25.0 | 26.4 | 20.7 |
| B10 | I am willing to buy fewer things in order to save energy. | 9.1 | 18.8 | 33.0 | 21.7 | 17.4 |

*The Contribution of the Cognitive and Affective Dimensions to the Behavioral Dimension of Energy Literacy among Form 2 Students*

Stepwise multiple regression analysis results (see Table 8) showed that the affective dimension of energy literacy significantly contributed to the Form 2 students' energy-related behaviors [$F(1,274) = 147.17$, $p < 0.01$]. Based on the $R^2$ value, the affective dimension of energy literacy explains 34.9% of the variance in the From 2 students' energy-related behaviors.

The role of student affect in determining responsible energy-related behavior cannot be overlooked. If energy literacy encompasses not only knowledge but attitudes, values, decisions, and action (Kuhn, 1979), then one of the primary goals of energy education is to foster positive

Table 7. Pearson's Product Moment Correlations among Cognitive, Affective, and Behavioral Dimensions of Energy Literacy

| | Cognitive dimension | Affective dimension | Behavioral dimension | Overall Energy Literacy |
|---|---|---|---|---|
| Cognitive dimension | - | 0.21** | 0.12* | 0.36** |
| Affective dimension | | - | 0.59** | 0.93** |
| Behavioral dimension | | | - | 0.82** |

*$p < 0.05$, ** $p < 0.01$

attitudes toward energy conservation (Lawrenz & Dantchik, 1985) and to improve students' critical thinking and decision-making skills. Studies that show positive changes in energy-related behaviors after participating in an educational program (e.g., Volk & Cheak, 2003; Zografakis *et al*., 2008) often involve programs that use relevant projects, case studies, decision-making exercises, and action strategies to emphasise a shift in student values, beliefs, and attitudes. The results described in this study tend to suggest that the Malaysian educational system could be doing more to impact student attitudes toward energy issues, which may in turn help improve their conservation behaviors.

Table 8. Multiple Regression Analysis Results for Energy Literacy Data

| Predictor variables | B | SE | β | t |
|---|---|---|---|---|
| Constant | 11.88 | 2.12 | | **5.61 |
| Cognitive dimension | -0.01 | 0.12 | -0.00 | -0.09 |
| Affective dimension | 0.39 | 0.03 | 0.59 | **11.86 |

** $p < 0.01$

*Mean Differences in Form 2 Students' Understanding of Energy Concepts Based on Gender*

Independent samples *t*-test analyses results showed that there was no significant difference based on gender, in the Form 2 students' overall understanding of energy concepts as well as in the cognitive, affective and behavioral dimensions (see Table 9 and Figure 1). Generally, the male Form 2 students demonstrated more energy-related knowledge, more energy-related behaviors and higher understanding of energy concepts as compared to their female counterparts. Female Form 2 students displayed more positive energy-related attitudes than their male counterparts. However, the differences were not statistically significant.

Table 9. Analysis of Form 2 Students' Responses based on Gender

| Dimensions | Gender | n | m | sd | Mean Difference | t | p |
|---|---|---|---|---|---|---|---|
| Cognitive | Male | 119 | 9.50 | 3.82 | 0.07 | 0.15 | 0.88 |
| | Female | 157 | 9.44 | 2.94 | | | |
| Affective | Male | 119 | 61.47 | 2.46 | -0.58 | -0.40 | 0.69 |
| | Female | 157 | 62.05 | 1.69 | | | |
| Behavioral | Male | 119 | 35.96 | 7.64 | 0.60 | 0.63 | 0.53 |
| | Female | 157 | 35.36 | 7.98 | | | |
| Overall understanding | Male | 119 | 106.93 | 19.20 | 0.09 | 0.04 | 0.97 |
| | Female | 157 | 106.85 | 18.43 | | | |

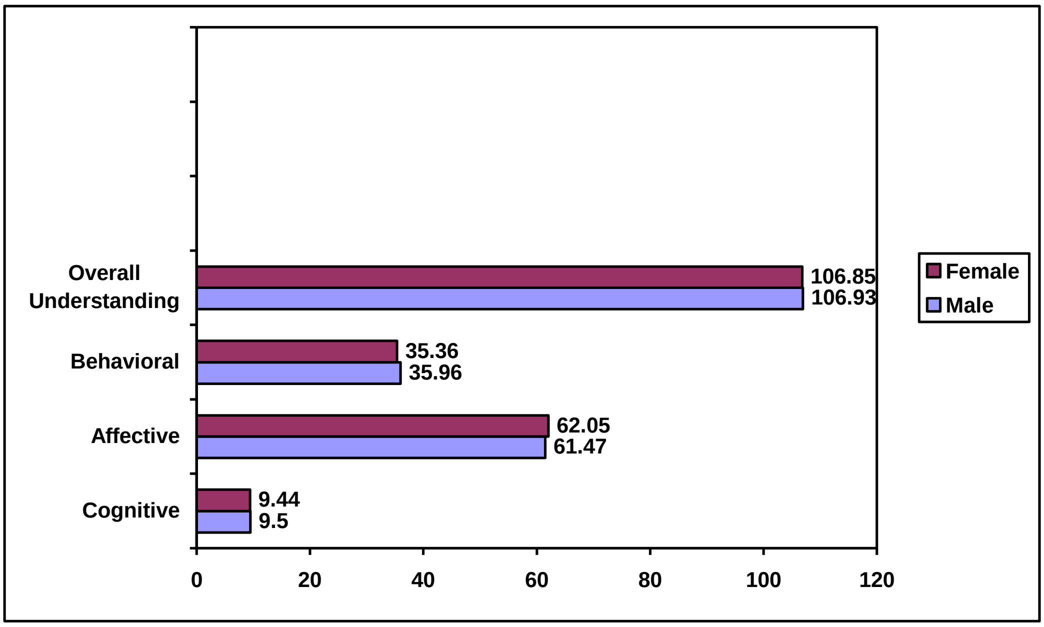


Figure 1. Mean scores of form 2 students' understanding of energy concepts based on gender

DeWaters and Powers (2011) found that female students had significantly more positive energy-related attitudes and values than males, yet there was no difference in their cognitive or behavior scores. Gender differences were only apparent in the affective dimension of the survey, with female students showing significantly greater positive attitudes and values toward energy issues than males. Earlier studies have also shown that females tend to have a greater positive attitude toward energy issues than males (e.g., Ayers, 1977; Barrow & Morrisey, 1987; Lawrenz & Dantchik, 1985), are more concerned with the need for energy conservation, and more strongly recognise the importance of individual efforts (Kuhn, 1979). For example, Ayers (1977) found females to be more cautious in their feelings toward the production of electricity. Kuhn (1979) attributed the observed gender effects to differences in the "attitudes and value systems" of the subjects.

Like several other studies (e.g., Barrow & Morrisey, 1989; Gambro & Switzky, 1999), the study by Lawrenz (1983) also found gender disparities in energy and environmentally-related knowledge. These previous findings reflect general trends of gender differentiation in science achievement, and increased differentiation as students progressed through school, that is well documented (e.g., Clewell & Campbell, 2002; Haertel *et al*., 1981). The lack of gender-based cognitive differences in this current study is encouraging, and will be corroborated in the future as the survey is applied to a greater variety of student groups.

*Mean Differences in Form 2 Students' Understanding of Energy Concepts based on School Location*

As shown in Table 10 and Figure 2, independent samples *t*-test analyses results showed that there was significant difference in the overall as well as the cognitive, affective, and behavioral dimensions of the Form 2 students' understanding of energy concepts based on school location. Generally, rural secondary school students demonstrated higher energy-related knowledge as compared to their urban Form 2 counterparts. Urban Form 2 students demonstrated better overall understanding of energy concepts as well as better knowledge and more positive energy-related attitudes and behaviors, as compared to their rural counterparts.

Table 10. Analysis of Form 2 Students' Responses based on School Location

| Dimensions | School Location | n | m | sd | Mean Difference | t |
|---|---|---|---|---|---|---|
| Cognitve | Urban | 127 | 9.01 | 3.49 | 0.85 | 2.125* |
| | Rural | 149 | 9.86 | 3.16 | | |
| Affective | Urban | 127 | 64.94 | 8.33 | -5.81 | -4.279** |
| | Rural | 149 | 59.13 | 13.90 | | |
| Behavioral | Urban | 127 | 37.39 | 6.76 | -3.29 | -3.618** |
| | Rural | 149 | 34.10 | 8.36 | | |
| Energy Literacy | Urban | 127 | 111.34 | 13.00 | -8.25 | -3.878** |
| | Rural | 149 | 103.09 | 21.82 | | |

*$p < 0.05$; ** $p < 0.01$

## Conclusion

Our intent is that the answers to the research questions will inform the future development of energy-related educational curricular and materials, thereby improving students' overall energy literacy and empowering them to be more engaged in energy-related decisions as they become adults. With respect to Research Question 1 (To what extent does the Malaysian secondary science curriculum facilitate Form 2 students in displaying their knowledge, concern and behavior about energy-related issues in their daily lives?), this study has shown that energy literacy levels among Malaysian Form 2 students especially in the state of Sabah are discouragingly low. Scores were particularly low on topical questions related to current events, home energy use, and energy conservation. It appears that the implemented curriculum has failed to meet the specifications of the intended curriculum that emphasises the relevance of energy-related issues to students' everyday life experiences. These results emphasise the need for improved energy education programs in Malaysian public schools, with broader coverage of topics related to current events and practical issues, such as the way we use energy in everyday life. The next revision of the

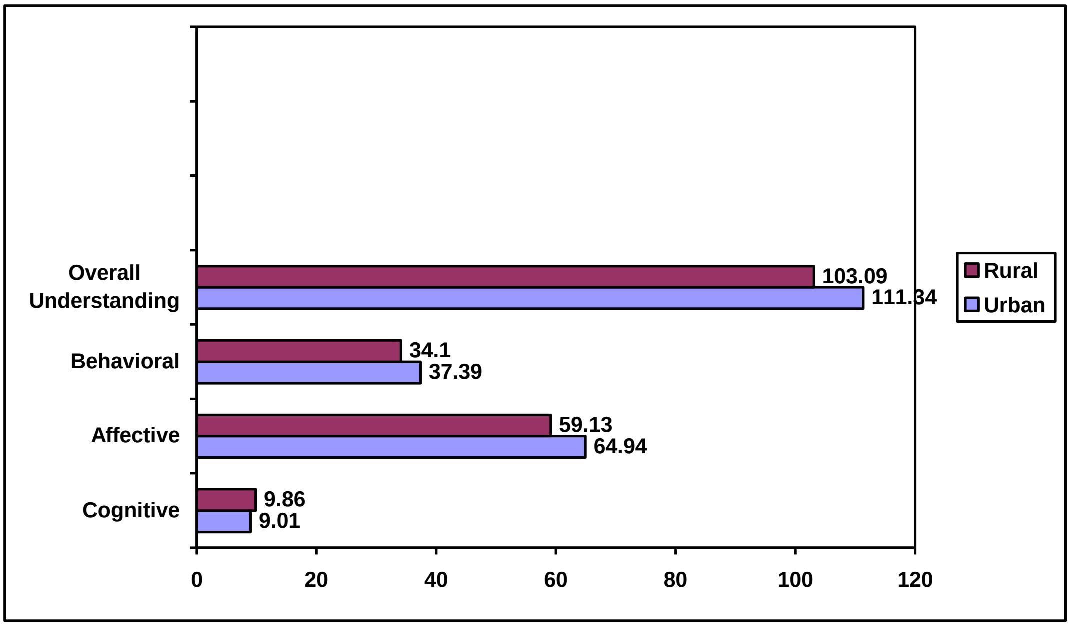


Figure 2. Mean scores of form 2 students' understanding of energy concepts based on school location

secondary school science syllabus should emphasise the importance of a context-based curriculum specifying criteria that embrace broad energy literacy with benchmarks related not just to science-related energy content but also recognising the importance of practical energy-related knowledge, decision making skills, value judgments, ethical and moral dimensions, and issues of personal responsibility related to energy resource development and consumption.

High correlations between students' energy-related affect and their energy consumption behaviors, in contrast with low correlations between cognitive and behavioral aspects, suggest that effective educational programs should target not just content knowledge, but should also strive to impact student attitudes, beliefs, and values. Energy curricula should be hands-on, inquiry-based, experiential, engaging, and as mentioned earlier, should involve real-world problem solving, providing an avenue for students to learn content-based material while they are engaged in projects that relate to their own lives. Besides that, curricula should use relevant projects, case studies, decision-making exercises, and action strategies to emphasise a shift in student values, beliefs, and attitudes (Ramsey & Hungerford, 1989; Volk & Cheak, 2003; Zografakis *et al*., 2008).

With respect to Research Question 2 (What is the difference, if any, in the students' proficiency in displaying their knowledge, concern and behavior about energy-related issues in their daily lives based on gender?), the difference between male and female students' overall energy literacy was negligible and not significant; the same was true for the three dimensions. As for Research Question 3 (What is the difference, if any, in the students' proficiency in displaying their knowledge, concern and behavior about energy-related issues in their daily lives based on school location?), students from urban schools seemed to be more 'energy literate' than their rural counterparts suggesting the need for greater efforts to bring about changes in the attitudes of rural students in order that they may act more responsibly towards conserving the environment, particulary by making them more aware of the energy cycle in nature in relation to the extensive deforestation that is occurring in several developing countries.

In conclusion, we would like to emphasise that the Malaysian science curriculum clearly emphasises the need to manage the environment and its resources in a responsible manner. What is lacking is probably the awareness among teachers about the need to relate this emphasis in the curriculum to the energy cycle in nature. We therefore, recommend that steps be taken to provide teachers with relevant instructional materials that will enable them to emphasise the relevance of energy-related concepts using a context-based approach so that the aims of the seconday school science curriculum with respect to the energy cycle in nature may be achieved as intended.

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