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Energy Literacy Assessment: A Comparative Study of Lower Secondary School Students in Thailand and Japan*

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Abstract: Understanding the structure of energy literacy is of importance to provide an effective energy education. This article reports the difference in attributes of energy literacy by applying the energy literacy structural model proposed in our previous study through lower secondary school students in Thailand (N = 635) and Japan (N = 1070). Results indicated that Thai students scored higher than those of Japan except the basic energy knowledge and awareness of consequences. On the other hand, the amount of basic energy knowledge did not affect to increase the entire energy literacy of Japanese students. Moreover, mean values of Japan tended to decrease with the school year progression. The energy literacy model was able to support our previous outcome that the awareness of consequences plays a critical role to link between basic energy knowledge and energy-saving behavior. The social expectations or pressures may affect the structure of energy literacy of Thai students. This study suggested that the energy education required in Thailand is to enable students to derive solutions by their own critical thinking based on knowledge relevant to the energy and environmental issues. While, for Japan, it may be necessary to implement energy education as early as possible to enhance students' awareness of consequences in an appropriate manner incorporating with family participation and visiting energy-related facility. These findings contribute the development of energy education for improving energy literacy in an effective manner.

Keywords: *Energy literacy model, the Theory of Planned Behavior, the Value-Belief-Norm Theory, lower secondary students, Thailand and Japan.*

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Introduction

Few can dispute the importance and urgency of the Paris Agreement at Conference of the Parties, Twenty-first session (COP 21) which calls for all countries and their participation to cooperate with the problem solving for global climate change (United Nations, 2015). In particular, tackling energy issues is of significance to reduce greenhouse gas emissions and mitigate the deterioration of global environment. For that, people's energy literacy is critically required because energy issues intertwine scientific, technical, societal, psychological, economic, and environmental aspects of daily life (DeWaters & Powers, 2011), and every single individual is involved the issues. Hence, energy literacy is one of the greatest potential resources for solving global energy and environmental (EE) issues (DeWaters & Powers, 2011).

Definition of Energy Literacy

Today, literacy is not just knowledge but also "a way of being - curious, objective, and capable of assessing and applying information and skills to make sound decision and actions" (DeWaters & Powers, 2013, p. 41). The functional literacy is a public culture which is educated, cultivated, and sophisticated through school education to form the basis of social independence of individuals (Sato, 2003). And literacy contributes to understand and identify the issues to be solved, to make a decision, and to take an action. Hence, energy literacy can be considered a common culture to address energy issues and will be cultivated through education as a fundamental competency of people concerning energy problem-solving. Several agents and researchers have defined energy literacy or set a goal of energy education (e.g., Barrow & Morrisey, 1989; DeWaters & Powers, 2013; Office of Energy Efficiency & Renewable Energy, U.S., 2019; Hashiba et al., 2010; Information Center for Energy and Environment Education [ICEEE], 2013). Definition of energy literacy ranges broadly from an energy-use of individual in everyday life to national and global issues. It is obvious that the participation of well energy-literate citizen in discussions on energy policy is expected. In this study, we defined an energy-literate individual as one who:

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- recognizes comprehensive energy process from resource productions to energy distributions through energy transportation, conversion, storage, and the waste management;
- understands the impact of our energy choices on economic efficiency, energy security, and the environment;
- is aware of the necessity and effectiveness of individual contributions to the energy-related problem-solving for developing sustainable society;
- strives to improve individual's knowledge, skills, and ability to understand energy-related information;
- cooperates with everyone addressing the energy-related problem-solving, and
- continues an appropriate action for energy-saving.

Although no one denies the need of energy education, unfortunately, a given time for energy education is limited in a tight school curriculum in Japan. Therefore, to provide an effective educational manner, it is needed to understand both the current status and structure of people's energy literacy through the investigation in different attributes. In particular, understanding the relation between the knowledge and behaviors is of critical importance (Akitsu & Ishihara, 2018). We need to examine these matters objectively and theoretically.

Energy Literacy Modeling

In the previous study, we have proposed the hypothesis model of energy literacy structure by integrating with the Theory of Planned Behavior (TPB: Ajzen, 1991, 2019a) and the Value-Belief-Norm Theory (VBN: Stern, Dietz, Abel, Guagnano & Kalof, 1999; Stern, 2000) (Figure 1).

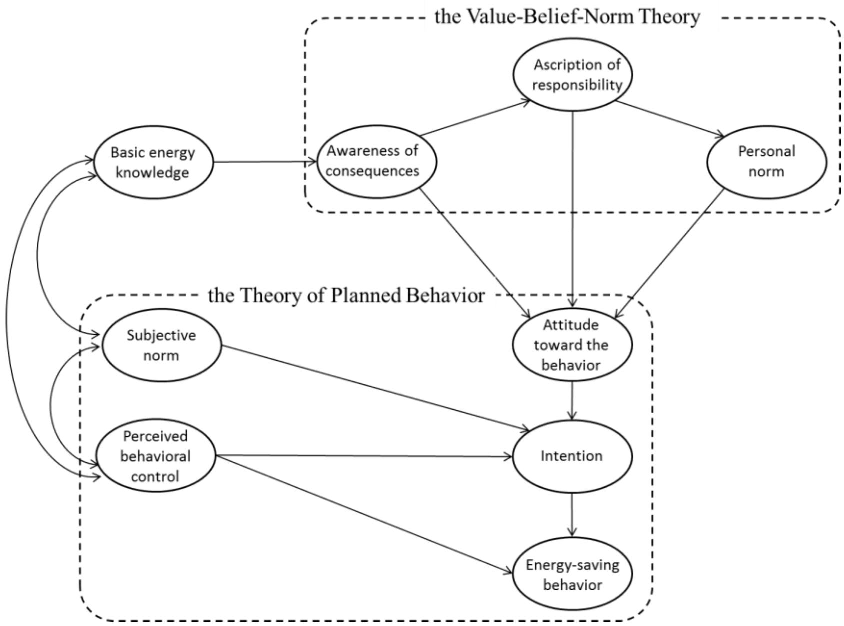


Figure 1. Hypothesis model of energy literacy structure adopted by Akitsu & Ishihara (2018)

It is depicted that the belief factors (awareness of consequences, ascription of responsibility) and personal norm (VBN components) which are activated by the basic energy knowledge predict the attitude toward the behavior. And the intention to energy-saving behavior is explained by the attitude toward the behavior, subjective norm, and perceived behavioral control (TPB components). The TPB explains the personal usefulness of a given behavior while focusing on external influences (subjective norms), on the other hand, the VBN emphasizes the benefit to others (altruism) activates an internal normative factor (personal norms). Since the extension based on the two theories while keeping the framework of existing models may help to interpret the energy literacy structure to identify the validity and potentiality of the components in energy literacy model (e.g., Klockner & Blobaum, 2010, Klockner, 2013), we employed it to examine the energy literacy structural model for lower secondary school students in Japan (age of 13-15). As a result, it was elucidated that the awareness of consequences plays an important role for the relation between the basic energy knowledge and the energy-saving behavior through the attitude toward the energy-saving behavior (Figure 2).

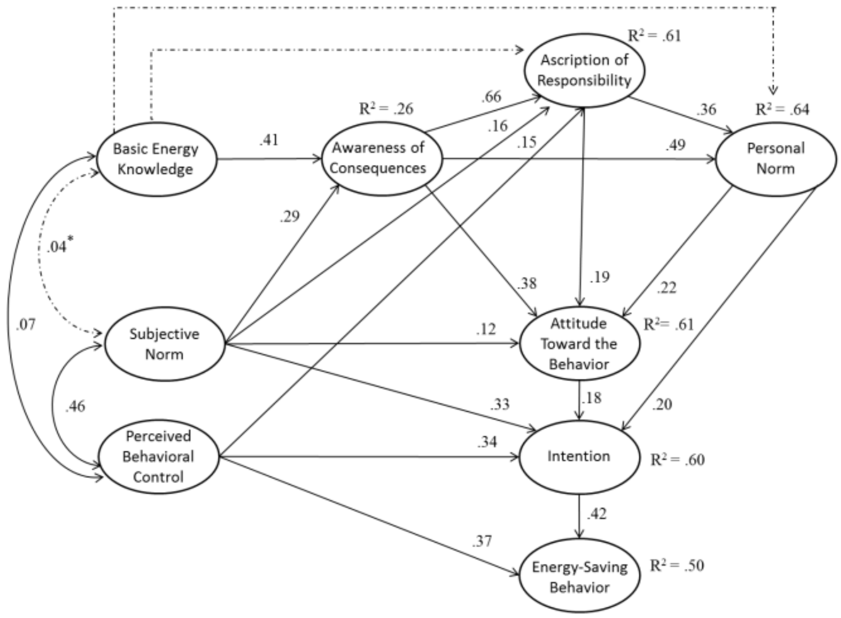


*Figure 2. Energy literacy structural model of lower secondary school students in Japan with standardized coefficients. Non-significant estimates are indicated by the * symbol and dashed lines adopted by Akitsu & Ishihara (2018)*

The current study attempts to assess the applicability of the energy literacy model through the international survey, and provides empirical data on cross-cultural perspectives on energy literacy. The conditions of candidates were: the low energy self-sufficient country; the island country, and the Southeast Asian countries where have been developing rapidly and consuming a large amount of energy. As a result of collecting samples, we focused on Thailand and compared with Japanese students adopted from our previous study (Akitsu & Ishihara, 2018).

Overview of Energy-Related Issues in Thailand

Thailand is the second largest economy in the Association of South East Asian Nations (ASEAN), its population is approximately 69 million (worldometers, 2018). The GDP is projected to a 152% grow from 2013 to 2040 (Asia Pacific Energy Research Centre [APEC], 2016). Since Thailand has limited resources, they depend on energy imports accounting for 46% of the total primary energy imports. In particular, oil and gas imports will be inevitable to continue because its domestic oil and gas resources will be assumed to deplete by 2019 and 2022, respectively (APEC, 2013, 2016). Thai Ministry of Energy recognizes the need for energy security and conservation for sustainable society and energy management, economic growth, and reducing greenhouse gases emissions (APEC, 2015). In 2016, the anti-coal groups, however, protested against the energy policy for the transition to clean coal technology for power generation and diversification of resources (APEC, 2016). To build a knowledge-based sound society, both the Ministry of Energy and Ministry of Education emphasize the need of participation of well energy-literate public in energy-related issues to promote harmonized cooperation in energy and other sectors (Fongsamootr, 2017).

Energy Education in Thailand and Japan

The goal of science education in Thailand is to cultivate those who make decisions on science, technology, and societal issues by utilizing multidimensional scientific and technological literacy (Institute for the Promotion of Teaching Science and Technology, 2002). Thus, learning energy issues is perceived as a good opportunity for Thai science education to improve school science program more practical for cultivating students' skills of understanding, analysis, decision-making, and values to deal with science, technology and social issues (Yuenyong, 2012). The Ministry of Energy and Ministry of Education have launched the project of promotion of teaching about energy in basic school education in Thailand in 2009 (Fongsamootr, 2017). Because they perceived that energy literacy is indispensable for Thai people, and lack of knowledge and understanding for energy-related issues is more likely to affect on various fields in society. They have developed educational materials in cooperation with the National Energy Education Development Project in the U. S. (2017), and these have been widely introduced throughout the country. Furthermore, over two thousands teachers participated in the workshops for capacity building to provide energy education (Fongsamootr, 2017). In 2014, the Energy STEM (Science, Technology, Engineering and Mathematics) Project has been launched, and four STEM Energy Activity Hand books were introduced in the science curriculum targeting from the 7th to 9th grade (Chanlen, 2016). Recently, they are seeking ways to evaluate students' energy literacy to assess the outcome of the project (Fongsamootr, 2017).

Although Japan has achieved major success not only economic society but the equal education opportunity and high academic standard of nation (Ministry of Education, Culture, Sports, Science and Technology, Japan [MEXT], 2012), reflecting rapid change and globalization, Japan has been facing with serious problems such as hollowing-out of industries, declining in the labor force population, and an aging society (MEXT, 2011). Learning EE issues is perceived as a part of the formation of character. Its objective is grounded on the idea where learning social problems encourages a zest for living that enables individuals to identify social challenges and to engage a problem-solving by sound values, skills, a decision-making, and actions. (ICEEE, 2013). Despite government recognized that energy education is one of the important parts in the environmental education in Japan (MEXT, 2009, 2011a, 2011b), a holistic teaching material which focusing on energy-related issues, and a common manner for evaluating the learning achievement have not been provided officially (Eda, 2008). The current situation of energy education in Japan may depend on the degree of contribution by teachers who summarize the EE topics dispersed throughout the formal education curriculum and provide their own classes to students (Akitsu, Ishihara, Okumura, & Yamasue, 2017).

Normative Aspects

Yuenyong, Jones, and Yutakom (2008) reported that students' idea regarding energy-related issues depend on their attribute affected by the socio-cultural perspective through their comparative study between Thailand and New Zealand. Thai students value on the country development and believe in science application for problem-solving. While, students in New Zealand are skeptical about whether science can solve social problems, they rather think it will damage the environment. People's beliefs and values are subject to social norms. The predisposition for evaluation is formed by social background and experience caused by diversity of religious, artistic, political, economic, and other attitudes within and between cultures (Ajzen & Cote, 2008, p. 290). Education reflects these values, norms, beliefs, culture, and science and technology, which are shaped by time and social background. And learning involves knowledge building and taking a position in the culture of one's community (Yuenyong et al., 2008). In addition, Thai identity comes from national religion, over 93% of nation is Theravada Buddhism. The belief system and values of Buddhism play a major role in daily life. The most important values Thai people hold throughout the country are respect, self-control, and non-contrary attitudes to avoid conflict with other people. Therefore, Thai children are expected humility and to respect seniority (Phillips, 1965; Yuenyong et al., 2008; Yuenyong, 2012).

Meanwhile, Japanese religion, Shinto generally defined as the way of kami, gods, or supernatural forces can be characterized as an ancient Japanese belief based on a mixture of nature- and ancestor-worship (Eliade, 1987; Shibata, 2005). Although Shinto teaches no dogma or no absolute truth of a single god or a church, the belief has permeated Japanese thinking through the religious practices of the people and worldview (Shibata, 2005). After the Second World War, the state of Shinto in Japan, used as a political tool for militaristic and ultra-nationalistic by the Meiji government, was prohibited from any support or control by any Japanese officials and governments by the order of Supreme Commander for the Allied Powered (Shibata, 2005). Today, "the separation of religion and state in Japan is as complete as in any country in the world" said the chief editorial director of the Shinto Directive (Bunce, 1978, p. 171). Therefore, Shinto and Buddhism are major religions in Japan for sure, while religions is rarely emphasized nor discussed in everyday life. Although the majority of Japanese do not make claims to be religious or worship regularly, it is rather difficult to distinguish religions clearly from Japanese social and cultural values, a code of moral, and way of living (InsideAsia Tours Ltd., 2019). Given another aspect of normative factor, Japan is distinguished one of the representatives of a collectivistic culture in the world and those respect their group memberships, decisions, and expectations (Oetzel & Ting-Toomey, 2003; Schimmack et al., 2002; Triandis, 1993; Wong & Ahuvia, 1998).

The subjective norm formed by social pressures and expectations may affect both students' energy literacy in some degree. Since the energy literacy structural model has proposed that the attitude toward the behavior is activated by normative factors (personal norm, subjective norm), it is worthwhile that understanding differences in attributes through the energy literacy assessment between two countries.

Objectives

Applying the common instrument and structural model, the current study elucidates the difference in attributes in energy literacy by employing the integrated sample of lower secondary school students in Thailand and Japan referring the difference in their culture.

Materials and Methods

This study was analyzed by quantitative data collected by employing the questionnaire developed in our previous study. The data was applied to the analysis of mean values and correlation coefficients, structural equation modeling for a model assessment, and conditional process analysis to elucidate the interaction of two countries and components in the energy literacy model.

Sampling

This study was carried out with the 7th, 8th, and 9th grades (ages 13-15) in Thailand in March 2017 by a convenience sampling method which is one of the nonprobability sampling techniques that a researcher uses to select a sample of subjects from a population (Etikan, Musa, & Alkassim, 2016). Seven schools selected by Thai researchers participated in the survey; those were in Chiang Mai, two in Udon Thani, Pathum Thani, Udonratchathani, Bangkok, and Trang (Figure 3). The questionnaire was carried out in the classroom by each school teacher.

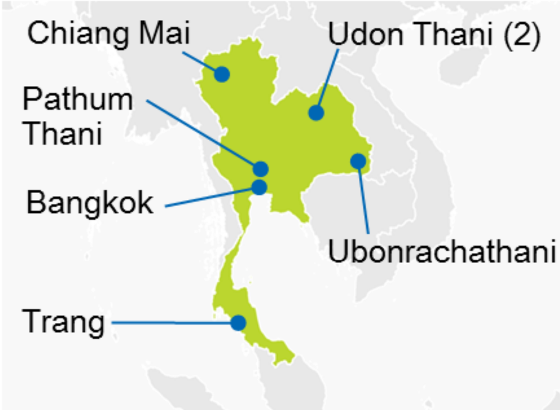


Figure 3. Locations of survey participants in Thailand.

The valid responses of 635 without missing values (58% valid response rate) were analyzed by integrated with the sample of Japan (*N* = 1070, Akitsu & Ishihara, 2018) to extract characteristics of each country from the common data. The distribution of gender and grade differs according to each teacher since the number of classes and the grade level that teachers are in charge vary by each school. Although the sample of Japan includes a private girls' junior high school (*N* = 310) which has excellent academic performance in Kansai area in Western Japan, it was determined that this school has no influence on gender differences on the basic energy knowledge or on energy literacy model (Akitsu & Ishihara, 2018).

Data Collection Tool

The survey employed the same instrument of our latest study (Akitsu & Ishihara, 2018), which was designed as a written, closed item questionnaire for a practical classroom application. It was translated into Thai language and modified to suit domestic energy circumstances with the cooperation of researchers in Kyoto University and Chiang Mai University. The questionnaire is consisted of nine components. After eliminating in the subsequent analysis for reliability and consistency of a set of items, seventy eight question items were selected from a set of eighty five items, which differ from the items selected in our previous survey in Japan. The Cronbach's alpha value ranged from 0.69 to 0.82. Alpha values are usually acceptable more than 0.70 (Nunnally, 1978), and as low as 0.60 is utilized for a set of items in educational evaluation scales (Linn & Gronlund, 1995; Qaqish, 2005). A summary of nine components and their abbreviations, number of items, and reliability is shown in Table 1. The items of civic scientific literacy, critical thinking ability, and new ecological paradigm which were investigated in the previous study were not employed due to mitigate Thai students' burden. All items except for a series of basic energy knowledge items were shuffled across domains. Details are omitted to conserve space, descriptions of each component is in Akitsu & Ishihara (2018), and question items are presented in Appendix. A subgroup assessment of five attributes was carried out to compare: gender, school year grade (7th, 8th, and 9th), energy education experience (Yes/No), energy-related facility tour experience (Yes/No), and home discipline in energy-saving (Yes/No).

Table 1. Components and their abbreviations, number of items, and Cronbach's alpha values (α) for energy literacy assessment

Predictors	Abb.	Survey items	Analysis items	Omitted items	α
Basic energy knowledge	BEK	20	20	-	0.712
Awareness of consequences	AC	11	11	-	0.822
Ascription of responsibility	AR	7	6	AR06	0.713
Personal norm	PN	5	5	-	0.693
Attitude toward the behavior	ATB	7	7	-	0.730
Subjective norm	SN	9	9	-	0.818
Perceived behavior control	PBC	7	5	PBC02, PBC 05	0.718
Intention to act	INT	5	4	INT01	0.718
Energy-saving behavior	ESB	12	11	ESB05	0.708
Total		83	78		

Statistical Analysis

Energy Literacy Assessment

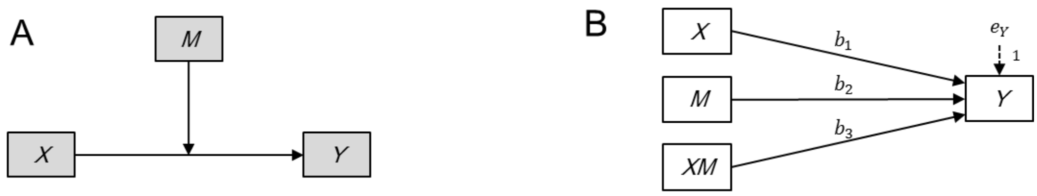
Item responses were converted into numerical scores in the same way of our previous study. For the basic energy knowledge, one point for each correct answer and zero points for each incorrect answer were assigned. The five-point Likert-type response (AC, AR, PN, ATB, SN, PBC, INT, and ESB) was converted into numerical scores from one point for the least preferred response to five points for the most preferred response in this study. The maximum attainable scores for each component were converted into a percentage as a common scale to compare among the components simply. The question items of each component were combined to produce the overall score of each component (Ajzen, Joyce, Sheikh, & Cote, 2011). Since all components were not normal by examining normality by the Kolmogorov-Smirnov Test, the mean values were compared by a non-parametric statistical analysis using Mann–Whitney U test and Kruskal-Wallis Test. The correlations between the components were evaluated with the non-parametric Spearman's rank correlation coefficient (ρ).

- Assessment of Energy Literacy Structural Model

To examine the applicability of energy literacy model we proposed, a structural equation modeling (SEM) with maximum likelihood estimation was utilized to analyze whether the model fits the data and estimates the relation and magnitude among the predictors. The model fit indices were employed to evaluate the model fitness. The goodness-of-fit index (GFI), the adjusted goodness-of-fit index (AGFI), the normed-fit index (NFI), and the comparative fit index (CFI) are expected larger than 0.95 for a good model interpretation. The standardized root mean square residual (SRMR) is expected less than 0.05, and less than 0.08 for the root mean square error of approximation (RMSEA) is considered acceptable (Browne & Cudeck, 1992; Hooper, Coughlan, & Mullen, 2008). To estimate the validity of each model for selection, the Akaike information criterion (AIC) was employed.

- Conditional Process Analysis

To determine whether the country (Thailand, Japan) affect the strength or direction of the effect of predictor for an outcome, we employed a conditional process analysis (Hayes, 2013). Figure 4 presents the conceptual diagram (A) and statistical diagram (B) for a simple moderation model moderated by M (panel A). The conditional effect of X on Y is calculated by Eq. 1.



$$\text{Conditional effect of } X \text{ on } Y = b_1 + b_3 M \quad (1)$$

Figure 4. A Conceptual Model (A) and statistical model (B) for a conditional process analysis of simple moderation adopted from Hayes (2013)

The current study examined the interaction effect of country (Thailand, Japan) as a moderator and X on Y in the energy literacy model by employing a regression-based path analysis with PROCESS 2.13.2 for SPSS to estimate and probe the interactions and conditional direct effects (Hayes, 2014). The parameters were estimated by ordinary least squares (OLS) regression. The mean values of the variables, which are centered in advance, were employed to construct a moderation model.

A statistical analysis was carried out at the 0.05 significance level with a two-tailed test by IBM® SPSS®, and Amos™ Version 24.

Results

Energy Literacy Assessment

Overall

The performance summary of survey in Thailand and Japan is presented in Table 2. Sample ratios in Thailand and Japan are 37% and 63%. Students in Japan indicated significantly higher scores on the basic energy knowledge than those in Thai (48%, 41%, p < .001). The performance of both countries on the basic energy knowledge was not necessarily sufficient to the ideal correct answer rate 70% for five multiple-choice items (University of Washington, 2005). On the other hand, Thai scored significantly higher on the other components than those of counterpart ($p < .001$) except the awareness of consequences. In particular, they scored larger than Japanese students on the subjective norm (73%, 61%, $p < .001$). Despite Japanese students showed a large amount of knowledge with respect to EE issues, it seems not to affect other components in the energy literacy.

Group Comparison

- Gender

A distribution between males and females in both countries was about the same as 33% and 67%, respectively. Gender differences for Japanese students were significantly indicated on the basic energy knowledge (Males 42%, Females 51%, $p < .001$), ascription of responsibility (Males 75%, Females 77%, $p < .05$), and energy-saving behavior (Males 68%, Females 66%, $p < .005$). Meanwhile, there was no statistical difference between genders for Thai students.

- School Year Grades

A distribution of school year grade in Thai was 19%, 25%, and 56% for the 7th, 8th, 9th grade, for Japan, 33%, 23%, and 44%, respectively. There was no grade difference on the basic energy knowledge in both countries. Thai 9th graders scored significantly higher than those of Japan on most components except the basic energy knowledge and awareness of consequences. In particular, Thai all graders showed significantly higher scores than those of counterpart on the subjective norm. Moreover, it is interesting that mean values of Japanese students seem to decrease with the school year progression. The 7th graders of Japan indicated higher scores than those of 9th grade on the awareness of consequences (82%, 78%, $p < .001$), ascription of responsibility (78%, 75%, $p < .01$), personal norm (76%, 73%, $p < .005$), attitude toward the behavior (79%, 76%, $p < .005$), intention (70%, 66%, $p < .01$), and energy-saving behavior (68%, 65%, $p < .001$). Conversely, Thai mean values tended to increase according to the grade progression, in fact, the 9th graders showed higher scores than those of 7th on the perceived behavioral control (73%, 67%, $p < .01$) and energy-saving behavior (72%, 68%, $p < .05$). It can be discussed that the scores of energy literacy of Japanese students may decline according to the school year progression.

- Experience of Energy Education

The percentage of students who have experienced energy education was 91% for Thai, 81% for Japan. They indicated significantly higher scores than those of counterparts on the basic energy knowledge (Thai: Yes 41%, No 34%; $p < .05$, Japan: Yes 49%, No 43%, $p < .001$), awareness of consequences (Thai: Yes 79%, No 74%, $p < .05$; Japan: Yes 80%, No 77%, $p < .01$), and attitude toward the behavior (Thai: Yes 83%, No 79%, $p < .05$; Japan: Yes 78%, No 74%, $p < .001$). Furthermore, Japanese students who have experienced energy education showed significantly higher scores than those of counterpart on the ascription of responsibility (Yes 77%, No 74%, $p < .01$), perceived behavioral control (Yes 67%, No 63%, $p < .05$), and energy-saving behavior (Yes 67%, No 65%, $p < .05$). Meanwhile, Thai students indicated a significant difference on the personal norm (Yes 79%, No 72%, $p < .001$). Although the difference of subjective norm was significant between two countries, the experience of energy education does not seem to affect this component.

- Experience of Energy-Related Facility Tour

Over thirty percent of students in both countries have experienced some sort of energy-related facility tour. Thai students experienced it indicated high scores on the subjective norm (Yes 75%, No 71%, $p < .001$) and energy-saving behavior (Yes 74%, No 71%, $p < .005$). While, Japanese students who experienced the tour indicated significantly higher scores than those who have no experience it for all components except the basic energy knowledge ($p < .01$). It can be suggested that the experience of energy-related facility tour is more likely to affect students' energy literacy in Japan.

- Home Discipline for Energy-Saving

The ratio of students that their parents train their son(s)/daughter(s) about energy-saving was 61% for Thai and 63% for Japan. There were significant differences on the subjective norm (Yes 74%, No 71%, $p < .05$) and intention (Yes 76%, No 73%, $p < .05$) for Thai students. On the other hand, Japanese students who responded "Yes" to the presence of home-discipline in energy-saving indicated significant high score on all components except the basic energy knowledge ($p < .001$). It can be assumed that attitudes of parents in energy-saving are more likely to affect Japanese students' value, beliefs and behavior.

Table 2. Results of Energy Literacy Assessment and Subgroup Comparisons between Thailand and Japan

		N	BEK				AC				AR			
			Mean %	***SD***	***SE***	***p***	**Mean %**	***SD***	***SE***	***p***	**Mean %**	***SD***	***SE***	***p***
Total		1705	45.27	18.79	0.46		79.43	11.87	0.29		77.80	12.83	0.31	
Thai	Overall	635	40.78	17.09	0.68		78.91	11.33	0.45		80.08	11.75	0.47	†
Japan	Overall	1070	47.94	19.25	0.59	†	79.74	12.18	0.37		76.45	13.25	0.41	
Gender														
Thai	Male	209	39.40	18.04	1.25		79.76	11.30	0.78		80.27	11.60	0.80	†
	Female	426	41.46	16.58	0.80		78.49	11.34	0.55		79.99	11.84	0.57	***
Japan	Male	348	41.81	19.71	1.06		78.40	12.39	0.66		74.80	14.05	0.75	
	Female	722	50.89	18.31	0.68	†	80.38	12.02	0.45	*	77.24	12.79	0.48	
Grade														
Thai	7th	121	39.09	14.59	1.33		77.18	11.63	1.06		78.98	11.66	1.06	
	8th	159	42.08	20.75	1.65		77.75	12.74	1.01		79.81	13.11	1.04	
	9th	355	40.77	16.03	0.85		80.02	10.44	0.55		80.58	11.14	0.59	†
Japan	7th	352	47.74	17.72	0.94	†	81.61	11.66	0.62	**	78.03	12.80	0.68	
	8th	251	46.93	19.29	1.22		80.63	12.52	0.79		76.99	13.97	0.88	
	9th	467	48.63	20.31	0.94	†	77.84	12.12	0.56		74.97	13.06	0.60	
Education														
Thai	Yes	576	41.46	17.13	0.71		79.38	11.23	0.47		80.44	11.59	0.48	†
	No	59	34.15	15.32	1.99		74.24	11.34	1.48		76.61	12.81	1.67	
Japan	Yes	866	49.15	19.09	0.65	†	80.31	11.99	0.41		77.10	13.17	0.45	
	No	203	42.86	19.17	1.35	**	77.30	12.71	0.89		73.61	13.25	0.93	
Facility tour														
Thai	Yes	205	41.59	19.20	1.34		78.04	12.04	0.84		79.54	13.24	0.92	
	No	430	40.40	15.99	0.77		79.32	10.97	0.53		80.34	10.98	0.53	†
Japan	Yes	316	49.51	19.16	1.08	†	82.15	11.52	0.65	***	78.89	13.26	0.75	
	No	753	47.30	19.26	0.70	†	78.72	12.31	0.45		75.41	13.13	0.48	
Discipline														
Thai	Yes	388	41.97	17.76	0.90		79.28	11.24	0.57		80.76	11.81	0.60	*
	No	247	38.91	15.83	1.01		78.32	11.47	0.73		79.03	11.60	0.74	†
Japan	Yes	675	48.96	18.98	0.73	†	81.63	11.18	0.43	**	78.62	12.64	0.49	
	No	395	46.20	19.60	0.99	†	76.50	13.10	0.66		72.73	13.47	0.68	

		N	PN				ATB				SN			
			Mean %	***SD***	***SE***	***p***	**Mean %**	***SD***	***SE***	***p***	**Mean %**	***SD***	***SE***	***p***
Total		1705	76.11	13.05	0.32		79.45	11.96	0.29		65.66	13.17	0.32	
Thai	Overall	635	78.87	12.81	0.51	†	82.57	11.88	0.47	†	72.66	11.59	0.46	†
Japan	Overall	1070	74.46	12.92	0.39		77.59	11.61	0.35		61.51	12.27	0.38	
Gender														
Thai	Male	209	79.89	12.49	0.86	†	82.41	11.93	0.82	†	74.41	12.22	0.85	†
	Female	426	78.38	12.95	0.63	†	82.66	11.88	0.58	†	71.80	11.18	0.54	†
Japan	Male	348	73.72	13.50	0.72		77.36	12.09	0.65		62.76	12.49	0.67	
	Female	722	74.82	12.62	0.47		77.70	11.38	0.42		60.91	12.12	0.45	
Grade														
Thai	7th	121	76.96	12.47	1.13		80.85	12.02	1.09		69.84	10.76	0.98	†
	8th	159	77.96	14.16	1.12		81.42	13.81	1.09		76.04	13.09	1.04	†
	9th	355	79.93	12.21	0.65	†	83.68	10.77	0.57	†	72.11	10.80	0.57	†
Japan	7th	352	76.23	12.47	0.66		79.19	11.56	0.62		62.01	12.56	0.67	
	8th	251	75.14	13.79	0.87		78.69	11.68	0.74		62.62	11.93	0.75	
	9th	467	72.77	12.57	0.58		75.79	11.39	0.53		60.54	12.18	0.56	
Education														
Thai	Yes	576	79.58	12.52	0.52	†	82.96	11.67	0.49	†	72.70	11.58	0.48	†
	No	59	72.00	13.72	1.79		78.79	13.34	1.74		72.24	11.72	1.53	†
Japan	Yes	866	74.84	13.00	0.44		78.31	11.48	0.39		61.85	12.44	0.42	
	No	203	72.85	12.50	0.88		74.43	11.65	0.82		60.07	11.46	0.80	
Facility tour														
Thai	Yes	205	77.95	13.87	0.97		82.09	12.37	0.86		75.50	12.52	0.87	†
	No	430	79.31	12.27	0.59	†	82.80	11.65	0.56	†	71.31	10.87	0.52	†
Japan	Yes	316	76.38	13.19	0.74		80.41	11.30	0.64		63.94	12.76	0.72	
	No	753	73.66	12.73	0.46		76.39	11.54	0.42		60.49	11.93	0.43	
Discipline														
Thai	Yes	388	79.08	12.92	0.66	*	82.99	11.64	0.59	†	73.74	12.00	0.61	†
	No	247	78.54	12.66	0.81	†	81.92	12.25	0.78	†	70.97	10.71	0.68	†
Japan	Yes	675	76.61	12.37	0.48		79.85	10.89	0.42		64.95	11.23	0.43	
	No	395	70.79	13.01	0.65		73.72	11.80	0.59		55.62	11.73	0.59	

Table 2. Continued

		N	PBC				INT				ESB			
			Mean %	*SD*	*SE*	*p*	Mean %	*SD*	*SE*	*p*	Mean %	*SD*	*SE*	*p*
Total		1705	67.92	15.51	0.38		70.84	15.13	0.37		68.83	11.41	0.28	
Thai	Overall	635	70.95	13.38	0.53	†	74.97	13.47	0.53	†	72.17	10.70	0.42	
Japan	Overall	1070	66.12	16.39	0.50		68.39	15.53	0.47		66.84	11.36	0.35	
Gender														
Thai	Male	209	69.21	12.83	0.89		75.53	14.45	1.00	†	73.13	11.36	0.79	†
	Female	426	71.80	13.58	0.66	†	74.69	12.97	0.63	†	71.70	10.34	0.50	†
Japan	Male	348	66.39	16.62	0.89		68.39	15.62	0.84		68.51	11.24	0.60	
	Female	722	65.98	16.28	0.61		68.39	15.50	0.58		66.04	11.34	0.42	
Grade														
Thai	7th	121	67.14	12.64	1.15		72.77	11.88	1.08		68.58	9.30	0.85	
	8th	159	69.66	13.28	1.05		76.70	15.56	1.23	†	74.91	12.62	1.00	†
	9th	355	72.82	13.37	0.71	†	74.94	12.89	0.68	†	72.17	9.84	0.52	†
Japan	7th	352	67.38	17.28	0.92		70.03	15.37	0.82		68.40	11.78	0.63	
	8th	251	66.93	15.43	0.97		69.72	15.38	0.97		68.00	11.91	0.75	
	9th	467	64.73	16.12	0.75		66.43	15.55	0.72		65.05	10.47	0.48	
Education														
Thai	Yes	576	71.34	13.54	0.56	†	75.30	13.33	0.56	†	72.43	10.72	0.45	†
	No	59	67.12	11.12	1.45		71.69	14.49	1.89		69.68	10.29	1.34	†
Japan	Yes	866	66.76	16.26	0.55		68.87	15.65	0.53		67.30	11.40	0.39	
	No	203	63.29	16.67	1.17		66.28	14.90	1.05		64.89	11.03	0.77	
Facility tour														
Thai	Yes	205	70.44	13.35	0.93		76.90	14.85	1.04	†	74.48	12.18	0.85	†
	No	430	71.19	13.41	0.65	†	74.05	12.68	0.61	†	71.07	9.74	0.47	†
Japan	Yes	316	69.03	16.08	0.90		71.61	15.51	0.87		70.11	11.39	0.64	
	No	753	64.87	16.37	0.60		67.02	15.36	0.56		65.48	11.08	0.40	
Discipline														
Thai	Yes	388	71.66	13.45	0.68		76.13	13.62	0.69	†	73.00	11.09	0.56	†
	No	247	69.83	13.23	0.84	†	73.14	13.06	0.83	†	70.87	9.94	0.63	†
Japan	Yes	675	69.47	15.53	0.60		72.56	13.87	0.53		69.22	10.84	0.42	
	No	395	60.38	16.23	0.82		61.27	15.66	0.79		62.78	11.08	0.56	

* $p < .05$, ** $< .01$, *** $< .005$, † $< .001$

Assessment of Energy Literacy Structural Model

A summary of intercorrelation between components is shown in Table 3 with the descriptive statistics. All correlation coefficients were significant ($p < .001$) except the coefficient between the basic energy knowledge and subjective norm ($r = .002$, $p = 0.92$).

Table 3. Intercorrelation matrix between components

	M%	SD%	BEK	AC	AR	PN	ATB	SN	PBC	INT
Basic energy knowledge	45.3	18.8	1							
Awareness of consequences	79.4	11.9	.394***	1						
Ascription of responsibility	77.8	12.8	.313***	.743***	1					
Personal norm	76.1	13.0	.292***	.741***	.728***	1				
Attitude toward the behavior	79.4	12.0	.273***	.726***	.711***	.707***	1			
Subjective norm	65.7	13.2	.002ns	.344***	.449***	.466***	.527***	1		
Perceived behavioral control	67.9	15.5	.168***	.369***	.451***	.443***	.476***	.413***	1	
Intention	70.8	15.1	.154***	.529***	.581***	.620***	.650***	.624***	.567***	1
Energy-saving behavior	68.8	11.4	.092***	.447***	.505***	.509***	.543***	.635***	.512***	.681***

*** $p < .001$

The energy literacy model with the integrated sample of Thailand and Japan ($N = 1705$) is presented in Figure 5, and Table 4 shows a summary of estimates of standardized and unstandardized regression weights of the energy literacy models of the integrated sample, Thailand, and Japan, and their model fit indices. Applying integrated sample to the original energy literacy model (Figure 2), two paths: from the subjective norm to personal norm, and from the perceived behavioral control to awareness of consequences, were added after considering the model fitness according to the modification indices. Considering the Norm-Activation Theory (NAT, Schwartz & Howard, 1981), we have discussed the potentiality that the energy literacy model can be depicted across the TPB and the VBN (Akitsu & Ishihara, 2018). The NAT focuses on altruism which is activated by personal norms. The personal norms are activated by subjective norms, awareness of consequences, ascription of responsibility, and perceived behavioral control, while these predictors covariate with each other (Klockner, 2013). Therefore, these two paths may be considered. The standardized estimates ranged from 0.14 to 0.62 and were significant except the covariance between the basic energy knowledge and subjective norm ($\beta = 0.02$, $p = 0.51$).

According to the energy literacy model of integrated sample, the intention and perceived behavioral control explained 50% of the variance in energy-saving behavior (Standardized estimate $\beta = 0.58, 0.20$, $p < .001$), it was as same as the previous study. The TPB variables and personal norm accounted for 62% of the variance in intention (ATB: $\beta = 0.22$, SN: $\beta = 0.32$, PBC: $\beta = 0.20$, PN: $\beta = 0.21$, $p < .001$). The subjective norm, ascription of responsibility, personal norm, and awareness of consequences were able to explain 67% of the variance in attitude toward the behavior. Similar to the previous report, the awareness of consequences strongly predicted the attitude toward the behavior than other predictors not only integrated sample but also Thai and Japan models (integrated sample: $\beta = 0.38$, $p < .001$; Thai: $\beta = 0.40$, $p < .001$; Japan $\beta = 0.44$, $p < .001$). The basic energy knowledge predicted the awareness of consequences significantly ($\beta = 0.36$, $p < .001$) and accounted for 32% of the variance in awareness of consequences along with the subjective norm and perceived behavioral control.

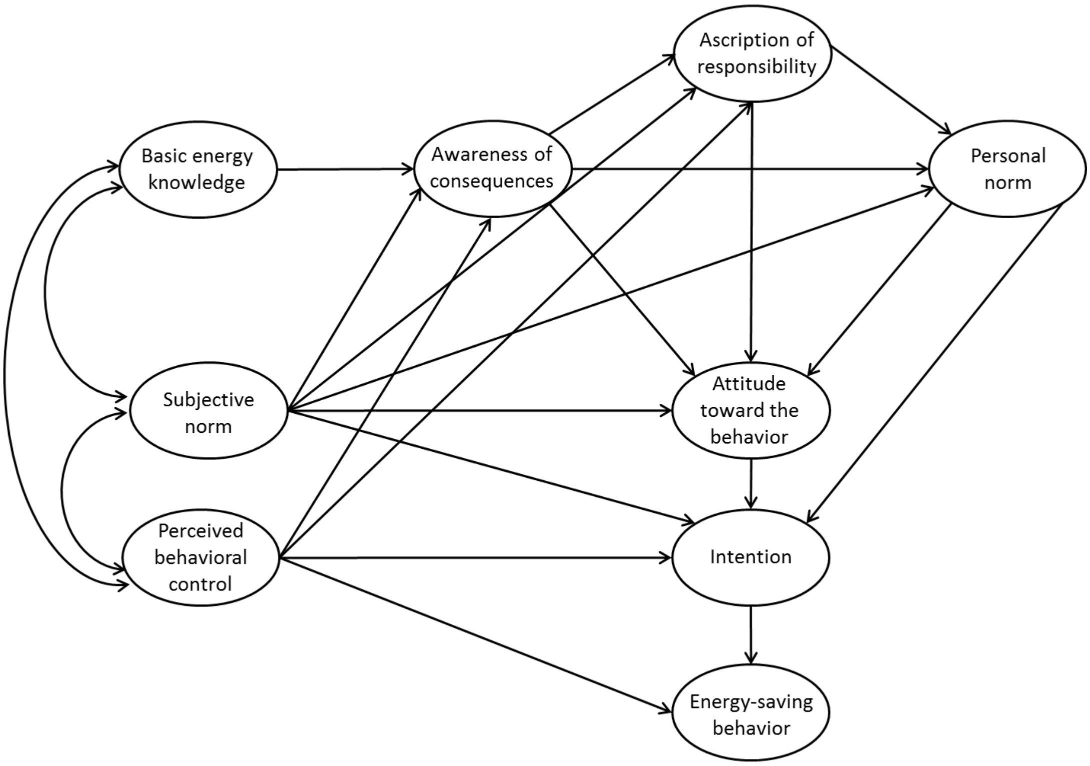


Figure 5. Energy literacy model for an integrated sample of Thailand and Japan

Table 4. A Summary of Estimates of Standardized and Unstandardized Regression Weights of the Energy Literacy Models of Integrated Sample, Thailand, and Japan, and their Model Fitness Indices.

Constructs			**Integrated sample**			**Thailand**			**Japan**		
			β	*B*	*p*	*β*	*B*	*p*	*β*	*B*	*p*
BEK	→	AC	0.36	0.23	†	0.26	0.17	†	0.36	0.23	†
SN	→	AC	0.27	0.24	†	0.43	0.42	†	0.21	0.21	†
PBC	→	AC	0.21	0.16	†	0.16	0.14	†	0.26	0.19	†
AC	→	AR	0.62	0.67	†	0.59	0.61	†	0.67	0.73	†
SN	→	AR	0.19	0.18	†	0.19	0.19	†	0.12	0.13	†
PBC	→	AR	0.14	0.12	†	0.12	0.11	†	0.15	0.12	†
AR	→	PN	0.32	0.32	†	0.29	0.32	†	0.32	0.31	†
AC	→	PN	0.45	0.49	†	0.50	0.57	†	0.47	0.50	†
SN	→	PN	0.18	0.17	†	0.09	0.10	***	0.14	0.15	†
AC	→	ATB	0.38	0.38	†	0.40	0.42	†	0.44	0.42	†
AR	→	ATB	0.21	0.20	†	0.27	0.28	†	0.17	0.15	†
PN	→	ATB	0.17	0.16	†	0.12	0.11	***	0.18	0.16	†
SN	→	ATB	0.21	0.19	†	0.14	0.15	†	0.16	0.15	†
ATB	→	INT	0.22	0.27	†	0.29	0.32	†	0.20	0.27	†
SN	→	INT	0.32	0.36	†	0.33	0.38	†	0.29	0.36	†
PBC	→	INT	0.26	0.25	†	0.10	0.10	†	0.33	0.31	†
PN	→	INT	0.21	0.24	†	0.22	0.23	†	0.20	0.23	†
INT	→	ESB	0.58	0.44	†	0.65	0.51	†	0.49	0.36	†
PBC	→	ESB	0.20	0.14	†	0.06	0.05	*	0.29	0.21	†

Table 4. Continued

			Corre.	***Covar.***		***Corre.***	***Covar.***		***Corre.***	***Covar.***	
BEK	↔	SN	0.02	3.92	0.51	0.23	44.60	†	0.04	9.52	0.19
BEK	↔	PBC	0.15	43.76	†	0.40	92.38	†	0.09	27.80	***
SN	↔	PBC	0.44	88.95	†	0.27	42.56	†	0.48	96.41	†
			R^2			***R^2***			***R^2***		
		AC	0.32			0.39			0.32		
		AR	0.62			0.58			0.64		
		PN	0.65			0.64			0.65		
		ATB	0.67			0.67			0.65		
		INT	0.62			0.57			0.62		
		ESB	0.50			0.45			0.51		
Model fit indices			**Integrated sample**			**Thailand**			**Japan**		
		X^2	358.33			331.34			119.11		
		df	14			14			14		
		GFI	0.958			0.908			0.976		
		AGFI	0.865			0.705			0.924		
		SRMR	0.045			0.075			0.033		
		NFI	0.963			0.909			0.980		
		CFI	0.964			0.912			0.982		
		RMSEA	0.120			0.189			0.084		
		AIC	420.33			393.34			181.11		

β is standardized and *B* is unstandardized coefficients. * $p < .05$, *** <.005, † < .001

Conditional Process Analysis

The interaction effect of country as a moderator between predictors in the energy literacy model was examined by a conditional process analysis. Countries were coded one and zero for Thailand and Japan, respectively. Table 5 summarized the results of the direct effect of subjective norm on the awareness of consequences, personal norm, and attitude toward the behavior were moderated by country (AC: $b_3 = .166$, 95% $CI = .076$ to .255, $p < .001$; PN: $b_3 = .103$, 95% $CI = .009$ to .197, $p < .05$; ATB: $b_3 = .139$, 95% $CI = .054$ to .223, $p < .005$). Moreover, the conditional effects of subjective norm at value of Thai indicated larger than those of Japan (AC: $b_{3\_thai} = .51$, $t(1701) = 13.95$, $p < .001$, $b_{3\_japan} = .35$, $t(1701) = 13.01$, $p < .001$; PN: $b_{3\_thai} = .57$, $t(1701) = 14.58$, $p < .001$, $b_{3\_japan} = .46$, $t(1701) = 16.41$, $p < .001$; ATB: $b_{3\_thai} = .58$, $t(1701) = 16.65$, $p < .001$, $b_{3\_japan} = .44$, $t(1701) = 17.41$, $p < .001$).

In conclusion, the direct effects of subjective norm on the awareness of consequences, personal norm, and attitude toward the behavior depend on the country, and Thai estimates were larger than those of Japan.

Table 5. Unstandardized OLS Regression Coefficients with Confidence Intervals Estimating Awareness of Consequences (AC), Personal Norm (PN), and Attitude Toward the Behavior (ATB) with the Moderation by Country. Variables are Mean Centered.

			AC (*Y*)					**PN (*Y*)**					**ATB (*Y*)**			
			Coeff.	*SE*	95% CI	*p*		Coeff.	*SE*	95% CI	*p*		Coeff.	*SE*	95% CI	*p*
SN (*X*)	b_1	→	.411	.022	.369, .454	†	→	.504	.023	.459, .549	†	→	.491	.020	.451, .531	†
Country (*M*)	b_2	→	-5.890	.609	-7.084, -4.696	†	→	-1.501	.643	-2.761, -.240	*	→	-.882	.572	-2.003, .239	0.12
X ×*M*	b_3	→	.166	.046	.076, .255	†	→	.103	.048	.009, .197	*	→	.139	.423	.054, .223	***
Constant	i_M	→	78.99	.287	78.432 79.558	†	→	75.84	.303	75.244 76.431	†	→	79.08	.269	78.556 79.613	†
			$R^2 = 0.177$ *F* (3, 1701) = 122.158, *p* < .000					$R^2 = 0.242$ *F* (3, 1701) = 180.594, *p* < .000					$R^2 = 0.285$ *F* (3, 1701) = 225.740, *p* < .000			

Discussion

By employing a questionnaire, the current study has investigated the differences in attributes on energy literacy through lower secondary school students in Thailand and Japan.

Difference of Basic Energy Knowledge

A significant difference of basic energy knowledge between Thailand and Japan can be discussed on a basis of the achievement of the OECD Programme for International Student Assessment (PISA) (2015a). Science, mathematics and reading were evaluated with around 540,000 participants, representing approximately 29 million 15-year-olds in the schools of the 72 participating countries and economies. Japanese students presented ranked the second among the participating countries and economies. While, the Thai result was ranked the 54th which was far below the OECD average and other Asian countries. This is also obvious in comparison with the performance in science. Japan has achieved 538 points, whereas Thailand, 421 points which was below OECD average (493 points) (PISA, 2015b). It can be discussed that the scientific outcome affects students' energy literacy to discuss broad topics not only EE issues but science and technology. Furthermore, mathematics and reading skills are also indispensable to understand the context of global EE issues from not only data, tables, and graphs but descriptions. The PISA performance in 2015 may be of help to understand the difference between Thai and Japan on the basic energy knowledge.

Thai researchers reported that Thai school science teaching and learning seem not to provide students that science concepts can apply to activities in their communities. Moreover, Thai recent trend in education is that learners value education to achieve high scores for passing the examination of well-known schools and universities, rather than as a basis for lifelong learning. Therefore the disparity in educational opportunities for students has been expanding according to household income (Yuenyong & Yuenyong, 2012). On the other hand, although the school system in Japan ensures equality in education opportunities and remains its level stability, fewer Japanese students in PISA (2015a) reported that they enjoy learning science comparing with 2006 and the low level of enjoyment of science than the OECD average is reported. Only about 18% of Japanese students expect to pursue a science career, while the OECD average is approximately 24% (PISA, 2015a). Furthermore, PISA (2006, pp. 233-234) reported that about 40% of Japanese students are enrolled in schools where school principals feel constant pressure from parents who expect schools to aim high academic levels and to have their son(s)/daughter(s) achieve them. If the parents' expectations have only students to pursue high level of academic achievement to pass the exams of famous schools and universities, it may be difficult to improve their energy literacy with only the basic energy knowledge provided in school education.

Awareness of Consequences

The model assessment supported our previous report that the awareness of consequences plays a vital role in linking between basic energy knowledge and attitude toward the behavior in the energy literacy model (Akitsu & Ishihara, 2018). In details, Thai students tend to expect more government leadership and energy-saving than those in Japan (Appendix: AC01, AC03, AC04, and AC07, $p < .01$). It can be supported by the previous report that Thai students believe in country's development and scientific application into society for solving energy-related issues (Yuenyong et al., 2008). On the other hand, Japanese students tend to concern more than Thai students regarding environmental destructions as global warming by massive consumption of energy, depletion of resources, and deforestation (AC05, AC08, AC09, AC10 and AC11, $p < .001$). These results are more likely to be reflected the most valuable context providing into EE education in each country. In case of Japan, environmental issues tend to be more emphasized rather than social economic aspects in EE education in elementary and lower secondary school (Former Information Center for Energy and Environment Education, 2009). For example, despite Japan has been facing declining in the energy self-sufficiency ratio, increasing in electric power costs, and increasing in the amount of CO2 emissions (Ministry of Economy, Trade and Industry, Japan, 2016), it is difficult for teachers and students to discuss about advantage of nuclear power energy for the perspective of the social economy after the severe nuclear accident in Fukushima, 2011 (Akitsu & Ishihara, 2018). On the other hand, Japanese students who positively responded to the experience of energy education and energy-related facility tour, and home discipline in energy-saving indicated higher score on the awareness consequences than those of counterparts. Hence, it may be required that energy education in Japan provide with practical and informative contents including ongoing EE issues which emerge adverse consequences for the future generation and society. In addition, experience learnings and involving students' family to learn EE issues may activate more students' awareness of consequences.

School Year Grade

Mean values of Japanese students on the AC, AR, PN, ATB, INT, and ESB tend to decrease according to the school year progression ($p < .01$ or less). To examine this trend, this study carried out a survey on high school students (HS) with the same questionnaire to compare with lower secondary students (LS). The 10th graders (age of 16) of the private high school in Kanagawa prefecture adjacent to Tokyo were evaluated ($N = 242$). Blanks and ambiguous responses in each component were eliminated case-wise from the analysis. A summary of this survey presents in Table 6.

Table 6. Mean Comparisons between Lower Secondary (LS) and High School (HS) Students.

	BEK					AC					AR				
	N [a]	Mean %	*SD*	*SE*	*p*	*N*	Mean %	*SD*	*SE*	*p*	*N*	Mean %	*SD*	*SE*	*p*
LS	1356	51.5	0.23	0.01		1468	82.2	0.13	0.00		1479	76.1	0.13	0.00	*
HS	239	75.1	0.20	0.01	†	242	82.9	0.13	0.01		241	73.9	0.13	0.01	
	PN					ATB					SN				
LS	1484	78.3	0.14	0.00		1482	77.4	0.12	0.00		1475	61.6	0.12	0.00	†
HS	242	79.5	0.15	0.01		241	77.2	0.12	0.01		242	58.6	0.12	0.01	
	PBC					INT					ESB				
LS	1488	61.0	0.18	0.00	*	1490	66.9	0.17	0.00	†	1474	68.3	0.11	0.00	†
HS	242	58.2	0.16	0.01		242	60.6	0.17	0.01		242	65.0	0.11	0.01	

[a] Blank or vague responses in each component were omitted case-wise from the analysis. *$p < .05$, † < .001

The HS indicated significantly higher on the basic energy knowledge than the LS (HS 75%, LS 51%, $p < .001$). While, the LS scored higher than the HS on the ascription of responsibility, subjective norm, perceived behavioral control, intention, and energy-saving behavior ($p < .05$). There was little difference on the awareness of consequences, personal norm, and attitude toward the behavior. It was elucidated that even though the knowledge relevant to the EE issues is high, it does not necessarily affect individual norms, values, or derive the preferable attitudes and behavior towards the EE issues. Rather, it can be discussed that the cognitive dissonance has already emerged in the early stage of lower secondary education in Japan. Moreover, it is discussed that social and political attitudes of youth are considerably formed until they complete secondary education, and those are kept throughout their lives (Christensen & Knezek, 2015). If so, EE education should be provided by an appropriate manner to the proper target age while taking account of developmental stage. The earlier phase in secondary education in Japan may be a critical period to implement energy education that stimulates students to be aware of global EE issues as an individual matter, and to form values and beliefs for problem-solving toward a sustainable development society.

Country Effect on Energy Literacy Model

Our attitudes are formed by social backgrounds in the growth process (Ajzen & Cote, 2008). Thai students showed a significant performance on all subjective norm items than those of Japan (SN01-SN09, $p < .001$). The subjective norm is assumed to be determined by the sum of accessible normative beliefs on the expectation of important referents (Ajzen, 2019b). Thai children are taught that good children should obey parents, teachers, and adults who understand better (Yuenyong et al., 2008). Thus, it can be discussed that respecting seniority in Thai norms derived high scores of the subjective norms. On the other hand, it was reported that it is more important to meet the expectations of others in interdependent cultures, and this normative factor, namely, the subjective norms play a vital role in determining the environmental behavior for children in Japan (Ando, Yorifuji, Ohnuma, Matthies, & Kanbara, 2015). This suggestion can support that the current study elucidated the parental influence on energy literacy of students in Japan by examining the presence of home discipline in energy-saving. Although, both students in Thailand and Japan imply the effect of social expectations and pressures in their background, it plays greater in Thai norms than those of Japan. This can be also supported by the result of interaction effect of Thailand was larger than that of Japan in the relation between subjective norm and awareness of consequences, personal norm, and attitude toward the behavior.

To improve fitness of Thai model, adding a direct path from the subjective norm to the energy-saving behavior was considered according to the modification indices. The model fitness was improved as: GFI = .962, AGFI = .868, SRMR = .043, RMSEA = .112, NFI = .968, and CFI = .972. Its regression coefficient estimated 0.51, and the estimation of regression coefficient of intention to the energy-saving behavior decreased from 0.65 to 0.33. The variance in energy-saving behavior explained by the intention, perceived behavioral control, and subjective norm increased from 45% to 61%. Although the Theory of Planned Behavior assumes that person's behavior is controlled by the intention to act, we cannot overlook the potentiality in Thai case that students unconsciously take actions to follow the expectations of their important referents. If so, it may imply unconscious energy-saving behavior, namely, a kind of obedience expected by social pressure. Not only children but people accept the potential requests of someone who we like or respect (Cialdini, 2009). Information and values from a perceived seniority and important referents can provide children an invaluable shortcut for deciding to act without critical thinking toward a given behavior. Once children understand that obedience to social norms is worthwhile, it is easy to allow themselves to automatically act in obedience (Cialdini, 2009). Behaviors are usually activated by the intention to act, which strongly correlates with the critical thinking ability reported in our previous study ($r = 0.52$, $p < .01$, Table 3 in Akitsu & Ishihara, 2018). In future study, it is required an assessment of critical thinking ability on Thai students and an investigation whether energy education alter their structure of energy literacy.

By applying the common energy literacy model and comparative assessment, the current study elucidated the respective characteristics of energy literacy. Implications obtained may contribute to develop and provide energy education in more effective manner.

Conclusion

The current study has investigated the differences in attributes on energy literacy referring the difference in their culture by utilizing integrated sample of lower secondary school students in Thailand and Japan. Thai students presented higher performance than those of Japan on most components in energy literacy except the basic energy knowledge and the awareness of consequences. In particular, the subjective norm was significantly higher than those of counterpart. There was no difference in gender and the mean values tended to increase according to the school year grade. On the other hand, the result of Japan suggested that the amount of basic energy knowledge did not necessarily contribute to increase the overall energy literacy. Moreover, the mean values except the basic energy knowledge tended to decrease according to the school year progression. Energy literacy model was able to support our previous outcome that the awareness of consequences strongly predicting the attitude toward the behavior plays a critical role to linking between basic energy knowledge and energy-saving behavior. It was uncovered by a conditional process analysis that the interaction effect of subjective norm and Thailand on the awareness of consequences, the personal norm, and the attitude toward the behavior was larger than that of Japan. Social expectation on students in Thailand might affect energy literacy. This study suggested that the energy education required in Thailand is to enable students to derive solutions by their own critical thinking based on knowledge relevant to the energy and environmental issues. While, for Japan, it may be necessary to implement energy education as early as possible to enhance students' awareness of consequences in an appropriate manner incorporating with family participation and visiting energy-related facility.

Although the current study found a number of interesting differences among energy-related knowledge, attitudes, and behavior between Thailand and Japan, the energy literacy model is required its universality because teachers are able to obtain a strong theoretical background to implement energy education. For that, more randomly and a wide range of survey will be expected not only a comparison between countries but also between different generations and a variety of regions such as urban/rural, warm/cool climate, energy production/consumption, and so forth. In addition, this study did not compare the degree of achievement of the energy literacy survey among schools to avoid findings being misunderstood with the competence or contribution of the teacher. For future studies, energy education programs can be designed and implemented to improve the awareness of consequences and attitudes toward behavior regarding energy and environmental issues according to the energy literacy structural model. Then it is expected that the effectiveness of educational design will be assessed by a common scale and shared with teachers, educators, practitioners, and any agents that work for energy-related social issues. Sharing the significance of improving citizens' energy literacy will be the ultimate strategy for energy policy.

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Appendix. *Question Items for Energy Literacy Model Assessment on Thai Students (Adopted by Akitsu & Ishihara, 2018).*

Predictors	Question items
Basic energy knowledge	
BEK01	Each and every action on Earth involves…(**2. Energy**) [a]
BEK02	One advantage to using nuclear power instead of coal or petroleum for energy is that…**(2. there is less greenhouse gas emission)**
BEK03	How much does our energy consumption depend on imported energy resources? **(1. Almost 100%)**
BEK04	It is impossible to…(**3. build a machine that produces more energy than it uses**)
BEK05	Which of the following is produced by photosynthesis? **(5. All of the above: Coal, Petroleum, Natural gas, Shale gas)**
BEK06	Which of the following statements best DEFINES energy? **(4. The ability to do work)**
BEK07	Which two things determine the amount of ELECTRICAL ENERGY (ELECTRICITY) an electrical appliance will consume? (**4. The power rating of the appliance (watts or kilowatts), and the length of time it is turned on**)
BEK08	Which of the following description is correct about energy? Energy …(**5. is indispensable whenever we act**)
BEK09	How do you know that a piece of wood has stored chemical potential energy? (**3. It releases heat when burned**)
BEK10	All of the following are forms of energy EXCEPT…(**5. Coal**)
BEK11	What does it mean if an electric power plant is 35% efficient? (**5. For every 100 units of energy that go into the plant, 35 units are converted into electrical energy**)
BEK12	Which of the following choices ALWAYS SAVES energy? (**3. Less frequent washing until a certain volume of laundry is obtained**)
BEK13	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? (**1. Most electricity is currently produced from fossil fuels such as coal, oil, and natural gas.**)
BEK14	Which of the following descriptions is correct about petroleum, which is the energy source that our country consumes most? (**4. There is a risk because petroleum is imported from the middle east**)
BEK15	The original source of energy for almost all living things on the earth is…**(1. The Sun)**
[b] CEI01	The best reason to buy an appliance that is labeled "energy efficient" …**(3. use less energy)**
CEI02	Which of the following descriptions is correct about increasing CO_2 emission as the cause of global warming? (**5. Burning of large amounts of fossil fuels**)
CEI03	Many scientists say the Earth's average temperature is increasing. They say that one important cause of this change is…(**4. increasing carbon dioxide concentrations from burning fossil fuels**)
CEI04	Which of the following energy-related activities is LEAST harmful to human health and the environment? (**5. Generating electricity with photovoltaic (solar) cells**)
CEI05	Which of the following is the MOST appropriate description about the environmental impact by energy resource development and use? (**4. Impact on environment cannot be avoided when humans develop and use energy resources**)
Awareness of consequences	
AC01	All electrical appliances should have a label that shows the resources used in making them, their energy requirements, and operating costs.
AC02	Saving energy is important.
AC03	The government should place stronger restrictions on the gas mileage of new cars.
AC04	People in our country should save more energy.
AC05	If global warming progresses due to mass energy consumption, thousands of plant and animal species will become extinct.
AC06	If global warming progresses due to mass energy consumption, environmental threats to public health will become serious.
AC07	Energy-saving is beneficial for environmental protection and for my health.
AC08	Massive consumption of fossil fuel causes global warming, environmental damage, and affects people all over the world.
AC09	Resource depletion by massive energy consumption will be a very serious problem for the country.
AC10	Climate change will be a very serious problem for me and my family.
AC11	The destruction of tropical forests to meet humans' demand will be a very serious problem for me and my family.
Ascription of responsibility	
AR01	Even if the school pays for the electricity, I should worry about turning off the lights or computers in the classroom.
AR02	Even if new technologies will be developed to solve the energy problems for future generations, we should continue energy-saving.
AR03	Even if it would be produced more energy for future, the laws that protect the natural environment should be made strictly.
AR04	The way I personally use energy makes a difference in the energy problems that face our nation up.
AR05	Every member of the public should accept responsibility for energy-saving to protect the global environment.
* AR06	The authorities, not the public, are responsible for energy-saving and the environment (R)[c]
AR07	I am not worried about energy-saving and the global environment (R).
Personal norm	
PN01	I feel guilty when I squander energy
PN02	I feel I ought to save energy to prevent climate change and protect the global environment.
PN03	Business and industry should conserve energy consumption to reduce greenhouse gas emissions to help prevent climate change.
PN04	The government should take a strong leadership role in developing energy policy to reduce greenhouse gases emissions and prevent global climate change.
PN05	I feel a personal obligation to do whatever I can contribute including energy-saving to prevent climate change.
Attitude toward the behavior	
ATB01	For me, energy-saving is important.
ATB02	For me, saving energy is valuable.
ATB03	For me, saving energy is effective.
ATB04	For me saving energy is interesting.
ATB05	Energy-saving will help us reduce greenhouse gas emissions.
ATB06	Energy-saving will help us save money.
ATB07	Energy-saving will give us an opportunity to consider new lifestyle values.

Appendix. Continued.

Subjective norm	
SN01	My family thinks that I should save energy.
SN02	Most of the people who are important to me think that I should save energy.
SN03	Most of the students in this class think that I should save energy.
SN04	My family has saved energy.
SN05	Most of the people who are important to me have saved energy.
SN06	Most of the students in this class have saved energy.
SN07	Most of the people who I respect appreciate my energy-saving behavior.
SN08	When it comes to energy-saving, I want to do what the important people expect me to do.
SN09	Generally, how much do you care about that the people around you think you should save energy?
Perceived behavior control	
PBC01	For me, saving energy is difficult. (R)
* PBC02	Energy-saving is up to me.
PBC03	I am confident that I can save energy.
PBC04	For me saving energy is possible.
* PBC05	How often do you encounter unanticipated events that you cannot do saving-energy? (R)
PBC06	How often do you forget to save energy? (R)
PBC07	How often do you feel that it is troublesome to save energy? (R)
Intention	
* INT01	If there were ten people around you, what do you think how many people save energy? (Choose the number of 1-10 persons).
INT02	I am always thinking about ways to save energy.
INT03	I will make an effort to save energy.
INT04	I would do more to save energy if I knew how.
INT05	I believe that I can contribute to solving the energy problems through appropriate energy-related choices and actions.
Energy-saving behavior	
ESB01	When I leave a room, I turn off the light.
ESB02	I always sort household waste according to the regulations.
ESB03	I usually set the temperature on the air-conditioners higher in summer and lower in winter.
ESB04	I turn off the computer when it is not being used.
* ESB05	I always keep the water running when brushing my teeth, washing my face or shampooing. (R)
ESB06	I try to choose appliances/products that are labeled “energy efficient”.
ESB07	When I (my family) travel to remote area, I use public transportation such as a bus or a train instead of own car as possible.
ESB08	I cut down on my consumption of disposal items whenever possible, e.g., plastic bags from the supermarket and excessive packaging at the department store
ESB09	I try to reduce the amount of garbage that I produce.
ESB10	In the past six months, I have made an effort to save energy.
ESB11	For me to gain a better understanding of energy-saving is important.
[d] ECB01	Many of my everyday decisions are affected by my thoughts on energy use.
ECB02	I am willing to buy fewer things to save energy.

Some wordings are adapted from the DeWaters’ questionnaire for the middle students’ energy literacy survey (DeWaters, Qaqish, Graham, & Powers, 2013).

* Items with this symbol were eliminated in the subsequent analysis for reliability and consistency of a set of items.

[a] Correct answer is in parentheses in bold.

[b] Items of cognition of environmental issues (CEI) are embedded into the basic energy knowledge.

[c] (R) is a reverse question, which is allocated a reverse point.

[d] Items of energy-use conscious behavior (ECB) are embedded into the energy-saving behavior.