A Study of Energy Literacy among Lower Secondary School Students in Japan

Yutaka Akitsu

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Introduction

Energy is indispensable for human activities and a fundamental resource for maintaining and developing our societies. A large scale of energy consumption to satisfy human desires has, however, triggered critical issues of deforestation, desertification, resource depletion, global warming, and climate change. These environmental problems are primarily caused by energy production and consumption [1].

The intergovernmental Panel on Climate Change (IPCC) created in 1988 by the World Meteorological Organization (WMO) has been working on "*. . . to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation*" [2]. The Fifth Assessment Report released in 2013 and 2014 have determined that it is evidently clear that anthropogenic emissions of greenhouse gases (GHGs) influence on the climate system and recent climate changes have had widespread impacts on human and natural systems [3]. The projections of GHGs emissions will vary depending on both socio-economic development and climate policy. Adapting comprehensive strategies to reducing of substantial GHGs emissions will contribute to mitigating risks, costs, and challenges with respect to climate change in the 21st century and beyond [3]. The IPCC has indicated that the effective policy for climate change issues depends on perception of risks and uncertainties by individuals and organizations. In particular, international cooperation are urgently required to address the issues because "GHGs emissions accumulated by any agent (e.g., individual, community, company, organization, and country, and so forth) affects others" [3].

The United Nations adopted the Paris agreement in 2015, which requires a wide range of cooperation by all countries and their participation in an effective and appropriate international effort to reduce GHGs emissions. Human society requires the perception of irreversible threat of climate change, and cooperation of international efforts to address the issues [4]. A solution to the climate change issues depends not only on policy administration, technology development but also on participation by general public, in particular, it is of significant importance of energy choice, conservation behavior, and reducing fossil fuel dependency. One of the greatest potential resources for meeting the global issues is citizen's energy literacy [5,6]. Because when energy-literate individuals make efforts to address the energy issues with the sufficient skills to do so, it is highly expected that these citizens empower government and industry to develop significant policies and energy solutions for a secure energy future. This positive influence enables government and industry to take truly responsible action on behalf of citizens [7]. As such, the improvement of citizen's energy literacy is urgent matter to constructing a sustainable development society facing with "defining new directions and values for energy development, energy consumption, lifestyles, and global environmental protection" [5]. Energy literacy is fostered by energy education regardless formal and informal with an effective manner. Hence, high expectations are given to energy education to develop citizens and human resources for addressing energy and environmental (EE) challenges.

1.1 Overview of energy education

1.1.1 Background

During the 1960s through the 1970s, it was much concerned about harmful development to human beings and environmental destruction through human activities of unprecedented economic growth, technological progress, and industrial development. While this brought benefits many people, it was primarily caused by developed countries and influenced all of humanity [8].

Since the 1970s, educators and experts in environmental education have emphasized the application of knowledge and societal impact as educational outcomes [9]. In 1975, The United Nations Declaration for a New International Economic Order called for a new concept of development which takes into account the needs of everyone and the harmony between humanity and the environment. That is environmental education. The Belgrade Charter set the goal of environmental education to developing a population being aware of the environmental issues and cultivating their knowledge, attitudes, skills, motivation, evaluation ability and efforts to address the problem-solving, and preventing the next concerns [8]. The world's first intergovernmental conference of environmental education in 1977 adopted the Tbilisi Declaration which listed the categories of environmental education objectives, that are awareness, knowledge, attitudes, skills, and participation [10].

In this era, the world faced two oil crisis in 1973 and 1979, has discovered the ozone layer destruction in the 1980s, and has recognized global warming caused by a large scale consumption of fossil fuels. The world's concern has shifted to global problems, and then, it has derived the concept of sustainable development. Sustainable development is defined in the Brundtland Report that "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [11]. The choices, decisions, and actions made at this time will impact the future generation and society. The world is heading toward the new direction, value, and social reformation with overpopulation and limited natural resources. Both individuals and society need to learn for constructing sustainable society.

In 1992, the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro adopted the Rio Declaration and Agenda 21, which recognized the importance of education for sustainable development (ESD) for raising public awareness (Chapter 36, [12]). Education was viewed as a fundamental tool to accomplishing sustainable development. Four major domains to act in ESD were identified as follows [13]:

- Improving access and retention in quality of basic education
- Reorienting existing educational programmes to address sustainability
- Increasing public understanding and awareness of sustainability
- Providing training to advance sustainability across all sectors.

In 2002, at the recommendation of Japan, a statement on the "Decade of ESD" was included in World Summit implementation plan, and the decade from 2005 to 2014 was designated the United Nations Decade for ESD (UNDESD) [14]. This international trend altered environmental education to be regarded education for sustainable society [15]. The concept map by the Ministry of Education, Culture, Sports, Science and Technology (MEXT, Japan) about ESD consists of eight pillars: environment, climate change, energy, biodiversity, disaster prevention, international understanding, world heritage sites and local cultural properties, and other areas of study (Fig. 1.1 [16]). Learning energy is identified from the environmental education and recognized its importance of improving public awareness of the energy choice, use, conservation, and participation in discussions over energy issues.

Fig. 1.1. Concept Map of Education for Sustainable Development [16].

In 2014, Japan hosted the World Conference on ESD. The conference adopted the Aichi-Nagoya Declaration on ESD that called for all concerned stakeholders, including not only governments but also civic orginazations and educational personnel, and so forth, "urgent action to enable current generations to meet their needs while allowing future generations to meet their own" [17].

In Japan, there are energy relevant topics in the subjects of science, social studies, technology & home economics in the education curriculum in Japan. However, energy education is not specified as one curriculum subject. It is recognized as part of environmental education. The objective of environmental education in school was first officially defined as "education that engages in solving global environmental issues" in the first edition of Teacher's Guide for Environmental Education for Elementary School in 1991 [15]. Subsequently, it has been redefined in the second and third editions to " environmental education for a sustainable society" in response to the UNDESD [15, 18, 19]. Although there is also no subject so called "environmental education" in formal school education, a variety of learning of environment topics is provided in the curriculum of science, social studies, technology & home economics with encompassing the integrated study.

Since school year 2002, the MEXT Guidelines introduced the global environment and energy issues from the comprehensive perspectives of science and social studies classes [20]. In 2006, the Central Education Council (CEC) has indicated the direction to the current energy issues as a critical part of environmental education from the perspective of a sustainable development society [21]. The goal of environmental education indicates not only cultivating human resources with knowledge and understanding the energy issues but also enabling students with ability to proactively participate in constructing a sustainable society [18].

To respond to social change, in 2008, the CEC stipulated a report that energy topics are clearly positioned as a critical part of environmental education that is of significant importance to be learned across subject boundary for the perspective of harmonizing between humanity and environment for sustainable society [22,23]. Subsequently, in new educational guidelines 2008 of Elementary and Junior High School, the education topics regarding the environment, energy and resources including nuclear energy, and radiation have been expanded [22]. It is noteworthy that radiation education has been resumed in 2012 after thirty years absence.

1.1.2 Energy education in school

On the basis of ESD concept, a variety of organization not only government but also educational institutes, non-profit organization relevant to energy education have assisted teachers' energy education activity in school. They provide energy education program, teaching materials, current energy data that can be used in school education, and administer workshops for teachers to capacity building (e.g., [6, 24–30]).

The European Commissions emphasizes the role of energy education to be aware of the impact of choosing energy-efficient appliances and services that lead to the success for energy reduction without compromising performance [26]. The Energy Education Governance Schools (EGS) launched the Enrgy Revolution Project from 2008 to 2011 [30]. The concept of EGS is that energy literacy is important for Europe's economic and environmental future, and the energy topic must be an indispensable part of the school curriculum to cultivate energy-literate citizens. According to their survey at 39 schools from 10 countries for primary, secondary, and vocational schools, the energy topic has been integrated into school curriculum in more than 80% of schools in principle with more than one subject. Then, the EGS aimed for improving school capacity from the perspective of improving students' awareness of energy-efficiency and renewable energy sources to allow a reduction of environmental destruction. Moreover, the external networks such as students' family and local agents were created to share and disseminate knowledge, ideas, and motivation for energy-efficiency into their community.

On the other hand, according to the survey of Special Eurobarometer 409 for climate change (2014) reported that 50% of all Europeans think that climate change is one of the most serious problems in the world, but the proportion of those who agree to this idea ranges from 81% in Sweden to 28% in Estonia. Furthermore, 90% of Europeans think that their government should provide support for improving energy-efficiency by 2030, while one fourth (25%) of Europeans think they feel a personal responsibility to overcome climate change [31]. The need of energy-efficiency is recognized by Europeans for tackling climate change but it is expected to their government policy and leadership.

In the U. S., for example, the National Energy Education Development Project (NEED) is working on energy education for over 35 years. Their work has begun the same year when President Jimmy Carter issued a Proclamation 4738, "National Energy Education Day" in 1980. Since its founding, the NEED has promoted kids' and students' awareness of energy issues and educated teachers and society to improve their energy literacy by creating effective networks among students, educators, and energy-related leaders to achieving objective [32]. Moreover, the textbooks and materials of energy education produced by NEED have been shared to countries where address energy education (e.g., [33, 34]). The Wisconsin K-12 Energy Education Program (KEEP) has been started by the Wisconsin Center for Environmental Education since 1995 aiming for promote energy education in Wisconsin (the U. S.). They recognize that students are needed the improvement of energy literacy, and energy education must be integrated part of the school curriculum to produce energy-literate citizens. It is highly expected to improve citizen's energy literacy for Wisconsin's economic and environmental future [35].

In spite of the longitudinal effort on energy education in the U. S., the survey of American adults in 2005 indicated that the majority of respondents concern over energy prices, imported oil dependence, and agree with renewable energy development, however, only 12% could achieve the 70% of correctness [36]. Subsequently, in the 2009 survey, 39% of respondents could not describe a name of fossil fuel nor 51% renewable energy, and 56% incorrectly answered the cause of global warming is nuclear power and 31% solar power [37]. Bittle, the leader of the survey in 2009, concerns that this lack of knowledge may be likely to be the biggest challenge the nation faces on energy issues, and be greater than economic or technical problems [37].

In Japan, the MEXT supports for nuclear energy education by each prefecture themselves to develop human resources in school with a pertinent and comprehensive learning from the broad perspectives of energy, environment, science, technology, and radiation [38]. Furthermore, the Japan Science Foundation (JSF) has undertaken the Energy Education Model Schools Project since 2002 commissioned by the Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI) [39]. The project introduces a school appoint system to learn four objectives: energy security, global warming, energy resource diversity, and energy conservation.

More than 500 schools ranging from elementary to high school have been encouraged by this project as an energy education practice model. The Japan Association of Energy and Environmental Education (JAEEE) has established in 2005. The outstanding of JAEEE is that it is consisted of faculties of department of Science, Technology, Education and so forth where they address EE education, and teachers in broad educational stage from the elementary to technical colleges [40]. They aim to providing informative transmission on EE education both at home and abroad through the promotion of theoretical and practical research [41]. The JAEEE has taken leadership in creating effective networks to achieve the objective among teachers, educators, business, government, academic researchers and in promoting the development of the materials and practical methods of energy education.

Notwithstanding a variety of energy education practices have been reported and accumulated by teachers and educators in recent years in Japan, neither a comprehensive education program focusing on energy issues nor a common evaluation of energy education achievement have been presented by the official curriculum guidelines [42]. According to the survey of the Former Information Center for Energy and Environmental Education in 2009, more than 90% of schools think that energy and environmental education is important [43]. Eighty-eight percent (88%) of elementary school and 66% of junior high school have addressed the environmental education, while only 15% of elementary and 9% of junior high school have worked on the energy topics into the period for integrated study. More than half of respondents of teachers in elementary and junior high school emphasized the need for producing the consistent curriculum of energy and environmental education from elementary school to high school. As similar to the situation of current environmental education pointed out by Kodama [15], it is difficult to constantly provide sufficient energy education in school without support by government unless energy relevant topics dispersed in the teaching curriculum might be intentionally integrated by individual teacher [44]. Educators and researchers working on energy and environmental education have perceived that energy education has not been disseminated into school education in Japan [43].

Furthermore, energy education in Japan has been facing major challenges after the disasters of Great East Japan Earthquake, Tsunami, and accident of the Fukushima Daiichi Nuclear Power Plant, Tokyo Electric Power Company Ltd. (TEPCO) on March 11, 2011. After the nuclear accident, the government at that time undertook severe measure of suspending operation of all nuclear power plants in Japan until a new safety regulation allows operation resumption under the initiative of the Nuclear Regulation Authority. People ignorance and misunderstanding about radiation and radioactivity have expanded adversely the protests against nuclear power and the damage of fears and rumors due to radioactive contamination. It is quite difficult to provide energy education including nuclear energy as same as other energy sources in the current controversial situation over nuclear energy and to enable students understanding factual energy issues in Japan. Thus, the current energy education in Japan is likely to depend on the contribution of teachers who produce their own energy education while keeping the range of the given official education curriculum.

Japan is one of the largest energy consumers in the world and depends on 94% imported energy resources. Since the disasters in 2011, the current energy situation in Japan has been facing declining in the energy self-sufficiency ratio, increasing in electric power costs, and increasing in the amount of CO_2 emissions [45]. Every single citizen is strictly required to understand the energy situation in Japan and to participate in and take actions for problem-solving to overcome the energy issues [45].

Allocated time to the energy education is limited in a tight school curriculum. To achieve effectively the goal of energy education that develops a well-informed public with positive attitudes and behavior toward energy-related issues [46], it is of critical importance to firstly confirm the requirements for an energy-literate individual.

1.2 Energy literacy definition

Numerous studies have been conducted to evaluate energy-related knowledge, attitudes, and behavior among the general public and students (e.g., [1, 36, 37, 46–67]). However, one of the limiting factors of studies that aim to measure these dimensions is the range of topics and questions which are selected [9]. Because topics and question items are linked to each purpose of the survey, it may be difficult to compare the actual conditions of subjects. A survey instrument often focused narrowly or specifically on consumer-oriented topics or curriculum-based objectives is obviously limited in its ability to measure general energy-related knowledge, attitudes, and behavior [9]. Moreover, to provide an effective energy education, it is of paramount importance to understand the status of students' energy-related knowledge, attitudes, and behavior, and to identify elements to be emphasized in energy education by evaluating their learning outcomes. From the perspective above, the definition and conceptualization of "energy literacy" is required.

1.2.1 Conception of literacy

The meaning of literacy has expanded from solely individual abilities to read and write text and use, to the capacity to understand more complex views encompassing the broad social issues [68]. DeWaters & Powers described that "literacy is not only a way of knowing, but also a way of being curious, objective, and capable of assessing and applying information and skills to make sound decisions and actions" [9].

Sato defines literacy as a common culture with functional literacy [69]. Literacy is public culture which is educated, cultivated, and sophisticated through school education to form the basis of social independence of individuals. Furthermore, knowledge and information have been sophisticated, complicated, constantly updated in rapidly changing societies, more advanced critical thinking and communicative abilities are also required [69]. Hence, the literacy used with various terms nowadays, it refers not only to knowledge but also to ability to select and judge necessary information and to widely discuss social issues. That ability is also needed understanding the issues to be solved are associated and entwined with a wide range of industry, economy, and society, and making a decision and taking an action. Hence, energy literacy can be considered a common culture to addressing energy issues and will be cultivated through education as a fundamental competency of people concerning energy problem-solving. It is highly expected to be able to clarify the goal of energy education by defining energy literacy.

1.2.2 Definition of energy literacy

Lawrenz proposed that the ultimate goal of energy education is to develop a "well-informed public with positive attitudes toward energy conservation" [46]. The effective energy education is expected to promote not only knowledge outcome but also values and attitudes toward energy-related issues and to encompass to energy-saving behavior [9]. Therefore, energy literacy needs to include the broad aspects regarding energy-related issues encompassing scientific, technological, environmental, and social context.

The U. S. Department of Energy have defined energy literacy as "an understanding of the nature and role of energy in the world and daily lives accompanied by the ability to apply this understanding to answer questions and solve problems" [6]. Furthermore, they describe an energy-literate person:

- can trace energy flows and think in terms of energy systems.
- knows how much energy they use, for what purpose, and where the energy comes from.
- can assess the credibility of information about energy.
- can communicate about energy and energy use in meaningful ways.

- is able to make informed energy use decisions based on an understanding of impacts and consequences.

DeWaters & Powers have defined energy literacy in terms of three domains: cognitive (knowledge), affective (attitudes, values), and behavioral. The definition of energy literacy was developed based on the conceptions of scientific and technological literacy, critical thinking ability, and environmental literacy. It was also taken into account the curriculum materials, educational standards, and literature in the fields of energy literacy and energy education [7, 9]. The definition by DeWaters & Powers includes practical perceptions and efforts of individuals to engage energy-related issues. It has been defined an energy-literate individual as one who:

- has a basic understanding of how energy is used in everyday life;
- understands the impacts that energy production and consumption have on all spheres of environment and society;
- is cognizant of the impacts of individual, collective, and corporate energy-related decisions and actions on the global community;
- is aware of the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources; and
- strives to make choices, decisions and take actions that reflect these understandings and attitudes with respect to energy resource development and energy consumption, and is equipped with the necessary skills to do so.

In Japan, the Information Center for Energy and Environment Education presents the objective of EE education as following: developing studen's in-depth understanding of EE issues through various activities relevant to energy and the environment and cultivating and fostering fundamental knowledge, skills, awareness to contribute to solving energy-related issues with positive attitudes and appropriate actions [70]. Furthermore, on the basis of idea that energy choice should be decided by general public as a whole, Hashiba et al. have emphasized more a multidisciplinary and comprehensive understanding of energy system in society from the perspective of energy resources, production, transportation, storage, distribution, consumption, and disposal [71].

Energy issues often intertwine with not only science and technology but social aspects such as citizen, history, economics, politics, sociology, and psychology [6]. Hence, the definition of energy literacy ranges broadly from individual energy use in daily life to national and global issues. Improving individual energy literacy is expected citizens participation in discussions on government energy policy for energy choice, investment, development, and regulation. Therefore, the definition of energy-literate individual in this study is as one who:

- recognizes life cycle of energy system and its impact on the environment from resource productions to energy distributions through energy transportation, conversion, storage, and the waste management;
- understands the impact of our energy choices on economical 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 appropriate action for energy-saving.

1.3 Literature review

A number of studies have contributed to the understanding of people's knowledge, attitudes, and behavior about energy-related issues.

Although people are concerned about EE issues and want to contribute to problem solving themselves, their basic scientific energy-related knowledge is insufficient [36, 37,48,50–52,54,55,72]. A random survey of Japanese adults with 1452 valid response, authors reported that people of twenty to sixty-five years old could answer only 42% correctly due to lack of energy relevant knowledge [73]. In particular, it seemed to be difficult for respondents to answer the items relevant to economy and energy (36% correct) and environment and energy (35% correct). A knowledge deficit and misconceptions about energy become a barrier when people seek solutions to global warming, and it may lead to inappropriate energy choices [50, 74, 75].

Frequently, findings indicate gender differences in which males show higher score in the knowledge of energy-related issues than females [5,48,49,76,77]. Females tend to represent positive attitudes to energy issues and conservation than males (e.g., [5,46–48,76–78]). In contrast, it has been discussed that the number of science classes taken contributed to the difference in the students' levels of knowledge about environmental issues related to energy [53]. Namely, gender differences may be considered a by-product of the disparity of literacy and interests in scientific issues [58, 79].

Barrow and Morrisey [47, 48] found that the efforts of implementing energy education based on energy crisis experience would cause a disparity in the knowledge and attitudes of energy-related issues of ninth graders by a geographical comparison between the U. S. and Canada. Another geographical comparison survey in Ehime Prefecture in Japan found that students who live near the Ikata nuclear power plant indicated a higher motivation for learning about energy than their counterparts. They were more knowledgeable about power generation and alternative energy. Moreover, they tended to think of energy associated with generation, whereas students who live far from the nuclear power plant tended to think of energy by the contents of school science classes [62]. More experience with energy would affect students' motivation toward energy issues and the contents of the energy education provided by a teacher.

A study of students in elementary, middle, and secondary schools in Japan indicated that students' behavior towards the EE issues were associated with their family behavior [67]. Pe'er, Goldman & Yavetz [80] also suggested that the environmental knowledge and attitudes of college students in Israel are positively related to their mothers' educational levels. Furthermore, effective energy education programs improved students' attitudes and energy conservation behavior and changed their parents' attitudes and behavior owing to the spillover effects of the students' education [61, 81, 82]. The interaction effects among students, parents, teachers, or other adults could promote their energy-saving behavior, and students disseminated what they have learned into their homes. The synergistic effect of students and family is one of the critical factors to understand students' energy literacy.

Yuenyong & Jones have reported regarding students' ideas about energy related to technological and societal issues through a comparative survey of the 9th grade students between Thai and New Zealand [83]. Students in each country indicated different values in decision-making on between society and energy. Thai students value on the country development and believe in the application of science for social problem-solving, while students in New Zealand prioritize the relation to environmental issues. They are skeptical about whether science can solve social problems, they rather think it will damage the environment. It seems that Thai students tend to believe the country policy and development. Students' ideas about energy-related issues may vary at their attributes which are influenced by the socio-cultural perspective.

For a comparative study of energy literacy, DeWaters et al. [9, 84, 85] have established an energy literacy framework and developed an instrument that consists of energy-related knowledge, attitudes, and behavior that can measure by using a written closed-item questionnaire for a practical classroom application. Utilizing this framework and instrument, their study reported that secondary students in New York State (U. S.) were concerned about energy problems yet discouragingly low in the cognitive domain, which implies that students may lack the knowledge and skills required to contribute effectively toward energy-related solutions. Moreover, the strongest intercorrelation between behaviors and attitudes rather than knowledge suggests the need for education that improves energy literacy by affecting students' attitudes and behaviors rather than pursuing the amount of knowledge [5].

In response to the DeWaters & Powers work, several studies have adopted it to evaluate students' energy literacy in their own countries. Students in Taiwan scored over 60% correct on a cognitive subscale, which was better relative to students in New York State. Moreover, their energy-saving behavior was more closely associated with attitudes than other variables. However, their finding of a notable discrepancy between attitudes and behavior was indicated. Namely, there might not be a correspondence between what students say they should do and how they actually behave [86]. In another comparative study of secondary students in Malaysia, in spite of the government promotion of energy education in formal (Ministry of Education Malaysia, 2002) [87] and informal [88] educations, the energy literacy of students was discouragingly low. The results emphasize 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 energy use in everyday life [89, 90]. Chen, S. et al. conducted a confirmatory factor analysis to investigate the relationships among energy-related knowledge, attitudes, self-efficacy, and influences of family behavior toward the personal behavior of their son(s)/daughter(s) in high school in Taiwan by structural equation modeling (SEM) [76]. The extent to which family members perform for energy-saving affected most to students' positive energy-saving behavior. Conversely, a negative relation between knowledge and personal behavior was evidently observed.

Although comparing each level of energy literacy components can be possible, the relationships between knowledge, attitudes, and behavior are complicated. Evidence from a number of studies has supported the relationship between attitudes and behavior (e.g., [91–95]). While, many studies on energy literacy have reported little correlation between EE knowledge and energy-saving behavior (e.g., [5, 56, 57, 76, 81, 86, 96]). Increased knowledge does not alone lead to the altering people's behaviors and lifestyles toward energy-saving nor does it affect the attitude-behavioral consistency (e.g., [5, 57, 76, 81, 86, 97–100]). However, knowledge is an important factor in overcoming psychological barriers, such as ignorance and misinformation, and making decisions to act. Its role is potentially complex, but necessary for successful action (e.g., [97, 101–104]). Even if relevant EE knowledge does not directly affect a specific energy-saving behavior, it may implicitly facilitate a given behavior through mediators, such as beliefs or confidence [105].

Earlier studies suggested that the amount of knowledge induces pro-environmental intentions and behaviors (e.g., [106, 107]). Hungerford & Volk assumed a simple linear model in which increasing knowledge induces positive pro-environmental behavior by activating a person's awareness and responsibility toward the environmental issues [92]. Many researchers have claimed that this simple linear model is insufficient, and more complex relationships between knowledge and behavior have been discussed (e.g, [56, 95, 108, 109]). Despite having high knowledge of energy-related issues, he/she does not necessarily carry out energy conservation or actions to promote more sustainable energy-related future (e.g., [5, 56, 76, 81, 86]).

Fabrigar, Petty, Smith, & Crites have discussed that, while the amount of knowledge does not affect attitude-behavioral consistency, people consider the relevance of the dimensional complexity of the knowledge that underlies their attitudes and behavior before deciding to act [110]. Because people's attitudes, intentions, and behaviors are consistent with their beliefs, which reflect the information that they hold, knowledge is one of the background factors that may influence a persons beliefs [111]. Although knowledge plays an inevitable role in energy literacy, the informative causality between knowledge and behavior has not been uncovered.

It is also vital important to understand people's conceptual structure of knowledge, attitudes, and behavior regarding EE issues in order to identify the factors to be considered and emphasized in energy education.

1.4 Social psychological approach of energy literacy structure

In psychology study, attitudes have been studied long time and used as important predictors of behavior because they precede the person's behavior toward an objective or concept [112]. In the early study of attitudes, Thurstone attempted to measure attitudes toward specific objective quantitatively in psychometrically scale [113].

Since the Thurstone's contribution, social psychologists have attempted to construct attitude formation, the structure of attitudes, attitude change, the function of attitudes, and the relationship between attitudes and behavior (e.g., [112, 114–117]). From the typical definition of attitudes, Rosenberg & Hovland indicated that "attitudes are predispositions to respond to some class of stimuli with certain classes of responses and designate the three major types of response as cognitive, affective, and behavioral" [118]. On the contrary, Fishbein discussed that attitude is viewed as a general factor of variables which predict behavior, and does not predispose the person to perform the specific behavior. Rather attitude leads to a series of intentions that have a certain amount of affect on the objective [119]. On the basis of this concept, Fishbein and Ajzen developed the Theory of Reasoned Action (TRA) [119]. The TRA described that behavioral intention is predicted by attitude toward specific object (behavior) and subjective evaluation of attitudes taking into account outcomes and benefits from the object (behavior). Ajzen more improved the predictive power of the TRA by adding perceived behavioral control, that is the Theory of Planned Behavior [120].

This study investigates the energy literacy conceptual structure by employing some theoretical models applied in various fields to understand people's belief, attitudes and behavior.

1.4.1 Theory of Planned Behavior (TPB)

As aforementioned, the TPB [120] was extended from the TRA (Fig. 1.2, the part surrounded by a dashed line, [119]) to improve on the predictive power of the model, observes an individual's behavior, which is predicted by a behavioral intention formed by attitudes toward the behavior, subjective norms, and perceived behavioral control (Fig 1.2) [120]. The TPB focuses on the behavior itself and explains how human action is influenced by main three factors of: an evaluation in favorable or unfavorable to perform (*attitude toward the behavior*), perception of social pressure to perform or not (*subjective norm*), and perceived capability to perform (*perceived behavioral control* or self-efficacy [121]) [122]. These combinations form a behavioral *intention*. Due to lack of sufficient information about all factors which may facilitate performance of behavior, as long as people are realistic in their judgement, a measure of perceived behavioral control can be a substitute for *actual behavioral control* and contribute to predict the behavior [122]. The TPB explains human behaviour and has been adopted into various fileds of study of the relationship among beliefs, attitudes, behavioral intentions and behaviors.

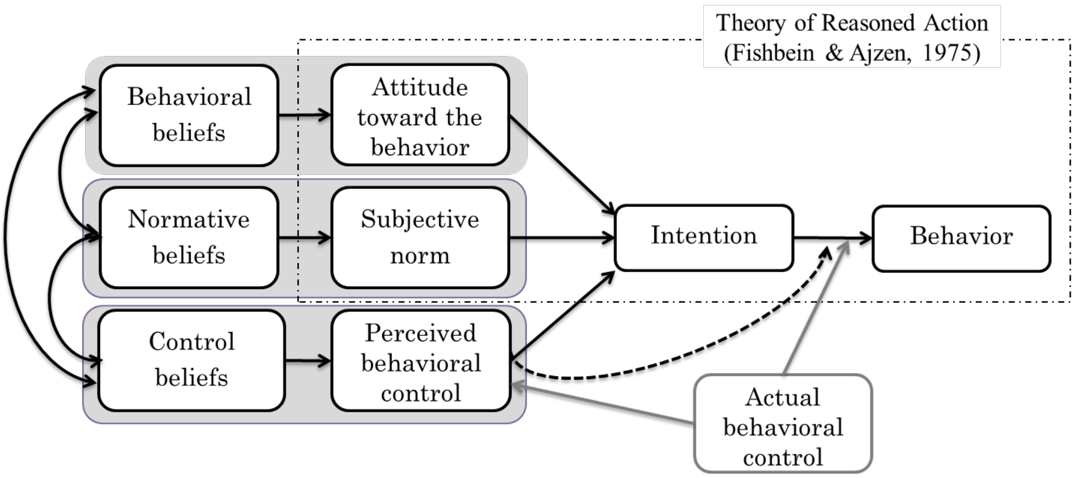

Fig. 1.2. Theory of Planned Behavior.

1.4.2 Linear assumption on pro-environmental behavior

One traditional linear model of responsible environmental behavior suggests that increasing knowledge would lead to environmental awareness and attitudes, which derive more positive pro-environmental behaviors (Fig 1.3) [92]. Although a behavioral change requires knowledge contributions to change attitudes toward the behavior [91, 109, 123], the relations between knowledge, attitude, and behavior have not been supported by simple linear causal models in the field of environmental attitudes and behaviors [5]. Thus, in this study, it was assumed that attitude plays a role between knowledge and behavior from the results of an intercorrelation (e.g., [5, 76, 86]).

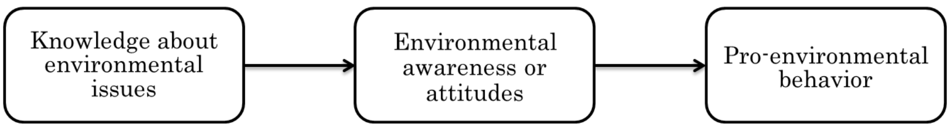

Fig. 1.3. Traditional Linear Model of Responsible Environmental Behavior.

1.4.3 Value-Belief-Norm Theory (VBN)

The VBN theory [124] is principally founded on Schwartz's Norm Activation Theory (NAT) [125], which focuses on the relationship between personal values, personal norms, and pro-environmental behavior that is determined by social motivation. The VBN was developed by Stern et al. as a causal model which explains the pro-environmental behavior is predicted by the personal norm activated by the ascription of responsibility and awareness of consequences (Fig. 1.4). The awareness of consequences connects the person's environmental worldview, which is assessed by the new ecological paradigm (NEP) [126]. The NEP is related to general value: altruistic values, egoistic values, traditional values, and openness to changes values. When people's behaviors are consistent with their beliefs, which reflect values that are based on the knowledge that they have, the pro-environmental behavior are activated.

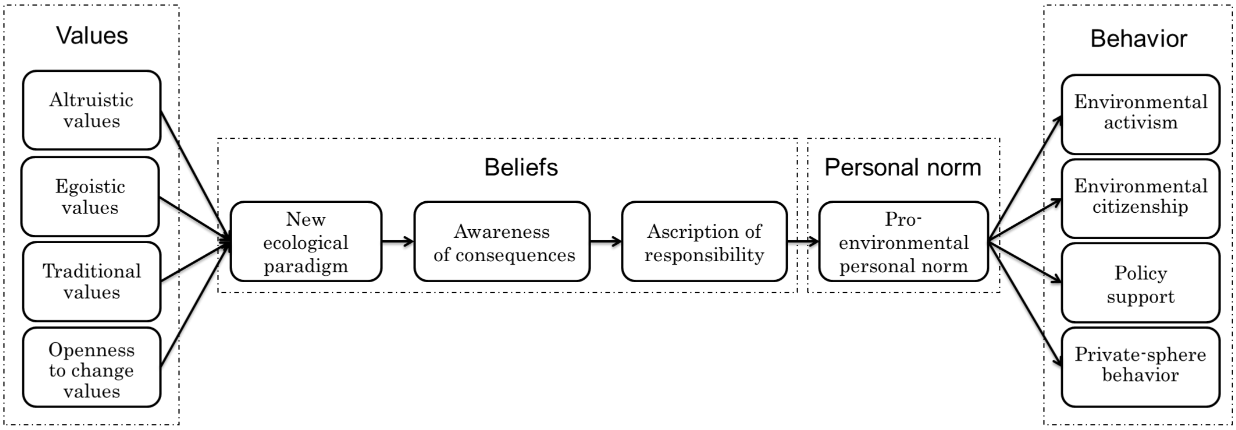

Fig. 1.4. Value-Belief-Norm Theory.

The application of these theoretical models and predictors helps to explore the complex relationships among energy literacy components. Research often employs a questionnaire survey when the results need high external validity by random sampling to obtain a sample of respondents that are representative of a population. Structural equation modeling (SEM) is used to test for potential causal relationships in this type of data [127]. This thesis adopts SEM to understand the conceptual structure of energy literacy.

1.5 Study objective

To provide effective energy education in limited school curriculum, this study investigates energy literacy and its conceptual structure of lower secondary students in Japan. The reasons of subject selection are that:

- the energy topics in the compulsory curriculum are relatively fulfilling than those in elementary school,

- it is relatively possible to compare with other energy literacy studies which adopted the same subject, and
- understanding energy literacy of adolescents who will affect directly and indirectly future decisions through their energy-use, choice, and action, is highly expected to give us some clues for effective energy education development.

First, the current status of students' energy literacy in Japan is investigated by a questionnaire survey, and given results are compared with those in the U. S. Subsequently, the energy literacy structural model is constructed. The interactions of moderation variables in the model are further analyzed in conjunction with energy literacy. The applicability of proposed energy literacy model is assessed and the differences in attributes in energy literacy to identify the characteristic of Japanese students are explored. Last, acquired knowledge through this study are summarized, and the findings which will contribute to the development of effective energy education are provided.

1.6 Thesis structure

The overall structure of this thesis is as follows:
The significance and objective of this study were described in Chapter 1. Chapter 2 describes the methodology of survey, questionnaires development, and statistical analysis. Chapter 3 surveyes the current status of energy literacy of lower secondary students in Japan, and compares with the results of students of middle school in the U.S. (New York State) [5]. Chapter 4 explores a conceptual model of students's knowledge, attitudes, and behavior in energy literacy by employing a factor analysis approach with the result of Chapter 3. An energy literacy structural model integrated with the Theory of Planned Behavior and the Value-Belief-Norm Theory in social psychology study is proposed in Chapter 5. In Chapter 6, the applicability of the energy literacy structural model will be assessed through the international survey in Thailand. Finally, Chapter 7 presents a summary of this study, limitations, and its recommendations for future research.

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Chapter 2

Methodology

2.1 Energy literacy framework

DeWaters & Powers established a working framework for developing instrument which can measure energy literacy by employing a written, closed-item questionnaire for students of middle and high school students in New York State [1] (Appendix A, Table A.1 adopted from DeWaters and Powers [2]). The framework was extended from conceptions of scientific, technological, and environmental literacy and criteria were set for the questionnaire. Furthermore, the criteria are selected topics grounding the current energy situation, and it will be necessary to be updated to accommodate changes in science, technology, society, and the environment [1]. It is also noted that the framework and criteria take account for the limitation imposed by both geographical and cultural conditions. Therefore, the framework is applicable to developed countries, and some of criteria may probably be adapted only to certain areas, the Northeastern United States.

The framework for instrument development consists of three domains: cognitive, affective, and behavioral. Self-efficacy which explains person's beliefs about his/her contributions toward solving energy-related problems [3, 4] is embedded within the affective subscale (Fig. 2.1). The cognitive, affective, and behavioral domains are categorized into sets of benchmarks to identify the characteristics within each attribute of literacy. The framework can support to develop an instrument's validity and identifies a variety of topics relevant to energy issues.

Cognitive characteristics include cognitive skills such as critical analysis, problem solving, and values clarification, which refer to basic scientific and technical content. Moreover, it is also included knowledge which relates to consumer's actions and decisions through energy comsumption ratings for electric appliances, electric supply, and fuel demands [5]. For example, there are listed regarding knowledge and understanding of: basic scientific facts; issues related to energy sources and resources; general trends in the country and global energy resource supply and use; the impact of energy source development and use on society and the environment; abilities to interpret, analyze, and evaluate, and abilities to examine energy-related information, argument, costs and benefits [5].

While, affective and behavioral characteristics generally describe a person who recognizes the current situation of global energy problems and exhibits a willingness to take part in their solution [5]. For example, in the affective domain, there are listed regarding: positive attitudes and values regarding awareness/concern with respect to global energy issues; economic responsibilities related to sustainable energy resource development and use; the potentiality of changing our lifestyles to solving energy problems, and so forth. In the behavioral domain, there are listed regarding behaviors toward energy conservation; thoughtful, effective decision-making and possibility to change advocacy for energy issues, and encourages others to make wise energy-related decisions and actions [5].

These criteria can be also applicable for assessing energy literacy of Japanese people. Hence, this study adopted this framework which was established by DeWaters and Powers [1], and some question items were modified to suit the current energy situation in Japan.

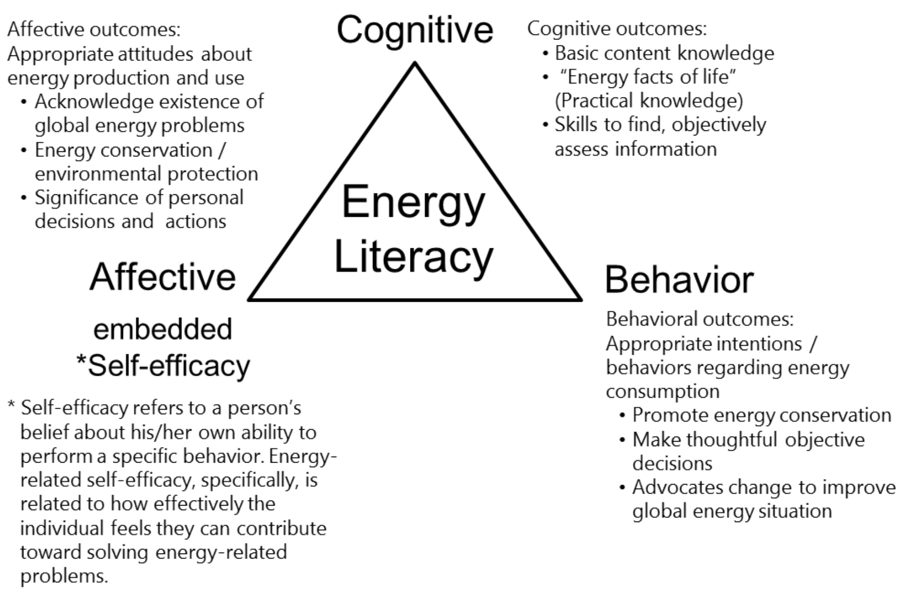

Fig. 2.1. Concept of Three Domains in Energy Literacy Framework.

2.2 Questionnaire development

There are two types of questionnaire developed. One is a basic questionnaire consisting of cognitive, affective, and behavioral domains. It was utilized to assess the energy literacy of Japanese students and to compare with the U. S. results.

Another questionnaire which was employed for modeling of energy literacy structure has been developed on the basis of the result of an exploratory factor analysis of the first questionnaire survey, and additional survey variables of theoretical models in social psychology study were designed.

2.2.1 A basic questionnaire for comparing with the U. S. results

A basic questionnaire was developed and modified according to the the Energy Literacy Survey for Middle School, Clarkson University [6]. It was translated into Japanese wording, reformulated to suit domestic energy circumstance, and reflects previous survey items in Japan. There are two items eliminated from the DeWaters' original questionnare. One in the cognitive subscale was deleted because there were two different data on the website in Japan in 2014 regarding the most electricity-use home appliance [7,8]. The rest of two items in behavioral subscale were integrated into one question as "I turn off the light and computer when I leave a room," because the past surveys in Japan have employed either one of both "the light" and "computer." As a result, fifty-five question items were selected to compare with the U. S. result [4]. A set of fifty-five items is denoted as *TS55* (This Study 55 items) to discriminate from other sets.

Furthermore, additional question items were administered by referring to the past surveys in Japan regarding the awareness of energy, radiation, and environment [9–14]. For example, in the cognitive subscale, fourteen items were added such as: basic understandings of energy; energy self-sufficiency and development in Japan; global warming; a basic knowledge of radiation; resource development and its impact on the environment; energy choices. Students also rated their attitudes and behavioral trend regarding that "Energy-best-mix policy" of developing both renewable energy and nuclear power, and strict burden by energy-saving regulation on economies, industries, and general public activities in Japan. Finally, a total seventy-three items for Japanese students survey was developed, which consisted of forty-three items for the cognitive, nineteen items for the affective, and eleven items for the behavioral subscales. This set was denoted as *TS73*. Inconsistent item of No. 33, "I obtain information on global warming and energy-related issues through television and newspapers" in the behavior subscale was eliminated beforehand.

Table 2.1 presents question items, where some of the phrases are adapted from the DeWaters' survey questionnaire for the middle students [6]. In the cognitive subscale, a correct choice from multiple options is in bold in parentheses. Self-efficacy items are indicated by the (Se) symbol, which is embedded into affective subscale. A reverse question is indicated by the (R) symbol, which is allocated a reverse point. The * symbol is the item which was eliminated for the comparison with the U. S.

Each subscale of *TS55* and *TS73* indicates the internal consistency and reliability by Cronbach's alpha values in the range between 0.66 to 0.78, which satisfied the criteria for educational assessment. They are presented in Table 2.2 with DeWaters' report (DW) [4]. A Cronbach's alpha value is a measure of internal consistency, that is, how closely related a set of items are as a group, which ranges in value from zero to one. Cronbach's alpha values should be at least 0.70 for a set of items in social science scales [15] and can be as low as 0.60 for educational assessment scales [16–19].

Cognitive items were prepared five-option multiple choice questions with one correct answer choice. Affective and behavioral scales were constructed using a variation of the Summated Ratings Method used by Likert [20], with five-point bipolar adjective scales, which ranges from "extremely agree" to "extremely disagree," and "always to do so" to "not at all," respectively.

Four items of self-efficacy were embedded within the affective subscale, which describe one's beliefs about his/her contributions toward the problem-solving for energy-related issues [3, 4]. Self-rating questions that ask students about: (1) how much you feel you know about energy; (2) when it comes to energy-use, how you describe yourself; (3) one thing which has contributed most to your understanding of energy issues and problems, and (4) the frequency of talking to your family about energy-saving, were provided to examine differences between the energy literacy assessment and self-rating report. Because some of studies have reported persistent concerns about the response of self-reported behavioral measures among school children, it is necessary noting what students show on a questionnaire is likely to be inconsistent with their actual feelings or behaviors [5, 21, 22].

Finally, the questionnaire also includes demographic items which are gender, school year, city they live in, experiences (energy education, energy-related facility-tour), and family influences (family discussion of energy issues, home discipline in energy-saving, and the age at which his/her parents have first requested energy conservation). The questionnaire which was used in school is presented in Fig. E.1 in Appendix E.1. A summary of question items linked to the framework is presented in Table 2.3. The items in bold number were added for this survey.

Table 2.1. Basic Question Items of Energy Literacy Assessment (*TS73*).

No.	Question items
Cognitive subscale	
36	Each and every action on the earth involves... [**2. Energy**]
37	The amount of ELECTRICAL ENERGY (ELECTRICITY) we use is measured in units called... [**1. Kilowatt-hours (kWh)**]
38	Which uses the MOST ENERGY in the average Japanese home in recent year? [**2. Heating and cooling rooms**]
39	One advantage to using nuclear power instead of coal or petroleum for energy is that... [**2. There is less air pollution**]
40	Which of the following energy resources is NOT renewable? [**2. Coal**]
41	Which resource provides about 85% of the energy used in developed countries like Japan, the United States, and Europe? [**5. Fossil fuels**]
42	The best reason to buy an appliance labeled "energy efficient" is... [**4. using less energy**]
43 *	The percentage of which our energy consumption depends on imported energy resources is... [**1. Almost 100%**]
44	It is impossible regarding energy to... [**3. Build a machine that produces more energy than it uses**]
45	When you turn on an incandescent light bulb, some of the energy is converted into light and the rest is converted into... [**3. Heat**]
46 *	Correct description about methane hydrate development in Japan [**5. It deposits under the seabed around Japan, but is difficult to extract and has not been put into practical use**]
47 *	Correct description about the CO_2 emission increasing which causes global warming [**5. For the rapid development of industry, a large amount of fossil fuels have been consumed**]
48	If a person travelled alone to work 10km every day and wanted to save gasoline, which one of the following options would save the MOST gasoline? [**4. Carpooling to and from work with one other person**]
49	Proper description about the amount and cost of petroleum imported to Japan over the past decade [**4. Decreased and become more expensive**]
50	Which energy resource was made by photosynthesis? [**5. All of the above**]
51 *	Incorrect description about radiation [**3. It does not exist in foods or drinks at all**]
52 *	The sector that consume oil MOST in Japan [**4. Transport sector**]
53	Which of the following statements best DEFINES energy? [**4. The ability to do work**]
54	Proper description about "renewable energy resources" [**5. Resources that can be replenished by nature in a short period of time than human beings use**]
55	Which two things determine the amount of ELECTRICAL ENERGY consumed by an electrical appliance? [**4. The power rating of the appliance (watts or kilowatts), and the length of time it is turned on**]
56	Scientists say the single fastest and most cost-effective way to address our energy needs is to... [**3. Promote energy conservation**]
57	Which resource provides MOST of the ENERGY used in Japan in 2010? [**1. Petroleum**]

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No.	Question items
58	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**]
59 *	Correct description about energy [**5. Any activity needs energy**]
60	Which of the following energy-related activities is LEAST harmful to human health and the environment? [**5. Generating electricity with photovoltaic (solar) cells**]
61 *	Which of the following correctly describes oil depletion? [**5. Oil depletion comes from constraints of geological, economical and technological factors**]
62	Which uses the LEAST ENERGY in the average Japanese home in recent year? [**4. Lighting the home**]
63	How do you know that a piece of wood has stored chemical potential energy? [**3. It releases heat when burned**]
64	Most of the RENEWABLE ENERGY used in Japan comes from... [**2. Hydro power**]
65 *	Incorrect description about nuclear power plant operating safely [**5. Near nuclear power plants have higher radiation dose than distant**]
66	Which one of the following sources generates the most ELECTRICITY in Japan in the past few years? [**5. Natural gas**]
67	All of the following are forms of energy EXCEPT... [**5. Coal energy**]
68	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**]
69 *	Correct description about energy resources development alternative to fossil fuels [**1. The idea of carbon neutral applies to biomass**]
70	Appropriate description about resource production in Japan [**3. Few fossil resources are produced in Japan**]
71	Which lifestyle of the following choices ALWAYS SAVES energy? [**3. Less frequent washing until a certain volume of laundry is obtained**]
72	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 (coal, oil, natural gas)**]
73 *	The MOST appropriate description about energy choices in current situation in Japan? [**4. It affects our energy consumption style**]
74 *	The MOST appropriate description about the environmental impact by energy resource development and use [**4. Any energy development and use affect the environment**]
75 *	Correct description about petroleum that Japan consumes most [**4. Petroleum is imported from the Middle East with high risks**]
76 *	Appropriate description about abandoning nuclear power in Japan [**3. Almost 100% of energy supply in Japan will depend on imported resources**]
77 *	Appropriate description about renewable and non-renewable energy [**4. Renewable energy is a source that is not depleted when used, non-renewable energy is a source that is limited**]
78	The original source of energy for almost all living things on the earth is... [**1. the Sun**]
Affective subscale	

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No.	Question items
5	We should make more of our electricity from renewable resources
6	(Se) I believe that I can contribute to solving energy problems by working with others
7	(Se) The way I personally use energy does not really make a difference to the energy problems that face our nation (R)
8	More wind farms should be built to generate electricity, even if the wind farms are located in scenic valleys, farmlands, and wildlife areas (R)
9	All electrical appliances should have a label that shows the resources used in making them, their energy requirements, and operating costs
10	Saving energy is important
11	Efforts to develop renewable energy technologies are more important than efforts to find and develop new sources of fossil fuels
12	The government should have stronger restrictions about the gas mileage of new cars
13	(Se) I don't need to worry about turning off the lights or computers in the classroom, because the school pays for the electricity (R)
14 *	Burden on general public by strict energy-saving is poor reality in everyday life even if energy issues are critical
15	We don' t have to worry about conserving energy, because new technologies will be developed to solve the energy problems for future generations (R)
16	Japanese should conserve more energy
17	Laws protecting the natural environment should be made less strict in order to allow more energy to be produced (R)
18	I would do more to save energy if I knew how
19	More Geothermal power generation should be developed as they are discovered to increase energy self-sufficiency ratio, even if they are located in areas protected by environmental laws (R)
20	Japan should develop more ways of using renewable energy, even if it means that energy will cost more (R)
21	(Se) I believe that I can contribute to solving the energy problems by making appropriate energy-related choices and actions
22	Energy education should be an important part of every school's curriculum
23 *	Need for the Energy-Best-Mix Policy which develops both nuclear power and renewable sources in Japan as an energy insufficient country
Behavioral subscale	
24	Many of my everyday decisions are affected by my thoughts on energy use
25	I am willing to buy fewer things in order to save energy
26	I always sort household waste according to the regulations
27	I am willing to encourage my family to turn the heat down at night or the air conditioner temperature up when we're not home to save energy
28	I always keep on running water when washing my teeth, face or shampooing (R)
29 *	I may change own idea if I understand that the energy choice is for sustainable society
30	When I leave a room, I turn off the light and computer
31	My family buys energy efficient compact fluorescent light bulbs

to be continued

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No.	Question items
32 *	Development of renewable energy is important, but the policy to become a burden on the economic and industrial activities should be considered carefully
34	For energy-saving, my family sets the temperatures on the air-conditioners higher in summer, lower in winter
35	I am willing to encourage my family to buy energy efficient compact fluorescent light bulbs and home appliance.

End of the table

Table 2.2. Cronbach's Alpha Values of *TS73*, *TS55*, and DeWaters' Report (*DW* [4]).

Questionnaire	No. of items	Cognitive	Affective	Behavior
TS73	73	0.78	0.66	0.68
TS55	55	0.70	0.68	0.66
DW	57	0.70	0.77	0.78

Table 2.3. Summary of Question Items Categorized into the Instrument Development Framework.

No.	Framework	No. of question items	No. of items	Total points & Answer options
I.	**Cognitive domain**		43	43 points
A.	Knowledge of basic scientific facts	37,44,45,53,55,63,67,68,**59**		Choose one correct answer from five multiple choices
B.	Knowledge of issues related to energy sources and resources	40,**43**,50,**52**,54,57,66,78		
C.	Awareness of the importance of energy use for individual and societal functioning	36,38,62		
D.	Knowledge of general trends in the country and global energy resource supply and use	49,64,70		
E.	Understanding of the impact energy resource development and use can have on society	**51**,60,**61**,**65**,**75**		
F.	Understanding of the impact energy resource development and use can have on the environment impact	39,**47**,58,**74**		
G.	Knowledge of the impact individual and societal decisions related to energy resource development and use can have on the ability of societies to effectively satisfy future energy needs	48,56,**69**,71,**73**		
H.	Cognitive skills	41,42,**46**,72,**76**,**77**		
II.	**Affective domain**		19	95 points
A.	Awareness/concern with respect to global energy issues	5,9,10,11,15,22,**23**		Five-point bipolar adjective scales ranging from "extremely agree" to "extremely disagree"
B.	Positive attitudes and values regarding prevention and remediation of societal and environmental energy resource development and use	8,12,**14**,16,18,17,19,20		
C.	Strong efficacy beliefs (self-efficacy)	6,7,13,21	(4)	

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No.	Framework	No. of question items	No. of items	Total points & Answer options
III. Behavioral domain			11	55 points
	Predispositions to behave			Five-point bipolar adjective scales ranging from "always" to "not at all"
A.	Willingness to work toward energy conservation	24		
B.	Thoughtful, effective decision-making	25,31,**32**		
C.	Remains open to new ideas	**29**		
	Behavior			
D.	Willingness to work toward energy conservation	26,28,30,34		
E.	Encourages others to make wise energy-related decisions and actions	27,35		

End of the table

2.2.2 A questionnaire for the energy literacy model integrated with the TPB and the VBN

A new questionnaire was developed with the aim of examining the energy literacy structural model including normative factors and attitudes–behavioral formation. The hypothesis energy literacy model was designed integrating with the Theory of Planned Behavior (TPB) and Value-Belief-Norm-Theory (VBN). The components are composed with factors extracted by factor analysis for the *TS73*, and predictors of the TPB and the VBN. Moreover, scientific literacy, critical thinking ability, and environmental literacy are evaluated. Self-rating items and demographics were included as well as the basic questionnaire.

A total 136 question items are presented in Table 2.4. In the basic energy knowledge section, a correct choice from multiple options is in parentheses in bold, and items of cognition of environmental issues are categorized separately as CEI. A reverse question is indicated by the (R) symbol, which is allocated a reverse point. In the energy-saving behavior section, items of energy-use conscious behavior are categorized separately as ECB. Question items in each component that are selected by assessing their validity and reliability were combined to produce an overall component score [23]. The questionnaire which was used in school is presented in Fig. E.2 in Appendix E.2. The followings are descriptions of the components of the questionnaire.

Basic energy knowledge (BEK)
Items were selected from the observed variables which were extracted for the energy literacy conceptual model, and were scrutinized internal consistency and validity. Students chose one correct answer from five multiple choice for twenty statements regarding basic energy knowledge in which embedded five items relevant to the cognition of environmental issues.

Awareness of consequences (AC)
Awareness of consequences refers to a disposition to perceive the adverse consequences of one's acts for values or valued objects during the decision-making process [24, 25]. Students rated their responses to eleven statements about their awareness of consequences regarding the EE issues [6, 26, 27]. Five-point bipolar adjective scales (e.g., from strongly disagree/definitely false to strongly agree/definitely true) was designed.

Ascription of responsibility (AR)
Ascription of responsibility refers to perceived ability that a person judges personally responsible for the outcome, that is beliefs about responsibility for cause or ability to reduce threats to any valued objects [27, 28]. Students rated their responses to seven statements about their responsibility toward the EE issues [6, 26]. Five-point bipolar adjective scales (e.g., from strongly disagree/hardly worry to strongly agree/always worry) was designed.

Personal norm (PN)
Personal norm about EE issues is beliefs and personal obligation that are linked to ones self-expectations about what ought to be done about various aspects of the EE problem [25, 27]. Students rated their responses to five statements about the personal norm toward the EE issues [26, 27]. Five-point bipolar adjective scales (e.g., from definitely false/disagree to definitely true/agree) was designed.

Attitude toward the behavior (ATB)
"Attitude toward a behavior is the degree to which performance of the behavior is positively or negatively valued, that is attitude toward a behavior is determined by the total set of accessible behavioral beliefs linking the behavior to various outcomes and other attributes" [29]. Students rated their responses to seven statements about

their attitudes towards the energy-saving behavior [30]. Five-point bipolar adjective scales (e.g., from extremely unimportant/worthless/boring to extremely important/valuable/interesting) was designed.

Subjective norm (SN)

"Subjective norm is the perceived social pressure to engage or not to engage in a behavior" [31]. Students rated their level of agreement with nine statements about the perception of social pressure to the energy-saving behavior [30, 32]. Five-point bipolar adjective scales (e.g., from definitely false/hardly ever/not at all to definitely true/almost always/very much) was designed.

Perceived behavioral control (PBC)

"Perceived behavioral control refers to people's perceptions of their ability to perform a given behavior" [33]. Students rated their level of agreement with seven statements how easy they think the energy-saving behavior is [30, 32]. Five-point bipolar adjective scales (e.g., from definitely false/impossible to definitely true/possible) was designed.

Intention (INT)

"Intention is an indication of a person's readiness to perform a given behavior, and it is considered to be the immediate antecedent of behavior" [34]. The intention is based on attitude toward the behavior, subjective norm, and perceived behavioral control, with each predictor weighted for its importance in relation to the behavior and population of interest [34]. Students rated their levels of agreement with five statements about their intentions toward energy-saving behaviors [6, 30, 32]. Five-point bipolar adjective scales (e.g., from extremely unlikely/I definitely will not to extremely likely/I definitely will) was designed.

Energy-saving behavior (ESB)

"Behavior is the manifest, observable response in a given situation with respect to a given target" [35]. Students rated their level of agreement with thirteen statements regarding energy-saving behavior, in which included two items of the energy-use conscious behavior [6,30,32,36,37]. Five-point bipolar adjective scales (e.g., from hardly ever/not at all to almost always/very much) was designed.

Actual behavioral control (ABC)

"Actual behavioral control refers to the extent to which a person has the skills, resources, and other prerequisites needed to perform a given behavior" [38]. Even if students want to act a preferable behavior for energy-saving, he/she will not be able to do that unless he/she knows or has skills to do so. Students rated their level of agreement with three statements regarding actual behavioral control. Five-point bipolar adjective scales (e.g., from not difficult/absolutely disagree to very difficult/absolutely agree) was designed.

Civic scientific literacy (CSL)

A sufficient level of civic scientific literacy is required for evaluating new science and technology and their associated policies, and discussing these issues in society [39,40]. The concept of civic scientific literacy differs essentially from practical science literacy, in other words, the acquisition of scientific information is not the same as the familiarity with science and awareness of its implications [40]. Miller suggested the civic scientific literacy is a minimal threshold level that (1) a basic vocabulary of scientific terms and concepts to read a daily information, (2) an understanding of the process or methods of science, and (3) the awareness of the impact of science and technology on both individuals and society [39,41]. In modern industrial societies, sound democracy depends on well-scientific literate citizen [42]. Students' civic scientific literacy was measured by eighteen items, which consist of twelve from Kawamoto et al., Miller, and NIESTEP [39, 43, 44] and six from Kusumi et al. and Mun et al. [45, 46]. The response option was set to "True," "False," and "Do not know."

Critical thinking ability (CTA)

For obtaining objective facts from media messages; considering, analyzing, and evaluating information; and understanding facts as well as possible [47–50], critical thinking ability is indispensable in modern society. Ennis defined critical thinking as "reasonable reflective thinking that is focused on deciding what to believe or do" [47]. It is an intellectually disciplined process of conceptualizing, analyzing, and evaluating information as a guide for belief and action [50]. Glaser stated that "critical thinking needs a persistent effort to examine any belief or supposed form of knowledge in the light of the evidence that supports it and the further conclusions to which it tends" [51]. To assess the critical thinking ability of Japanese students, it was adopted that twenty-two items regarding "logical thinking," "inquiring mind," "objectivity," and "evidence based judgement", which were employed in the study of Hirayama and Kusumi for the investigation of effect of critical thinking disposition on interpretation of controversial issues [52]. Students provided five-point bipolar adjective scales (e.g., from hardly ever/not at all to almost always/very much).

New ecological paradigm (NEP)

UNESCO defined environmental literacy as a "basic functional education for all people, which provides them with the elementary knowledge, skills, and motives to cope with environmental needs and contribute to sustainable development" [53]. The existing environmental paradigm was revised by Dunlap et al. [54] to produce the new ecological paradigm, which is a comprehensive pro-ecological worldview. In the new ecological paradigm, groups with pro-ecology worldviews, beliefs, and concerns for the environment can be identified. Since the space of the questionnaire was limited, nine question items were implemented by adopting the suggestions of previous studies [26,55]. Students provided five-point bipolar adjective scales (e.g., from extremely disagree to extremely agree).

Table 2.4. Question Items for Energy Literacy Structural Model Integrated with the TPB and the VBN.

	Question items
Basic energy knowledge (BEK)	
BEK01	Each and every action on the earth involves... [**2. Energy**]
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? (change to local content) [**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**]
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 energy**]
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: coal, oil, 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**]
CEI01	The best reason to buy an appliance labeled "energy efficient"... [**3. use less energy**]
CEI02	Which of the following descriptions is correct about CO_2 emission increasing 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**]

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	Question items
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 (AC)	
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 as a whole
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 (AR)	
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 of protecting the natural environment should be made strictly
AR04	The way I personally use energy does really make a difference to 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)
AR07	I am not worried about energy-saving and the global environment (R)
Personal norm (PN)	
PN01	I feel guilty when I squander energy
PN02	I feel I ought to save energy to prevent climate change and protecting the global environment

to be continued

Continued from the previous page

	Question items
PN03	Business and industry should conserve energy consumption to reduce greenhouse gas emissions to prevent climate change
PN04	The government should take a strong leadership 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 (ATB)	
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 to 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
Subjective norm (SN)	
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	Regarding energy-saving, I want to do what my important people are expecting from me
SN09	Generally speaking, how much do you care about that the people around you think you should save energy?
Perceived behavior control (PBC)	
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 can not 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 (INT)	
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

to be continued

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	Question items
INT05	I believe that I can contribute to solving the energy problems through appropriate energy-related choices and actions
Energy-saving behavior (ESB)	
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
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
Actual behavioral control (ABC)	
ABC01	If I encountered unanticipated events that demand my time, it would make it difficult for me turning off the lights (R)
ABC02	The difficulty of garbage separation would depend on less time or space to organize it (R)
ABC03	I feel that it would be difficult to solve energy issues by my own actions (R)
Civic scientific literacy (CSL)	
CSL01	The center of the earth is very hot
CSL02	All radioactivity is man-made
CSL03	The oxygen we breathe comes from plants
CSL04	It is the fathers gene that decides whether the baby is a boy or a girl
CSL05	Lasers work by focusing sound waves
CSL06	Electrons are smaller than atoms
CSL07	Antibodies kill viruses as well as bacteria
CSL08	The universe began with a huge explosion
CSL09	The continents have been moving their location for millions of years
CSL10	Human beings are developed from earlier species of animals
CSL11	The earliest humans lived at the same time as the dinosaurs
CSL12	Radioactive contaminated milk can be made safe by boiling it
CSL13	The cause which adversely affects on humans and the environment isn't necessarily only one reason
CSL14	One of reliabilities of scientific data requires the sufficient samples

to be continued

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Question items	
CSL15	The reliability of scientific data is based on reproducibility
CSL16	The results among similar studies may become different according to the purpose of survey or method
CSL17	Comparison between controlled and uncontrolled groups can elucidate the cause that has influenced
CSL18	When I collect data or find information, I am able to find similarities and differences
Critical thinking ability (CTA)	
CTA01	I am good at thinking in orderly sequence about a complex problem
CTA02	I can explain in way anyone can be convinced
CTA03	When considering something complicated problems, I organize it methodically
CTA04	I can strive to solve the difficult problems
CTA05	I always think coherently
CTA06	I want to learn a lot from various people
CTA07	I want to continue learning new things over a lifetime
CTA08	I think that it is significant to learn the people's thoughts in other countries
CTA09	I am interested in people who have different ideas from mine
CTA10	I want to learn more about any kind of topics
CTA11	I want to learn as much as possible, even if I do not know if it is useful
CTA12	It is interesting to discuss with people who have different ideas
CTA13	I want to ask a question if I do not know it
CTA14	I try to make a decision without bias
CTA15	I observe things in conformity with my belief
CTA16	I think objectively about an issue when I make a decision
CTA17	I try to think an issue with various points of view
CTA18	I always think whether I have prejudice unconsciously or not
CTA19	Even if its different opinion, I listen to it
CTA20	When giving a conclusion, I stick to the evidence
CTA21	I examine the evidences as many as possible when conclude it
CTA22	I do accept any information without wondering or asking questions (R)
New ecological paradigm (NEP)	
NEP01	We are approaching the limit of the number of people the earth can support
NEP02	When humans interfere with nature, it often produces disastrous consequences
NEP03	Humans are severely abusing the environment
NEP04	The earth has plenty of natural resources if we just learn how to develop them
NEP05	Plants and animals have as much right as humans to exist
NEP06	The balance of nature is strong enough to cope with the impacts of modern industrial countries
NEP07	Despite our special abilities, humans are still subject to the laws of nature
NEP08	The earth is like a spaceship with very limited room and resources
NEP09	If things continue on their present course, we will soon experience a major ecological catastrophe

End of the table

2.3 Statistical methodology

Completed questionnaires were returned from each school and students' responses in handwritten were input into the Excel spreadsheet by the author. Item which has no response, ambiguous response, or multiple selection to the item without any instruction were excluded from the aggregation for this study.

Item responses were converted into numerical scores in the same way as the investigation of secondary students in New York State (U. S.) by DeWaters & Powers [4]. Item responses to the cognitive subscale and basic energy knowledge were allocated one point for each correct response and zero points for each incorrect response. In civic scientific literacy, items were allocated one point for each correct response and zero points for incorrect and “Do not know” responses. Five-point bipolar adjective scales for the affective and behavioral subscales; awareness of consequences; ascription of responsibility; personal norm, attitude toward the behavior, subjective norm, perceived behavioral control; critical thinking ability, and new ecological paradigm were converted into numerical scores from one point (least preferred responses) to five points (most preferred responses) according to a predetermined preferable answer in this study. Scores of self-efficacy embedded into the affective subscale in the basic questionnaire were also calculated separately from the affective subscale. Because it is important to know whether students feel that their individual efforts contribute to solving energy-related problems [4]. The total scores for each subscales and components were converted into a percentage of the maximum attainable scores as a common scale for a simple comparison among the components.

The results were analyzed in subgroups: gender, school years, regions, and self-ratings. In self-rating items, samples were dichotomized into positive and negative response groups. Students who chose the positive two scales about the questions were allocated to a positive group, and those who chose the negative two scales were allocated to a negative group.

The mean values between subgroups were compared by a non-parametric statistical analysis using Mann-Whitney U Test and Kruskal-Wallis Test for multiple comparisons. The correlations between variables were evaluated with the non-parametric Spearman's rank correlation (ρ). Statistical analysis was carried out at the 0.05 significance level with a two-tailed test and performed with Microsoft Excel and IBM SPSS Version 23 and 24.

2.3.1 Item analysis

Item analysis examines student responses to individual test items to assess the quality of those items and test as a whole whether it should be improved or revised question items [56]. There are several indices to examine question items, for example, mean which is the average of students' response and standard deviation which indicates a measure of the dispersion of student scores on the item. In this study, item difficulty and discrimination index were also employed.

Item difficulty *(Df)* [56] is relevant for determining whether students have already known and learned the concept being asked. When items with one correct among choices, item difficulty is equal to the mean of item. The index of item difficulty ranges from 0 to 1 (or 100%), the higher the value, the easier the item. Ideal difficulty levels for multiple-choice items in terms of discrimination potential are presented in Table 2.5. Since the questionnaire in this study has been set five-response multiple-choice, the ideal level of *Df* will be 0.7, which means over 70% of the students answer questions correctly in the cognitive subscale.

Table 2.5. Item Difficulty Index (*Df*) [56].

Foramt	*Df*
Five-response multiple-choice	0.70
Four-response multiple-choice	0.74
Three-response multiple-choice	0.77
True-false (two response multiple-choice)	0.85

Discrimination index *(D)* [56] indicates how well the question item can discriminate between the high and low performance of respondents. The subscales were discriminated by the highest and lowest 27%-scoring groups. The consensus of the discrimination index is less than 0.2 and should be revised [15, 57, 58], and the question items with the lowest discrimination index below 0.15 should be eliminated [59]. Although item analysis can be used to improve individual question items and to increase the entire quality of the survey, some of cautions in using these results are provided [60]. Item analysis data are not equal to item validity. By using the internal criterion of total test score, item analyses reflect internal consistency of items rather than validity. Furthermore, the discrimination index does not necessarily measure item quality. There is a variety of reasons an item may have low discriminating power [56]:

- items that are extremely difficult or easy to discriminate are discriminatory,
- an item may show low discrimination if the test measures many different content areas and cognitive skills,
- however, these items are often needed to make the research objective properly.

2.3.2 Structural equation modeling (SEM)

SEM is a methodology for representing, estimating, and testing a theoretical network of (mostly) linear relations between observed variables and latent variables to understand the patterns of correlation/covariance among a set of variables and to explain as much of their variance as possible with the proposed model [61, 62].

To explore the energy literacy conceptual model and the energy literacy structural model, SEM was employed in this study. The concept of the energy literacy model employed the relationship between attitudes and behavior in the TPB [63], and the associations between environmental concerns, the awareness of consequences for valued objects, and the ascription of responsibility for reducing threats [25] in the VBN Theory [27].

To evaluate the model fitness, this study employed the following model fit indices [64, 65]. Because the Chi-square test of model-fit is sensitive to sample size and is likely to lead erroneous conclusions on analysis results. When sample size increases over 200, the χ^2 statistic tends to indicate a significant probability level, while when sample size decreases than 100, the levels of probability of χ^2 statistic indicates non-significant [64]. Descriptions of each indices are adopted from Hooper, Coughlan & Mullen (2008) [65].

Goodness-of-fit index (GFI)
The GFI was created as an alternative to the Chi-Square test and calculates the proportion of variance that is accounted for by the estimated population covariance [66]. By looking at the variances and covariances accounted for by the model it shows how closely the model comes to replicating the observed covariance matrix.

Adjusted goodness-of-fit index (AGFI)
The AGFI which adjusts the GFI based upon degrees of freedom, with more saturated models reducing fit [66]. Thus, more parsimonious models are preferred while penalised for complicated models. In addition to this, the AGFI tends to increase

with sample size.

Normed-fit index (NFI)
The NFI assesses the model by comparing the χ^2 value of the model to the χ^2 of the null model. The null/independence model is the worst case scenario as it specifies that all measured variables are uncorrelated.

Comparative fit index (CFI)
The CFI is a revised form of the NFI which takes into account sample size that performs well even when sample size is small. The CFI assumes that all latent variables are uncorrelated (null/independence model) and compares the sample covariance matrix with this null model.

Standardized root mean squared residual (SRMR)
The SRMR are the square root of the difference between the residuals of the sample covariance matrix and the hypothesised covariance model. The SRMR resolves the problem of the difficulty for model interpretation by the root mean square residual (RMR) that is calculated based upon the scales of each indicator (if a questionnaire contains some items range from one to five and others range from one to seven).

Root mean square error of approximation (RMSEA)
The RMSEA tells us how well the model, with unknown but optimally chosen parameter estimates would fit the populations covariance matrix if it were available [67]. In recent years it has become regarded as one of the most informative fit indices due to its sensitivity to the number of estimated parameters in the model.

Akaike information criterion (AIC)
The AIC measure is used when comparing non-nested or non-hierarchical models estimated with the same data and indicates to the researcher which of the models is the most parsimonious. The AIC value close to zero indicates a more parsimonious model, and model fit and model parsimony.

The statistics of the GFI, AGFI, NFI, and CFI are expected larger than 0.95 for the good model interpretation, the SRMR is expected less than 0.05, and the RMSEA is deemed acceptable less than 0.08 [65, 68]. The AIC was utilized to estimate the validity of each model for selection.

Statistical analysis was carried out at the level of 0.05 significance and two-tailed test and performed using IBM SPSS Amos Version 23 and 24.

2.3.3 Conditional process analysis

To determine whether the boundary conditions affect the strength or direction of the causal effect of a predictor on an outcome, this study employed a conditional process analysis. Conditional process analysis is used when one goal of analysis is to describe and understand the conditional nature of the mechanism or mechanism that the variables transfer its effect to each other [69]. Here, the moderators, for example, gender, grade, region, the presence of family discussion of energy-related issues, civic scientific literacy and so forth which may affect differences in students' energy literacy were tested to determine whether they would affect the energy literacy structure by using a regression-based path analysis with PROCESS for SPSS, The Ohio State University, Release 2.13.2 for estimating and probing the interaction and conditional direct and indirect effects [69–72].

Conditional process analysis uses the terms of *moderation, mediated moderation*, and *moderated mediation* [69]. *Moderation* is used for it provides a simple model when the effect of predictor (X) on an outcome (Y) is dependent on a moderator (M) or conditional (Fig 2.2, Panel B the effect of XM). *Mediated moderation* is a term used to describe the phenomenon in which the moderation of an effect is carried to an outcome Y through a mediator (M) (Fig. 2.3, Panel B the effect of XW). Lastly, if the indirect effect of X on Y through (M) depends on a particular moderator (W), that means that the indirect effect is a function of that moderator (M) (Fig. 2.3, Panel B the effect of MW). In other words, when a conditional process model containing a mediation process ($X \rightarrow M \rightarrow Y$) combined with moderation of the $M \rightarrow Y$ effect by W, it is *moderated mediation*.

Conceptual form of moderation is depicted in Fig. 2.2, Panel A, which shows a process in which the effect of a predictor (X) on an outcome (Y) is influenced or dependent on a moderator (M). The equation indicates a conditional effect of X on Y as follows ([69], p. 214–215):

$$Y = i_Y + b_1 X + b_2 M + b_3 XM + e_Y \tag{2.1}$$

$$\text{Conditional effect of } X \text{ on } Y = b_1 + b_3 M \tag{2.2}$$

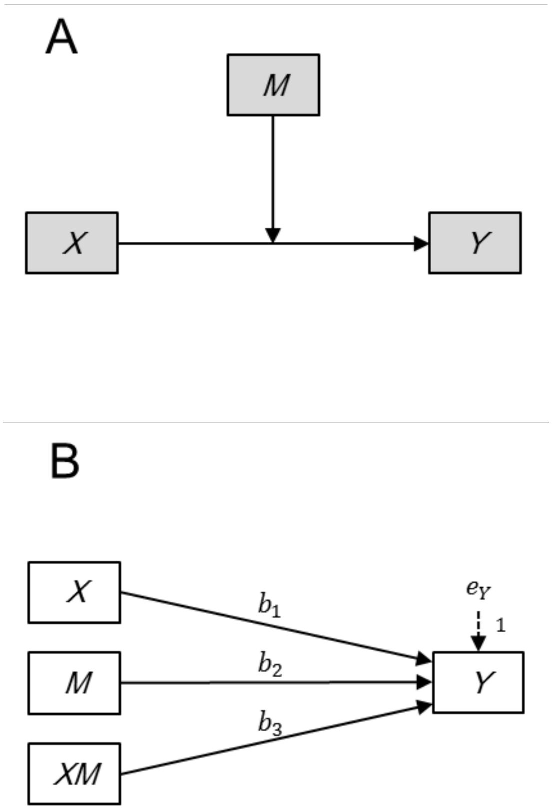

Fig. 2.2. A Conceptual (Panel A) and Statistical (Panel B) Diagrams Representing a Simple Moderation Model with A Single Moderator M Influencing the Size of X's Effect on Y (Adopted from Hayes 2013, P. 442 [69]).

This study also examines whether the mediation model that X affects Y through a mediator M depends on a moderator, W (e.g., gender, grade, region, and so forth). Fig. 2.3, panel A shows the model concept in which all three of the paths are moderated by W. Its statistical diagram is presented in Fig. 2.3, panel B. The effects for M and Y are calculated as follows ([69], p. 409–412):

$$M = i_M + a_1 X + a_2 W + a_3 XW + e_M \tag{2.3}$$

$$Y = i_Y + c_1' X + c_2' W + c_3' XW + b_1 M + b_2 MW + e_Y \tag{2.4}$$

A conditional indirect effect of X on Y through M and a conditional direct effect of X on Y are calculated with the following equations:

$$\text{Conditional indirect effect of } X \text{ on } Y \text{ through } M = (a_1 + a_3 W)(b_1 + b_2 W) \tag{2.5}$$

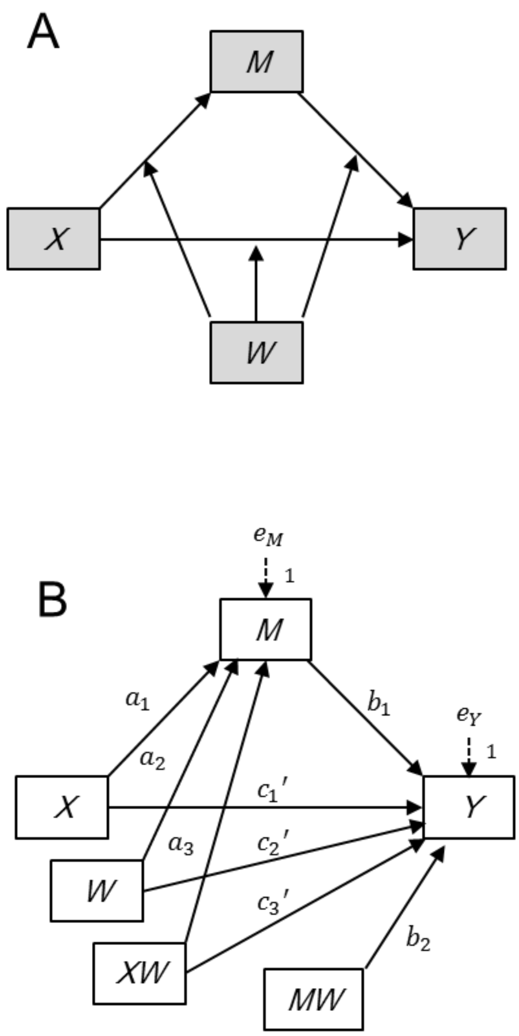

Fig. 2.3. A Conceptual (Panel A) and Statistical (Panel B) Diagrams Representing a Simple Mediation Model with All Three Paths Moderated by a Common Moderator (Adapted from Hayes 2013, P. 410 [69]).

$$\text{Conditional direct effect of } X \text{ on } Y = (c'_1 + c'_3 W) \tag{2.6}$$

The difference between the conditional indirect effect of X on Y through M when $W = \omega_1$ and $W = \omega_2$ is expressed as

$$(a_1{+}a_3\omega_1)(b_1{+}b_2\omega_1){-}(a_1{+}a_3\omega_2)(b_1{+}b_2\omega_2) = a_1b_2(\omega_1{-}w_2){+}a_3b_1(\omega_1{-}\omega_2){+}a_3b_2(\omega_1^2{+}\omega_3^2) \tag{2.7}$$

In case where the moderator W is dichotomous and coded 1 and 0, the index of moderated mediation corresponds to the difference between the indirect effects in the two subgroups. In the first and second stages of the mediation model when W is coded 1 (e.g., male) and 0 (e.g., female), the weight for W based on Eq. 2.7 is simplified to $a_1b_2 + a_3b_1 + a_3b_2$, which is the index of *moderated mediation* (See Hayes 2013, p. 411 [69]).

The moderators of this study were coded as one and zero according to the survey and the parameters were estimated using ordinary least squares (OLS) regression. The mean of variables that are used to configure the mediation model are centered beforehand [72].

2.4 Sample collection

2.4.1 Sampling bias and sample size

Sampling bias refers to errors that can occur in research studies by not properly selecting participants for the study. Study participants should be chosen completely randomly within the criteria of the study but without factors that might influence the results. It risks the internal validity of a study if any bias exists in the choosing of participants [73]. In the questionnaire survey, it is presumed that various statistical biases exist. The respondents of this study does not necessarily estimate the distribution of population of target since the survey was conducted by contribution of teachers who are interested in EE education. It is impossible to avoid this kind of bias always occurs in the sample survey. As a countermeasure against sampling bias, one of methods is increasing the sample size for the population so that the sample ratio falls within a certain error range.

According to the report on Basic Research on School in 2013 in Japan, the number of students of lower secondary school was 3,536,182 [74]. The validity of random survey is gauged by the survey's margin of error and confidence level. The margin of error is calculated by Eq. 2.8 [75]:

$$b = k\sqrt{\frac{N-n}{N-1}\frac{\sigma^2}{n}} \tag{2.8}$$

, where b is the margin of error and k is the confidence interval (CI) estimate of the population mean which can be replaced with 1.96 for a 95% CI or 1.645 for a 90% CI or 2.575 for a 99% CI. N is population, n is the number of sample and σ^2 is variance of population. Solving this equation for n goes to Eq. 2.9:

$$n = \frac{1}{\left(\frac{b}{k\sigma}\right)^2\left(1-\frac{1}{N}\right)+\frac{1}{N}} \tag{2.9}$$

When the population is large and $1/N$ is smaller than 1 and $(b/k\sigma)^2$, the general formula for calculating sample size needed is Eq. 2.10:

$$n = \left(\frac{k\sigma}{b}\right)^2 \tag{2.10}$$

For example, a valid size n of sampling from a large population is 1067, where the margin of error (b) is 3%, the confidence interval (k) is 95% (replaced with 1.96), and the standard deviation of population rate (σ) is 50%.

2.4.2 Sampling

This study conducted two surveys in Japan and one in Thailand. All of the survey are targeted at students in the 7th, 8th, and 9th grades (ages from 13 to 15) of lower secondary school. The printed questionnaires were distributed to students in the classroom by each teacher and carried them out. Valid samples without missing values were analyzed.

The first survey was carried out in March 2014 to explore energy literacy of lower secondary students in Japan, and was compared with the result of DeWaters et al. study [4]. A total of 1316 valid samples was analyzed. The second survey was conducted in July 2016 to construct of an energy literacy structural model which was integrated with the models of social psychology study. A set of 1070 valid samples was analyzed. The latest survey was administered in March 2017 in Thailand to assess the applicability of energy literacy structural model and to examine the difference in attributes in the energy literacy. Valid 635 samples were analyzed.

Distribution of gender and grade differs according to the classes selected by each school teacher, because it depends on the classes the teacher is in charge of. Therefore, this study did not carry out school comparison excluding the specific cases. Details will be described in each section.

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Chapter 3

Energy literacy survey and a comparison with the results of the U. S.

3.1 Introduction

There are some studies of energy literacy survey of Japanese students targeting lower secondary. For example, in the survey conducted energy literacy of students in elementary, lower secondary, and high school, students who are interested in the EE problems are more knowledgeable relevant to energy, and they mostly learn them through television and radio [1]. The extent to students' efforts to EE issues in everyday life correlates with their family's attitudes and behaviors for EE issues, and this trend increases with the school year progression. In addition, many of students recognize the importance of energy education and think that the EE issues will become more serious in the future than the current situation. According to the Misaki & Nakajima survey, school energy education provided to the students in elementary, lower secondary and high school are more likely not to influence their comprehensive judgement, knowledge and interest regarding energy [2, 3]. It is also reported students' lack of knowledge, low interest, and low linking between judgement and action related to energy issues. Inconsistency of these findings may be produced by the different research instrument administered for each purpose of the survey. On the other hand, as Fukuyama reported the difference of knowledge and interest concerning energy between the students living near the nuclear power plant and far from the facility [4], a geographical survey is effective in knowing how the practical energy-related experience affect students' energy literacy.

Turning to the DeWaters' result [5], the middle school students (MS) scored significantly lower than those in high school (HS) on the cognitive subscale (40%, 44%, $p < 0.001$), whereas the tendency is reversed on the behavioral sbscale (MS: 65%, HS: 63%, $p < 0.001$). Differences between the performance of MS and HS on the affective subscale were less, but still significant, with the HS students scoring higher than MS students (MS: 73%, HS: 74%, $p < 0.05$). There is no significant difference between the two groups on self-efficacy (MS: 72%, HS: 71%). The school year progression does not necessarily correlate positively with the energy literacy.

To understand the current status of energy literacy of lower secondary students in Japan, the survey was conducted by applying the same question items of DeWaters' survey, and the results were compared with the results of energy literacy of middle school students in the U. S.

3.2 Method

3.2.1 Sampling

In March 2014, six lower secondary schools in Fukushima, Tokyo (two schools), Kyoto (two schools), and Nagasaki participated in this survey (Fig. 3.1). The survey was carried out in the classroom by each teacher.

In total without missing values, 1316 valid responses (64% out of the response rate of 86%) from students in the 7th, 8th, and 9th grades (ages 13–15) were analyzed. Sample distribution for six school is presented in Table 3.1. Because of the participation of two private girls' schools, the gender distribution of the survey respondents was 36% for male and 64% for female.

Taking into account the circumstances of students in Fukushima, samples were assessed between regions divided into three groups: Fukushima, Tokyo (somewhat close to Fukushima), and the western region (Kyoto and Nagasaki) far from the radioactively contaminated area. The students in Fukushima have been facing difficulties in their daily lives and educational environment since the multiple disasters of the Great East Japan Earthquake, Tsunami, and the severe accident at the Fukushima Dai-Ichi Nuclear Power Plant, Tokyo Electric Power Co. on March 11 in 2011.

In subgroups comparison, it was examined the consistency between student self-assessment and energy literacy by dichotomizing the sample into positive and negative response groups for self-rating items and home discipline in energy-saving. Students who chose the positive two scales about these items were allocated to a positive group, and those who chose the negative two scales were allocated to a negative group, the neutral response group was excluded to discriminate the difference between two groups.

Fig. 3.1. Locations of Survey Participants in 2014.

Table 3.1. Sample Distribution of the Survey 2014.

Schools	N	Male	Female	7th	8th	9th	Collection	Rate of valid %
School_1	330	0	330	53	159	118	494	66.8
School_2	312	163	149	76	137	99	472	66.1
School_3	132	67	65	69	0	63	174	75.9
School_4	106	51	55	27	30	49	207	51.2
School_5	405	196	209	157	158	90	647	62.6
School_6	31	0	31	0	31	0	48	64.6
Total	1316	477	839	382	515	419	2042	64.4

3.3 Result of energy literacy of Japanese students

3.3.1 Overall

The summary of the performance of cognitive, affective, and behavioral subscales of the *TS73* questionnaire is presented in Table 3.2. Internal consistency of Cronbach's alpha values (α) are ranging from 0.66 to 0.78, which satisfied the adopted criteria for internal reliability in educational assessment (Chapter 2.2.1). The Cronbach's alpha of affective subscale includes four items of self-efficacy. The discrimination indices of three subscales ranging from 0.17 to 0.27 were also acceptable (Chapter 2.3.1). However, there are some critical items with a low discrimination index less than 0.15 including basic knowledge relevant to energy and domestic energy situation, they are No. 43, 49, 50, 52, 53, 54, 61, 66, 67, 69, and 76 (Appendix B, Table B.1). Since Hashiba [6] has reported that some of these items have been improved by providing the continuous energy education from the 6th grade in elementary school to the 9th grade of lower secondary school, it is expected to develop teaching contents that emphasize energy issues and its solutions, dissemination of these materials, and continuous energy education throughout the country.

Japanese students still scored insufficiently on the cognitive subscale that is 0.4 (*Df*) toward the ideal difficulty level for five-response multiple choice items regarding the discrimination potential, which is 0.7 (Chapter 2.3.1). The Standard Error of Measurement (*SE*) is a practical index of score precision. There are precision errors associated with any reported scores due to the fact that there are many variables involved in any individual performance on the test [7]. Namely, result may vary depending on participants condition. In general, a low *SE* value, less than 5%, is an acceptable value for diagnostic purposes for a test as a whole. If one is scoring a test on many subtest levels, for diagnostic purposes, then a *SE* value of 7.5% or less is realistic on the subtest level [7]. In this study, the *SE*s ranging from 4.4–6.7 are acceptable. The trend of students' item selection of affective and behavior subscales is shown in Tables B.2 and B.3 in Appendix B.

The energy literacy level of the lower secondary school students in Japan exhibited a low score on the cognitive subscale, whereas relatively high scores on the affective and behavioral subscales and self-efficacy.

Table 3.2. Overall Assessment of Energy Literacy of Lower Secondary Students in Japan.

TS73 (N = 1316)	Cognitive	Affective	Self-efficacy	Behavior
Median (%)	39.53	68.42	70.00	67.27
Mean (%)	39.53	69.02	68.89	66.86
SD (%)	14.32	7.51	12.67	10.61
Average item difficulty *(Df)*	0.40	–	–	–
Average discrimination index *(D)*	0.25	0.17	0.27	0.24
Reliability (α)	0.78	0.66	–	0.68
SE (%)	6.66	4.39	–	5.97

3.3.2 Subgroups comparison

Table 3.3 presents a comparison between subgroups. In gender comparison, it was indicated that the females scored higher than the males on the cognitive subscale (males 38%, females 40%, $p < .05$). Moreover, females showed significantly greater values than males regarding self-efficacy (males 67%, females 70%, $p < .001$) [5], while there was no significant difference between genders on the affective and behavioral subscales [8].

While considering the uneven sample distribution in the school years at each school, a comparison between the grades were carried out by Kruskal-Wallis Test. The 8th and 9th grades scored significantly higher than the 7th grade on the cognitive subscale (8th: 40%, $p < .05$; 9th: 41%, $p < .005$; 7th: 37%), and the 9th grade scored higher than the 7th grade on the affective subscale (9th: 70%, 7th: 68%, $p < .05$). Both self-efficacy and behavioral subscale score did not differ among school years.

The disparity in the energy literacy between Fukushima and Tokyo was significant on all subscales ($p < .05$), and Fukushima indicated the lowest mean values on all subscales among the regions in this survey.

Table 3.3. Subgroups Comparison of Gender, School Year Grade, Regions.

	N	Cognitive			Affective		
		Mean (%)	*SD* (%)	*p*	Mean (%)	*SD* (%)	*p*
Gender							
Male	477	38.42	15.36		68.45	7.72	
Female	839	40.16	13.66	*	69.35	7.37	
Grade							
7th grade	382	37.48	12.75		68.34	7.40	
8th grade	515	40.10	14.48	*	68.82	7.36	
9th grade	419	40.70	15.29	***	69.89	7.71	*
Fukushima, Tokyo, and the Western regions (Kyoto and Nagasaki)							
Fukushima	405	35.19	12.73		67.32	7.17	
Tokyo	444	41.37	14.75	†	69.95	7.47	†
Kyoto & Nagasaki	467	41.56	14.42	†	69.61	7.59	†

	N	Self-efficacy			Behavior		
		Mean (%)	*SD* (%)	*p*	Mean (%)	*SD* (%)	*p*
Gender							
Male	477	66.98	12.79		66.38	10.62	
Female	839	69.98	12.47	†	67.14	10.59	
Grade							
7th grade	382	68.23	12.46		66.18	10.63	
8th grade	515	68.34	12.28		66.71	10.43	
9th grade	419	70.18	13.24		67.66	10.77	
Fukushima, Tokyo, and the Western regions (Kyoto and Nagasaki)							
Fukushima	405	67.48	11.17		65.84	9.87	
Tokyo	444	69.71	12.75	*	67.90	10.69	*
Kyoto & Nagasaki	467	69.35	13.70		66.77	11.06	

* $p < .05$, *** < .005, † < .001

3.3.3 Self-rating and energy literacy

Table 3.4 summarizes students self-assessment and energy literacy. The positive respondents who self-described knowing about energy and save energy lifestyle indicated higher score than the negative respondents on the affective and behavioral subscales and self-efficacy ($p < .01$). These self-rating items did not indicate significantly high scores on the cognitive subscale. On the other hand, students who have family discussion about energy-related issues and those who have home discipline in energy-saving scored significantly higher than their counterparts on all subscales ($p < .01$). As such, the results between students' self-rating and energy literacy were relatively consistent.

Table 3.4. Comparison between Energy Literacy and Students' Self-Rating Report and Presence of Home Discipline in Energy-Saving.

		Cognitive			Affective		
Self-rating	*N*	Mean (%)	*SD* (%)	*p*	Mean (%)	*SD* (%)	*p*
Self-described participants' energy knowledge (high/low)							
Know	111	41.29	16.84		71.38	8.44	†
Don't know	693	37.89	13.49		68.00	7.54	
Energy use patterns (the degree of energy use)							
Save energy	227	37.02	13.71		70.10	7.89	**
High user	425	42.52	14.53	†	69.41	8.01	
The extent to which discuss with their families about energy-issues							
Talk a lot	223	43.26	14.98	†	73.00	6.96	†
Not at all	708	37.57	13.68		64.47	7.40	
Presence of home discipline in energy-saving							
Yes	960	40.16	14.38	**	69.91	7.20	†
No	356	37.85	14.04		66.62	7.80	

		Self-efficacy			Behavior		
Self-rating	*N*	Mean (%)	*SD* (%)	*p*	Mean (%)	*SD* (%)	*p*
Self-described participants' energy knowledge (high/low)							
Know	111	73.78	13.40	†	70.60	11.82	†
Don't know	693	67.45	12.76		64.88	10.48	
Energy use patterns (the degree of energy use)							
Save energy	227	71.59	12.54	***	71.00	11.14	†
High user	425	68.27	14.72		65.28	11.63	
The extent to which discuss with their families about energy-issues							
Talk a lot	223	75.25	11.41	†	72.87	9.91	†
Not at all	708	66.46	12.58		64.14	10.48	
Presence of home discipline in energy-saving							
Yes	960	70.35	12.35	†	68.71	9.96	†
No	356	64.96	12.69		61.86	10.69	

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

Furthermore, the trend of the students' selection on the most effective information sources which contribute to their understanding energy-related issues are presented in Fig. 3.2. They selected only one among twelve choices, and the sample that chose more than two was eliminated beforehand. As a result, 1282 samples were analyzed. Although school science class and TV/radio were chosen by approximately one third participants (31%, 28%, respectively), these information sources did little affect students energy literacy. Instead, students who selected books, newspapers/magazines, and museums/exhibitions indicated higher score than those selecting other information sources ($p < .05$) (Fig. 3.3). Information sources selected actively may affect students energy literacy. Each mean value of information sources and a result of multiple comparison are presented in Appendix B, Table B.4 and B.5.

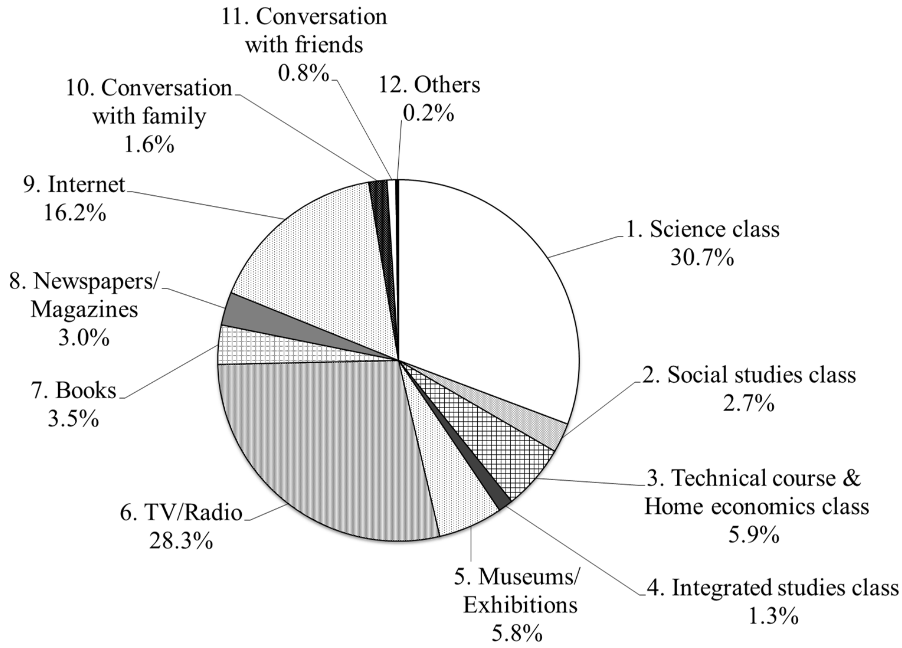

Fig. 3.2. Students' Self-Rating Report of Effective Information Sources Contributing of Understanding Energy-Related Issues (N = 1282).

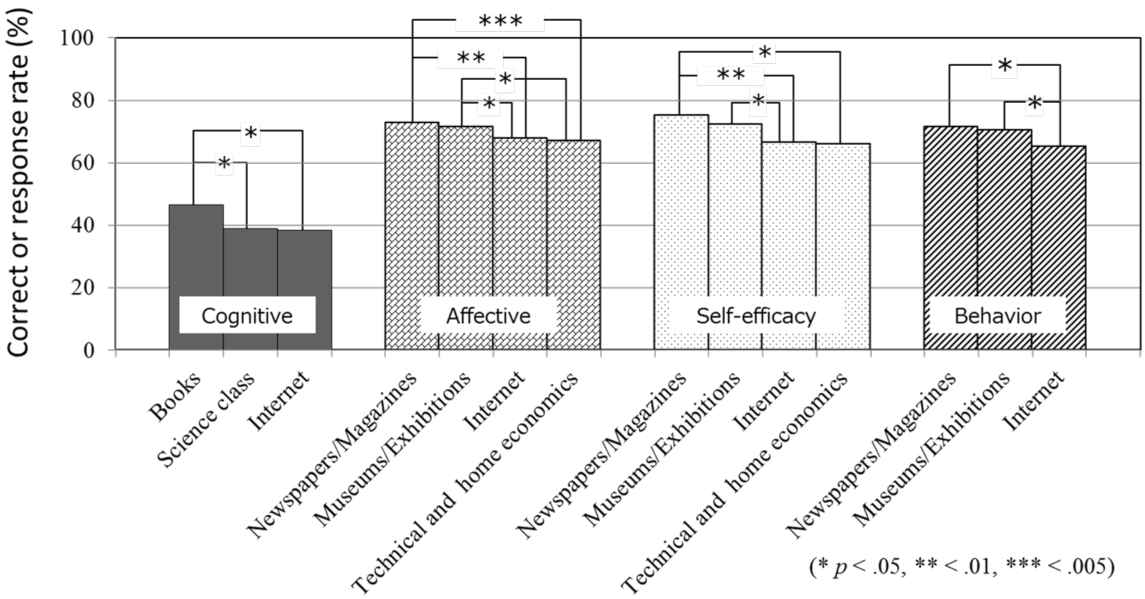

Fig. 3.3. Mean Comparison between the Effective Information Sources.

3.3.4 Intercorrelation between subscales

The coefficients of Spearman's rank correlation between each subscale are given, and all were positive and significant ($p < .01$) (Table 3.5). As previous studies have reported, this study also indicated that the affective subscale was more closely correlated to the behavioral subscale than the cognitive subscale and that there was little correlation between knowledge and behavior (e.g., [5, 8–10]). Although there was no significant differences in intercorrelations between gender and between the school years, School_4 that indicated $r = 0.511$ (Table 3.6) may affect the correlation between affective and cognitive subscales of 8th grade ($r = 0.505$) (Table 3.5), and it should be noted that verification with a sufficient sample size is needed.

Table 3.5. Intercorrelations between Cognitive, Affective, and Behavioral Subscales.

	N	Affective vs. Behavior	Affective vs. Cognitive	Cognitive vs. Behavior
Overall	1316	0.465	0.432	0.145
Male	477	0.463	0.408	0.120
Female	839	0.466	0.449	0.159
7th grade	382	0.483	0.378	0.123
8th grade	515	0.413	0.505 *	0.127
9th grade	419	0.508	0.379	0.178

7th and 9th grades < 8th grade, * $p < .05$

Table 3.6. A Test of Intercorrelation between Six Schools.

	N	Affective vs. Behavior	Affective vs. Cognitive	Cognitive vs. Behavior
School_1	330	0.416	0.426	0.163
School_2	312	0.501	0.432	0.117
School_3	132	0.503	0.381	0.102 (ns)
School_4	106	0.530	0.511	0.195
School_5	405	0.430	0.349	0.123
School_6	31	0.480	0.314 (ns)	0.160 (ns)

3.4 Result of energy literacy comparison between the U. S. and Japan

Table 3.7 presents the results of comparison between Japan (*TS55*) and the U. S. [5]. The energy literacy level of lower secondary school students in Japan indicated a similar trend to those in the U. S. The number of response for each subscale (N) in the U. S. report varies because student samples were eliminated for a particular subscale if more than half of the responses were blank. A single respondent could have acceptable results for one, two, or all three subscales [5] (Table 3.7). Therefore, number of total does not match the sum of males and females.

Both Japan and the U. S. indicated similar tendency on all subscales and self-efficacy, and they presented a low score on the cognitive subscale (JP 41%; US 40%, $p < .001$). According to the DeWaters' revision [11], there was no significant difference between the males comparison (Male: JP 40%, US 41%), while Japanese female students scored higher than those in the U. S. (Female: JP 42%, US 40%, $p < .05$). It can be discussed that the better result of Japanese students than the U. S. students on the cognitive subscale depends on the females' outcome. According to the pilot tests that of DeWaters' research for 35 college students enrolled in a renewable energy course, and of this study for seven students of Graduate School of Human and environmental Studies in Kyoto University, both students scored 74% [12] and 72% [13] on the cognitive subscale, respectively. Therefore, it can be considered that the question items of cognitive subscale were unlearned or unknown to lower secondary students in both countries. In behavioral subscale, Japanese students scored significantly higher than the U. S. (JP 66%; US 65%, $p < .05$), and it is likely a female contribution (Femal: JP 67%; US 65%, $p < .05$). The result of both females' high achievement than the males on the affective subscale was supported by previous studies (affective: JP female 70%, male 69%, $p < .005$; US female 74%, male 72%, $p < .001$) [5,9,14–19]. On the other hand, the US students scored significantly higher than those in Japan on the affective subscale and self-efficacy (affective: JP 69%; US 73%; self-efficacy: JP 69%; US 72%, $p < .001$). This outcome was also found in the intercorrelation between the attitude and behavioral subscales (Table 3.8). There was significant difference between Japan and the U. S. in the intercorrelation between the attitude and behavioral subscales. It is more likely to be produced by the fact that the U. S. scored higher than Japan on the affective subscale and self-efficacy ($r = 0.54$, US average of intercorrelations of the middle and secondary students; $r = 0.41$, JP *TS55*, $p < .005$). The U. S. high performance on the affective subscale and self-efficacy derived a stronger correlation with the behavioral subscale than those of Japan.

Table 3.7. Mean Comparison of Energy Literacy between *TS55* (JP) and the U. S. (US).

Subscale	Contry	N	Mean (%)	p	SD (%)
Cognitive	JP overall	1316	41.17	†	14.86
	US overall	2038	40.17		14.86
	JP male	477	40.34		15.91
	US male	1007	41.01		15.84
	JP female	839	41.65	*	14.21
	US female	950	40.30		13.69
Affective	JP overall	1316	69.58		8.06
	US overall	2339	73.03	†	10.45
	JP male	477	68.70		8.25
	US male	1144	72.28	†	10.99
	JP female	839	70.08		7.91
	US female	1099	73.90	†	9.74
Self-efficacy	JP overall	1316	68.89		12.67
	US overall	2339	72.06	†	16.26
	JP male	477	66.98		12.79
	US male	1144	69.85	†	16.87
	JP female	839	69.98		12.47
	US female	1099	74.74	†	15.09
Behavior	JP overall	1316	66.51	*	11.67
	US overall	2309	65.57		15.23
	JP male	477	65.64		11.65
	US male	1126	65.94		15.45
	JP female	839	67.01	*	11.66
	US female	1089	65.45		14.87

* p < .05, † < .001

Table 3.8. Intercorrelation between *TS55* and the U. S. (*DW*).

	N	Affective vs. Behavior	Affective vs. Cognitive	Cognitive vs. Behavior
TS55	1316	0.41	0.39	0.09
DW mean	3254	0.54 †	0.38	0.16
(*DW* HS-MS range)	(3254)	(0.53-0.57)	(0.32-0.45)	(0.05-0.27)

† p < .001

3.5 Discussion

The current status of energy literacy of Japanese lower secondary students have been surveyed and compared with the U. S. students. First, it is discussed Japanese students' outcome regarding gender difference on the cognitive subscale, regional difference between Fukushima and Tokyo, and students' self-assessment and energy literacy. And then, the details of individual question item are discussed by comparing between Japn and the U. S.

3.5.1 Energy literacy of Japanese students

Gender difference on cognitive subscale

Despite previous studies have reported that the males achieved relatively superior scores to the females on EE-related knowledge (e.g., [8, 10, 16, 20, 21]), the results of this survey indicated that the females scored higher than the males on the cognitive subscale (males 38%, females 40%, $p < .05$). One possible reason for the females' better cognitive performance can be considered that one of the private girls' junior high schools which has excellent academic performance in the Kansai area (western Japan) participated in this survey. Although this girls' school has not implemented energy education according to the teacher who was in charge of this survey, the students achieved the highest mean score on the cognitive subscale among six schools (44.3%, overall mean value is 39.5%, Table 3.2), and there was a significant difference on the cognitive subscale between the overall mean and five schools excluding the girls' school (overall: 39.5%, without the girls' school: 37.9%, $p < .01$). Therefore the students of the private girls' school may have raised the overall females' performance in the cognitive domain to be greater than that of male students. Although Gambro and Switzky suggested that the number of science classes taken would contribute to the level of high school students' knowledge about environmental issues [21], there is no difference in the number of science classes taken between genders in the compulsory education curriculum in lower secondary schools in Japan. Thus, it should be taken into account that the gender difference on the cognitive subscale in the current survey may be derived from academic achievement level rather the characteristics of gender.

Difference of Fukushima from other regions

Although identifying the cause of low performance in Fukushima might be difficult, at least two points of view can be discussed. First, regarding the National Educational Achievement Test in Japan, Fukushima represented the lowest performance among regions where the survey conducted, and it has not varied since the year before the disasters [22]. In fact, students in Fukushima scored significantly less than students in Tokyo on all subscales (See Table 3.3). Second, an economically, socially, and educationally disadvantaged region may lower the level of community environmental activeness [23]. After the Great East Japan Earthquake and Tsunami, and the nuclear power plant accident occurred in March 2011, a large number of people moved in and out of Koriyama City where the school located in to evacuate from the radioactively contaminated area. This phenomenon has, however, converged since 2013, the population of 13 to 15 years old in Koriyama has been decreasing compared with the year before the disasters [24, 25]. Although Koriyama City was not designated as an evacuation zone due to radioactive contamination, students' circumstances were dramatically changed by the evacuees from the disasters and the nuclear accident. It should be taken into account of the deterioration in educational circumstances through serious social situations and students' unstable and inconvenient everyday lives during that period.

Self-rating performance

Students' self-rating was almost consistency with their energy literacy. In particular, the high correlations between self-rating questions of family discussion about energy issues and home discipline in energy-saving, and actual scores were found on all subscales, implying that students who are enhanced energy-related knowledge, interests, and energy-saving behavior have more likely talked with their families regarding energy issues.

On the other hand, it was indicated that books, newspapers/magazines, visiting museums/exhibitions are likely to affect students' energy literacy as the effective information sources contributing to their understanding energy-related issues. Furthermore, when comparing between three information source groups: school education (Science, Social studies, Technical course & Home economics, and Integrated studies period), active learning (Books, Newspapres/Magazines, and Museums/Exhibitions), and other information sources including the internet, there were significant differences (Table 3.9). Students who selected the active learning sources scored significantly higher than those who selected school education and other sources on all subscales and self-efficacy. It implies that information sources that students obtain actively may further enhance students' energy literacy. There are many polls that investigate information sources which general public select to understand energy issues, however, it can be considered that the information sources selected by people do not necessarily contribute to the improvement of their knowledge, attitudes, and behavior that are required to cope with problem-solving. While, current school education does not seem to have much influence on students' energy literacy. It is noted that there has been little changing since the survey of Misaki & Nakajima that have reported that energy education in school is more likely not to affect students' comprehensive judgement, knowledge and interest regarding energy issues [2, 3].

Table 3.9. Mean Comparison of Effective Information Sources between School Education, Active Learning, and Other Information Sources (N = 1282).

		Cognitive			Affective		
	N	Mean (%)	*SD* (%)	p	Mean (%)	*SD* (%)	p
Information sources							
School education	520	38.99	13.80		68.93	7.40	
Active learning	157	43.39	15.36	***	71.75	7.29	†
Others	605	39.24	14.24		68.51	7.43	

		Self-efficacy			Behavior		
	N	Mean (%)	*SD* (%)	p	Mean (%)	*SD* (%)	p
Information sources							
School education	520	68.39	12.69		66.63	10.40	
Active learning	157	72.45	13.19	†	69.58	9.63	***
Others	605	68.41	12.23		66.51	10.84	

*** $p < .005$, † $< .001$

3.5.2 Energy literacy comparison between the U. S. and Japan

It was found that Japanese students indicate higher achievement than the U. S. students on the cognitive subscale. The difference can be discussed by the results of the comprehensive academic achievement in PISA 2012 [26] and TIMSS 2011 [27, 28]. PISA 2012 assessed the competencies of 15-year-olds in reading, mathematics and science in OECD 65 countries and economies. Around 510,000 students between the ages of 15 years 3 months and 16 years 2 months participated in PISA 2012 as a whole representing about 28 million 15-year-olds globally. TIMSS 2011 is the series of international assessments of student achievement dedicated to improving teaching and learning in mathematics and science. The results summarize the fourth and eighth grades student achievement in each of the 63 countries and 14 benchmarking entities which participated in this survey. In these surveys, Japan ranked within top ten in PISA 2012 and top five in TIMSS 2011, while the U. S. scored the OECD average or below in PISA 2012, and in TIMSS 2011, the U. S. ranked the 11th for mathematics and the 7th in science achievement. The high achievement of Japanese students on the cognitive subscale in energy literacy survey is more likely to be derived by the fundamental ability in scientific and mathematical literacy.

The performance of both students on a sampling of the individual questions in cognitive, affective, and behavioral subscales are presented in Table 3.10. The items, however, are limited to those reported in the DeWaters & Powers report [5]. The cognitive score is indicated by the percentage of correct answers. The students responses to items on the affective and behavioral subscales are presented by the percentage of students who responded to the positive two scales in a Likert-type question to each item.

Table 3.10. Item Comparison of Attainable Score Percentage between Japan and the U. S.

		% Correct	
Cognitive items		JP	US
Topic: Energy saving			
42	The best reason to buy an appliance labelled “energy efficient” is...	83.1	76.4
56	Scientists say the single fastest and most cost-effective way to address our energy needs is to...	51.1	30.7
Topic: Power and energy			
37	The amount of ELECTRICAL ENERGY (ELECTRICITY) we use is measured in units called...	36.6	10.0
55	Which two things determine the amount of ELECTRICAL ENERGY consumed by an electrical appliance?	44.3	43.7
Topic: Home energy use			
38	Which uses the MOST ENERGY in the average Japanese home in recent year?	49.8	34.9
Topic: Basic energy concepts			
45	When turning on an incandescent light bulb, some of the energy is converted into light and the rest is converted into...	75.8	65.0
67	All of the following are forms of energy EXCEPT...	16.5	43.8
68	What does it mean if an electric power plant is 35% efficient?	35.9	41.2
Topic: Energy resources			
54	Proper description about “renewable energy resources”	15.3	50.0
66	Which one of the following sources generates the most ELECTRICITY in Japan in the past few years?	8.2	20.9
70	Appropriate description about resource production in Japan	57.7	26.6
Topic: Critical analysis about renewable resources			
72	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?	36.2	50.3
Topic: Environmental impacts			

to be continued

Continued from the previous page

39	One advantage to using nuclear power instead of coal or petroleum for energy is that...	62.5	44.4
		% Positive response	
	Affective items	JP	US
5	We should make more of our electricity from renewable resources	65.1	77.0
13	(Se) I don't need to worry about turning the lights off in the classroom, because the school pays for the electricity (R)	69.8	53.0
16	Japanese should conserve more energy	63.6	75.0
20	Japan should develop more ways of using renewable energy, even if it means that energy will cost more (R)	24.3	37.3
21	(Se) I believe that I can contribute to solving the energy problems by making appropriate energy-related choices and actions	45.6	67.5
		% Positive response	
	Behavioral items	JP	US
24	Many of my everyday decisions are affected by my thoughts on energy use	11.6	20.7
30	When I leave a room, I turn off the light and computer	76.1	65.0

End of the table

Energy knowledge

Energy saving No. 42: both students well knew that as energy efficient labelled appliance save energy, and Japanese students scored more than the U. S. students (JP 83%; US 76%). Furthermore, No. 56: a half of Japanese students recognized energy-saving as the fastest and most cost-effective way to address our energy demand, and they scored more than those in the U. S. (JP 51%; US 31%). Although the five-option multiple choices include resources and technology development, energy-saving is the most critical for the sustainable future and should be facilitated throughout the world.

Power and energy No. 37 and 55: over 40% of both students knew two things (watts or kilowatts multiplied by the time it's used) that determine the amount of energy consumed by an electrical appliance. However, only 10% of the U. S. and 37% of Japanese students could identify the unit we use to measure electric energy. It was still poor for high school students in the U. S., indicated 19% correct response [5].

Home energy use No. 38: although it may be difficult identifying specific home energy use patterns, almost half of students in Japan recognized that heating and cooling rooms consumes energy most, and this score was better than those in the U. S. (35%).

Basic energy concepts No. 67: the U. S. students scored better than Japanese students on the basic energy concepts, energy forms (JP 16%; US 44%). Opitz et al reported that students scored highest on items for energy forms, whereas lowest for energy conservation through the investigation for students' progression in understanding four aspects of energy (forms and sources of energy, transfer and transformation, degradation and dissipation, and energy conservation) at the transition from primary to lower secondary school [29]. Therefore, for Japanese students it is necessary to further acquire basic energy concepts. No. 45 and 68: Although 76% of Japanese students understood that light bulbs convert electrical energy into heat as well as light, only one third could respond correctly to the meaning of 35% energy efficiency. Energy is the ability to do work. During energy is converted from one form to another, the amount of energy does not change, while the quality of energy has decreased irreversibly unless other energy input. As Duit pointed out, when introducing 'energy' to the lower grades (e.g., grades 7–10), it is needed to explain a very simple notion of entropy which is one of basic but important energy concepts [30].

Energy resources No. 54: a half of students in the U. S., compared with 15% Japanese students, could define renewable energy resources. For Japan, the discrimination index of this item is very low ($D = 0.061$). Although, one teacher participated in this survey suggested the wording "renewable energy" seems to be difficult for these ages, cognition and definition of energy terms are important to learning energy issues. No. 66 and No. 70: the U. S. students scored about 20% on these items respectively regarding domestic energy supply and resource production, while Japanese students indicated uneven scores, 8% and 58%. The latter is likely to learn in school social studies class, whereas the former is the current energy issues. Because all nuclear power plants were suspended the operation since the nuclear accident in 2011, the dependence on imported natural gas has increased in Japan. Interestingly, 39% of Japanese students, however, selected "nuclear power" as an energy source that generates the most electricity in Japan in the past few years. It may be considered that after the nuclear disaster, students were often exposed to the opportunity to touch the word "nuclear power" increasing in daily life through media, schools, and homes, and it may have influenced them.

Critical analysis about renewable resources No. 72: the discrimination index was good ($D = 0.36$) and the upper-27% group, however gained 56%, the average score of Japanese students was still lower than the U. S. students (JP 36%; US 50%). It should be understood the limitations of switching electric cars since most of the electricity is produced by fossil fuels.

Environmental impacts No. 39: more than half of Japanese students recognized that the nuclear power contributes less air pollution than fossil fuels. They scored more than the U. S. students (JP 62%; US 44%).

The basic energy knowledge required for energy choices is that the ability which can analyze the entire process of energy that affects our lives and the environment, which is from resource productions to energy distributions through transportation and conversion [31]. Since the cognitive subscale has been designed beyond topics in school curriculum to measure not only the amount of EE knowledge but also ability needed for decision-making in energy choices, Japanese students may have been given unknown and unlearned questions. Notwithstanding, Japanese students with insufficient in comprehensive energy education demonstrated better outcome on the cognitive subscale than the middle school students in the U. S. with long history in energy education.

Energy-related affect and behavior

On the other hand, the amount of knowledge did not contribute to the affective subscale and self-efficacy rather the U. S. middle school students scored higher than those in Japan. No. 13 and 30: Japanese students scored better than those in the U. S. on items related to turning off the power, while on other items, they could not perform better than the U. S. students. More than 70% of students who recognize energy-saving discipline at home responded that their parents have introduced them energy-saving by the age of 10 years old and over 90% of those were disciplined until graduating from elementary school. The distribution at the age between 10–12 can be considered as age heaping that is the tendency of people to round their age to the nearest 5 or 10 [32] since students cannot remember the actual age they disciplined. Considering their age (13–15 years old), however, the Great East Japan Earthquake occurred when they were in elementary school, energy-saving and power conservation must have been raised as a critical topics at home, in school and society. Habit such as turning off the power does not need specific investment and facility, and anyone can do with a little effort. Although energy-saving of Japanese students does not necessarily ground on energy use consciousness (No. 24: 12%), forming of an energy-saving habit contributes to energy conservation throughout the society and gradually may reshape social norms [33].

3.6 Conclusion

By employing and modifying the energy literacy instrument developed by DeWaters & Powers [34], energy literacy of lower secondary students in Japan has been surveyed through 1316 samples.

The knowledge level was discouragingly low. While female students scored higher than the males on the cognitive and self-efficacy subscales. The 8th and 9th graders scored significantly higher than the 7th graders on the cognitive subscale, and scores of affective and behavioral subscales and self-efficacy does not necessarily increase with the school year progression. Students in Fukushima scored low on all subscales among the surveyed regions: Tokyo and the western regions (Kyoto and Nagasaki). Students who positively responded to the existence of discussion of energy-related issues with their family, and home discipline in energy-saving scored significantly higher on all subscales than their counterparts. The results of students' self-rating were almost consistent with their energy literacy. Active learning such as books, newspapers/magazines, and museums/exhibitions more contributed to improving students' energy literacy than school education as an effective information sources to understanding energy-related issues. The intercorrelation between the affective and behavioral subscales was rather close, while there was little correlation between knowledge and behavioral subscales.

Comparing with the U. S. middle students, Japanese students indicated higher scores than those in the U. S. on the cognitive subscale. While, the U. S. students scored significantly higher than Japanese students on the affective subscale and self-efficacy. This result may contribute to reinforce the intercorrelation between the attitude and behavioral subscales for the U. S. students than those in Japan, and has produced the significant difference from the outcome of Japan. Through the comparative survey, it can be discussed that the amount of knowledge does not necessarily affect other domains in energy literacy of Japanese students. As such, in order to encourage continuous pro-environmental and energy conservation behavior, it is of importance of the improvement of individual energy-related self-efficacy through actions and experiences that they can recognize their contribution to objectives of energy-related issues. Effective energy educational programs should take into account contents which emphasize not only knowledge but impact students' attitudes, values, and behavioral change.

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Chapter 4

Investigating a conceptual model of energy literacy

4.1 Introduction

To understand the relationship of students' concept between knowledge, attitudes, and behavior in energy literacy, an energy literacy conceptual model was explored by an exploratory factor analysis (EFA) on the basis of the result of Chapter 3. An EFA is a heuristic approach when a researcher does not have a substantive theoretical model and extracts the latent variables used in strucutral equation modeling (SEM) [1]. Furthermore, to determine whether the boundary conditions affect the strength or direction of the causal effect of a predictor on an outcome, a conditional process analysis is employed.

4.2 Method

To determine the components of the energy literacy conceptual model, the EFA was carried out for three subscales using the maximum-likelihood method and Promax rotation. The number of factors by eigenvalue attenuation and proper interpretation of the criteria that the boundary value of the factor score was set larger than 0.35 were employed. Moreover, the minimum two observed variables were used to define each latent variable. As a result, three factors consisting of fourteen observed variables for the cognitive subscale, five factors of seventeen observed variables for the affective subscale, and three factors of eleven observed variables for the behavior subscale were set for exploring the energy literacy model. A set of forty-two variables was computed by EFA again.

4.2.1 Components of the energy literacy conceptual model

Employing the results from the energy literacy assessment and its factor loading, 32% of the raw data contributed to the interpretation of the energy literacy conceptual model. The six latent variables consisting of twenty-five observed variables were extracted. They are two cognitive, two affective, and two behavioral components to configure the energy literacy conceptual model, and were denoted as basic energy knowledge (BEK), cognition of environmental issues (CEI), awareness of consequences (AC), ascription of responsibility (AR), energy-use conscious behavior (ECB), and energy-saving behavior (ESB) (Table 4.1). Cronbach's alpha values for the internal consistency of factors were in the range of 0.52–0.70. This study adopted these values by conducting a confirmatory factor analysis to "specify a certain number of factors, which factors are correlated, and which observed variables measure each factor" [2] to explore the energy literacy conceptual model.

Table 4.1. Six Latent Variables and Their Abbreviations for Energy Literacy Conceptual Model.

Domain	Latent variables	Abb.
Knowledge	Basic energy knowledge	BEK
	Cognition of environmental issues	CEI
Attitude	Awareness of consequences	AC
	Ascription of responsibility	AR
Behavior	Energy-use conscious behavior	ECB
	Energy-saving behavior	ESB

The means, standard deviations, and factor loadings of the components measured by twenty five observed variables are summarized in Table 4.2, where some phraseology were adopted from Chen, S. et al. [3]. Internal consistency, Cronbach' alpha value was presented along with name of factors (*). A mark of 'a' (affective), 'b' (behavior), 'c' (cognitive), and 'se' (self-efficacy) is set with question number (**). Reverse items (R) were converted into reverse score (***).

The correlation coefficients among the six latent variables are presented in Table 4.3, which are all significant. The fitness indices, 0.957 for the GFI and 0.934 for the AGFI, were satisfied for values larger than 0.900; the SRMR of 0.056 and the RMSEA 0.053 were acceptable.

Table 4.2. Means, Standard Deviation, and Factor Loadings of Components of Energy Literacy Conceptual Model.

No.	Question Items	Mean (%)	SD	BEK	AC	ECB	AR	ESB	CEI
F1: Basic energy knowledge (BEK) (α = 0.70)*									
68c**	The meaning of 35% efficient electric power plant	35.9	0.48	**0.581**	-0.034	-0.016	0.045	0.011	-0.076
75c	The oil import trend in Japan	45.4	0.49	**0.538**	0.079	-0.072	0.032	-0.005	-0.055
72c	Wrong idea of electric car can be useful instead of running out	36.2	0.48	**0.480**	0.001	0.024	-0.060	-0.001	0.011
74c	Environmental impact by developing energy sources	40.4	0.49	**0.456**	-0.004	0.022	0.032	0.037	-0.095
60c	The least harmful energy-related activities to human health and the environment	58.5	0.49	**0.448**	-0.058	0.105	-0.011	-0.045	0.339
55c	Two things determine the amount of electricity consume	44.3	0.50	**0.429**	0.025	-0.015	0.012	-0.016	0.064
71c	The way of energy consumption reduction	66.3	0.47	**0.381**	-0.004	0.009	0.009	0.006	0.142
F2: Awareness of consequences (AC) (α = 0.69)									
16a	Japanese people should save energy more	77.1	0.98	-0.017	**0.705**	-0.028	0.034	-0.015	-0.056
18a	Intention to contribute energy conservation if I know how	73.3	1.03	0.014	**0.542**	0.225	0.097	0.025	-0.036
10a	Energy saving is important	89.0	0.82	0.022	**0.529**	-0.199	-0.019	0.167	0.125
12a	Strong government regulation on car CO_2 emission	68.4	1.00	0.008	**0.509**	0.065	-0.082	0.029	-0.075
9a	Labels showing resources used	60.3	1.01	0.010	**0.379**	0.314	-0.013	-0.100	-0.055
F3: Energy-use conscious behavior (ECB) (α = 0.57)									
24b	Many of my everyday decisions affected by own thoughts on energy use	46.7	1.02	0.037	0.064	**0.661**	-0.044	-0.117	-0.045
25b	Buy fewer things in order to save energy	50.7	0.98	-0.062	0.024	**0.557**	-0.085	0.046	0.184
35b	Encourage family to buy compact fluorescent light bulbs	52.6	1.17	0.063	-0.088	**0.384**	0.009	0.375	-0.187
F4: Ascription of responsibility (AR) (α = 0.61)									
15a	No worries about saving energy, because new technologies solve the energy problems (R)***	73.1	0.94	0.027	0.043	-0.046	**0.621**	-0.038	0.006
13se	No worries about turning the lights off in the classroom, because the school pays for the electricity (R)	78.8	1.10	-0.086	-0.048	0.143	**0.539**	0.061	0.207
17a	Law protecting the natural environment should be made less strict in order to allow more energy to be produced (R)	69.3	0.94	0.064	-0.071	-0.096	**0.504**	-0.005	-0.038
7se	My energy use contributes no difference to energy problems facing our nation (R)	70.1	0.96	0.021	0.051	-0.110	**0.433**	-0.019	-0.091
F5: Energy-saving behavior (ESB) (α = 0.55)									
31b	Family buys energy efficient compact fluorescent light bulbs	71.1	1.12	0.057	-0.022	0.042	-0.010	**0.571**	-0.127
30b	Turning off lights and computers	83.6	1.09	-0.114	0.056	-0.087	-0.045	**0.462**	0.243
26b	Separation and recycling of waste	78.7	1.08	0.064	0.059	-0.061	-0.026	**0.449**	0.047

to be continued

Continued from the previous page

No.	Question Items	Mean (%)	SD	BEK	AC	ECB	AR	ESB	CEI
34b	Minimizing the room temperature	70.9	1.14	-0.052	0.036	0.152	0.076	**0.363**	0.053
F6: Cognition of environmental issues (CEI) (α = 0.52)									
42c	The best reason to buy an ENERGY-EFFICIENT MARK appliance	83.1	0.38	0.079	-0.076	0.014	0.005	0.022	**0.562**
47c	Global warming by CO2 emission increasing	69.1	0.46	0.359	0.011	-0.008	-0.026	0.025	**0.385**
			Contribution (%)	14.65	8.65	3.5	2.09	1.95	1.27
			Cumulative contribution (%)	14.65	23.3	26.8	28.89	30.85	32.12

End of the table

Table 4.3. Factor Correlation Matrix Extracted by Maximum-Likelihood Method, Promax Rotated with Normalization of Kaiser.

Predictors	Mean (%)	*SD*	BEK	AC	ECB	AR	ESB
Basic energy knowledge	46.7	0.29					
Awareness of consequences	73.6	0.13	.23 **				
Energy-use conscious behavior	50.0	0.16	-.12 **	.22 **			
Ascription of responsibility	72.8	0.13	.48 **	.48 **	-.06 **		
Energy-saving behavior	76.1	0.14	.16 **	.55 **	.37 **	.39 **	
Cognition of environmental issues	76.1	0.35	.51 **	.38 **	-.27 **	.52 **	.27 **

** $p < .01$

4.3 Result

4.3.1 Energy literacy conceptual model by structural equation modeling

To improve the conceptual model statistically, modification indices and model fitness indices were considered. Applying the concepts of the TPB and the VBN, the energy literacy conceptual model was depicted as Fig. 4.1 with standardized regression coefficients (β). Unstandardized regression coefficients can examine the change across different samples, while standardized regression coefficients are useful for determining the relative importance of each variable to other variables for a given sample [2]. Moreover, the standardized coefficients enable the model interpretation more easily because the variables are on the same scale of measurement, and are able to easy convert back to the raw scale metric [2]. All paths in the model were significant, and the model fitness indices were obtained as: GFI = .947, AGFI = .936, SRMR = .048, RMSEA = .042, NFI = .847, and CFI = .888.

According to this model, the AC, AR, and ECB were able to explain 63% of the variance in the ESB. Both AC and AR are predicted by the BEK through the CEI. Ten percentage (10%) of the variance in the AC and 52% of the variance in the AR were explained respectively by the CEI in which 71% of the variance was predicted by the BEK. The affective components (AC and AR) perform a role of bonding between components of cognitive (BEK and CEI) and behavioral (ECB and ESB). Although the recent study by Ajzen et al. [4] reported that environmental knowledge had no effect on energy conservation from an evaluation with the TPB, it was observed that students with relative high knowledge (BEK and CEI) indicated a positive ESB mediated by the awareness of potential adverse consequences of energy-related issues (AC). Notwithstanding, students who had a higher score of BEK indicated stronger AR (standardized coefficient $\beta_3 = 0.55$) than AC ($\beta_2 = 0.31$), the negative estimated value of the AR on the ESB was mediated by the ECB ($\beta_6 \times \beta_9 = -0.45 \times 0.44$). While, the indirect effect of AC on the ESB through the ECB was positive ($\beta_5 \times \beta_9 = 0.61 \times 0.44$).

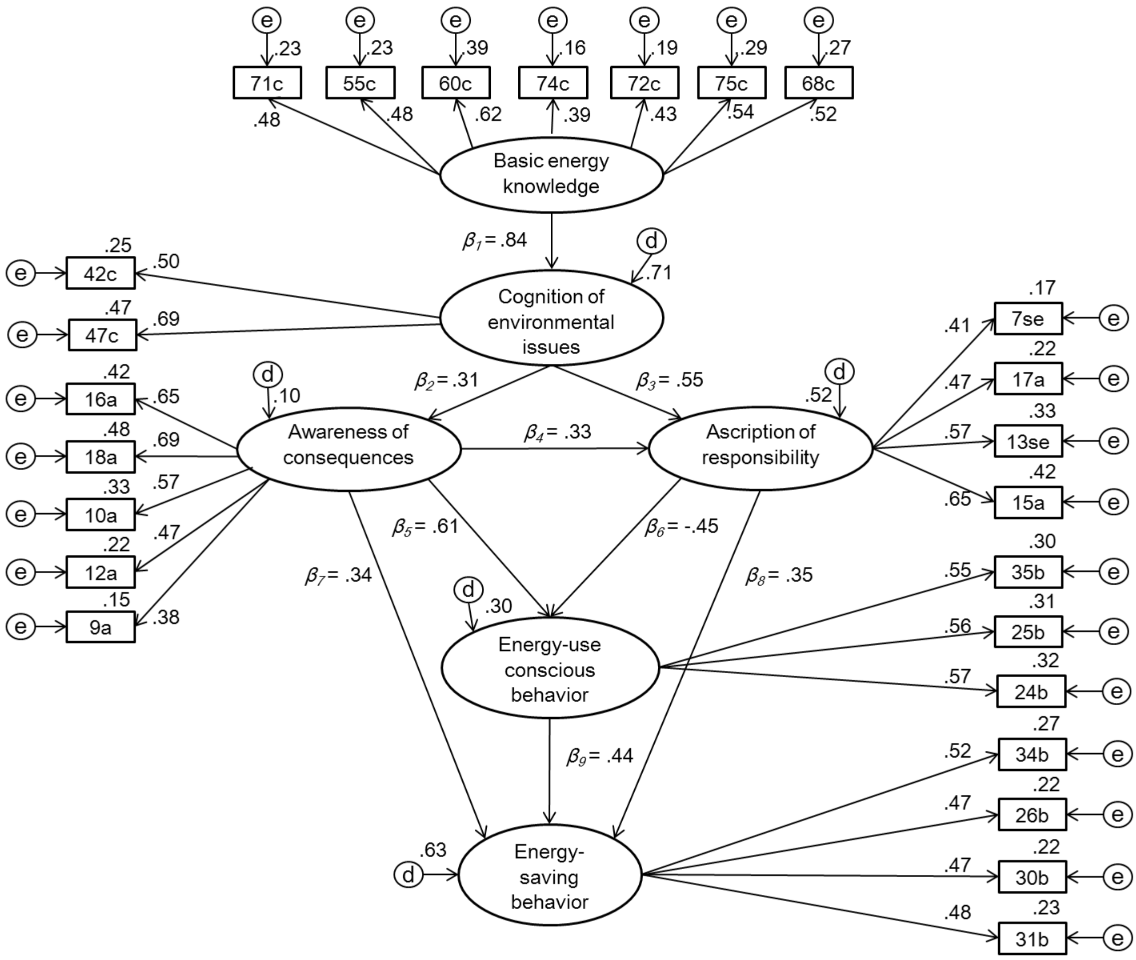

Fig. 4.1. Standardized Regression Coefficients of Energy Literacy Conceptual Model of Students of Lower Secondary School in Japan.

4.3.2 Conditional process analysis

Moderators of gender, school years (grade), region, and the family discussion of energy-related issues (Table 3.3 and 3.4) were tested to determine whether they affect the energy literacy conceptual model by using a regression-based path analysis with PROCESS for estimating and probing the interaction and conditional direct and indirect effects (Chap. 2.3.3) [5–8]. The moderators were coded one for male, Tokyo, response "Yes" to the family discussion, and coded zero for female, Fukushima, response "No" to the family discussion. Samples were dichotomized into the positive and negative response groups to the family discussion on energy-related issues to examine the influence of family on student's energy literacy conceptual model. Students who chose the positive two scales about family discussion were allocated to a positive group (17% overall), and those who chose the negative two scales (54% overall) and the neutral scale (29%, $N = 385$) were allocated to a negative group to distinguish the effect of the positive group from others (Table 4.4 adopted from Table 3.4). The parameters were estimated using ordinary least squares (OLS) regression, and the mean of variables that are used to configure the mediation model are centered beforehand [8].

Table 4.4. Positive and Neutral & Negative Groups Outcomes to the Presence of Family Discussion on Energy-Reated Issus (Adapted from Table 3.4).

		Cognitive			Affective		
Self-rating	N	Mean (%)	*SD* (%)	p	Mean (%)	*SD* (%)	p
The presence of family discussion on energy-related issues							
Positive	223	43.26	14.98	†	73.00	6.96	†
Neutral & Negative	1093	38.77	14.07		68.21	7.36	

		Self-efficacy			Behavior		
Self-rating	N	Mean (%)	*SD* (%)	p	Mean (%)	*SD* (%)	p
The presence of family discussion on energy-related issues							
Positive	223	75.25	11.41	†	72.87	9.91	†
Neutral & Negative	1093	67.60	12.52		65.64	10.33	

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

Five patterns of mediation model were investigated by conditional process analysis (Table 4.5). As a result, it was found interactions by gender in (1) the CEI on the AR through the AC, by region in (4) the AC on the ESB through the ECB, and by grade in (5) the AR on the ESB through the ECB. There was no interaction of family discussion of energy-related issues in the energy literacy model.

Table 4.5. Mediation Models for Investigating the Effect of Moderators.

Model	predictor (X)	Outcome (Y)	Mediator (M)	Moderator (W)
(1)	CEI	AR	AC	gender
(2)	AC	ECB	AR	ns
(3)	AC	ESB	AR	ns
(4)	AC	ESB	ECB	region
(5)	AR	ESB	ECB	grade

Table 4.6 presents the estimated regression coefficients of AC and AR in the mediated moderation model by gender. Students with relatively higher CEI expressed

higher AC (a_1 = 0.063, 95% CI = 0.043 to 0.083, $p < .001$). Moreover, holding CEI constant, the effect of AC on the AR depends on gender (b_2 = -0.136, 95% CI = -0.240 to -0.031, $p < .05$). For the reason that "the evidence of moderation of one of the paths in a mediation model is sufficient to claim moderated mediation" [8], this analysis supports the conclusion that the indirect effect of CEI on the AR through AC depends on gender. In this case, however, the 95% bootstrap confidence intervals for 10,000 resamples includes zero (-0.024 to 0.002). Thus, it cannot define that the indirect effect of CEI on the AR through the AC depends on gender since the confidence interval of the index of moderated mediation includes zero.

Table 4.6. Unstandardized OLS Regression Coefficients with Confidence Intervals Estimating Awareness of Consequences (AC) and Ascription of Responsibility (AR) in the Mediated Moderation by Gender. Variables are Mean Centered.

			AC (M)						AR (Y)			
			Coeff.	SE	95% CI	p			Coeff.	SE	95% CI	p
CEI (X)	a_1	$\rightarrow$	.063	.010	.043, .083	†	c'_1	$\rightarrow$	.116	.010	.096, .135	†
AC (M)							b_1	$\rightarrow$	.248	.027	.196, .300	†
Gender (W)	a_2	$\rightarrow$	-.021	.001	-.035, -.006	**	c'_2	$\rightarrow$	-.018	.007	-.032, -.005	**
$X \times W$	a_3	$\rightarrow$	-.012	.021	.558, -.053	.558	c'_3	$\rightarrow$	.040	.020	.001, .079	*
$M \times W$							b_2	$\rightarrow$	-.136	.053	-.240, -.031	*
Constant	i_M	$\rightarrow$	-.000	.004	-.007, .007	.962	i_Y	$\rightarrow$	.728	.003	.722, .735	†
			R^2 = 0.036						R^2 = 0.186			
			F (3, 1312) = 16.378, $p < .001$						F (5, 1310) = 59.922, $p < .001$			

* $p < .05$, ** $< .01$, † $< .001$

Table 4.7 presents the estimated regression coefficients of ECB and ESB in the moderated mediation model by grade. Students with relatively higher AR expressed less ECB (a_1 = -0.079, 95% CI = -0.142 to -0.017, $p < .05$). Moreover, holding AR constant, the effect of ECB on the ESB depends on the grade (b_2 = -0.063, 95% CI = -0.123 to -0.004, $p < .05$). Although there was no significant difference for the 7th grade by 95% bootstrap confidence intervals for 10,000 resamples (b_{7th} = -0.014, 95% CI = -0.054 to 0.025), there were significant differences for the 8th and 9th grades (8th grade: b_{8th} = -0.024, 95% CI = -0.049 to -0.000; 9th grade: b_{9th} = -0.030, 95% CI = -0.061 to -0.004). The conditional indirect effect of AR on the ESB through the ECB seems to decrease with the school year progression.

Table 4.7. Unstandardized OLS Regression Coefficients with Confidence Intervals Estimating Energy-Use Conscious Behavior (ECB) and Energy-saving Behavior (ESB) in the Moderated Mediation by Grade. Variables are Mean Centered.

			ECB (M)						ESB (Y)			
			Coeff.	SE	95% CI	p			Coeff.	SE	95% CI	p
AR (X)	a_1	$\rightarrow$	-.079	.032	-.142, -.017	*	c'_1	$\rightarrow$	.301	.027	.248, .355	†
ECB (M)							b_1	$\rightarrow$	.305	.024	.259, .352	†
Grade (W)	a_2	$\rightarrow$	.010	.006	-.001, .020	.085	c'_2	$\rightarrow$	-.003	.005	-.012, .006	.543
$X \times W$	a_3	$\rightarrow$	-.050	.041	-.131, .031	.226	c'_3	$\rightarrow$	.001	.035	-.068, .071	.969
$M \times W$							b_2	$\rightarrow$	-.063	.030	-.123, -.004	*
Constant	i_M	$\rightarrow$	-.000	.004	-.009, .008	.974	i_Y	$\rightarrow$	.761	.004	.754, .769	†
			$R^2 = 0.009$						$R^2 = 0.173$			
			F (3, 1312) = 3.740, $p < .005$						F (5, 1310) = 54.600, $p < .001$			

* $p < .05$, † $< .001$

Table 4.8 presents the estimated regression coefficients of ECB and ESB in the mediated moderation model by region. Students with relatively higher AC expressed higher ECB ($a_1 = 0.345$, 95% CI = 0.268 to 0.422, $p < .001$). Furthermore, this direct effect depends on the region: Fukushima and Tokyo ($a_3 = 0.280$, 95% CI = 0.126 to 0.434, $p < .001$). Therefore, this model is a mediated moderation model. Regarding the conditional direct effect of AC on the ESB for the region, it was significant at values of Fukushima ($b_{FUKd} = 0.414$, 95% CI = 0.316 to 0.513, $p < .001$) and Tokyo ($b_{TKYd} = 0.374$, 95% CI = 0.279 to 0.468, $p < .001$). Holding AC constant, the effect of ECB on the ESB does not significantly depend on the region ($b_2 = 0.062$, 95% CI = -0.053 to 0.176, $p = 0.291$). However, for the conditional indirect effect of AC on the ESB through the ECB for the region, there was a significant difference at values of Fukushima ($b_{FUKi} = 0.030$, 95% CI = 0.008 to 0.069) and Tokyo ($b_{TKYi} = 0.102$, 95% CI = 0.061 to 0.153). The 95% bootstrap confidence intervals for 10,000 resamples did not include zero (0.018 to 0.127). Thus, it can conclude that the conditional indirect effect of AC on the ESB through the ECB depends on the region, which is significantly stronger for Tokyo than Fukushima.

Table 4.8. Unstandardized OLS Regression Coefficients with Confidence Intervals Estimating Energy-Use Conscious Behavior (ECB) and Energy-saving Behavior (ESB) in the Mediated Moderation by Regions (Fukushima and Tokyo $N = 849$). Variables are Mean Centered.

			ECB (M)						ESB (Y)			
			Coeff.	SE	95% CI	p			Coeff.	SE	95% CI	p
AC (X)	a_1	→	.345	.039	.268, .422	†	c'_1	→	.393	.035	.325, .461	†
ECB (M)							b_1	→	.183	.029	.126, .241	†
Regions (W)	a_2	→	-.018	.010	-.038, .001	.068	c'_2	→	.027	.009	.010, .043	***
$X \times W$	a_3	→	.280	.079	.126, .434	†	c'_3	→	-.041	.070	-.177, .096	.559
$M \times W$							b_2	→	.062	.058	-.053, .176	.291
Constant	i_M	→	-.002	.005	-.012, .008	.666	i_Y	→	.763	.004	.755, .771	†
			$R^2 = 0.102$						$R^2 = 0.234$			
			F (3, 845) = 31.990, $p < .001$						F (5, 843) = 51.445, $p < .001$			

*** $p < .005$, † $< .001$

4.4 Discussion

4.4.1 Relation between knowledge and responsibility

Female students achieved higher mean values than the males for three factors: CEI, AC and AR (CEI: males 72%, females 78%, $p < .01$; AC: males 72%, females 74%, $p < .005$; AR: males 71%, females 74%, $p < .001$) and reported a strong estimate of CEI to the AR than the males (unstandardized coefficient of males $B_m = 0.75$, females $B_f = 1.42$, $p < .01$). One possible reason for the females' better cognitive performance may be that one private girls' junior high school in excellent academic performance is more likely to raise female scores (Chapter 3.5.1). However, this school does not affect the affective and behavioral subscales (Affective: Overall 69.3%, excluded the girls' school 68.7%; Behavior: Overall 67.1%, excluded the girls' school 66.4%, non-significant), and has little effect on the energy literacy conceptual model (the model fitness indices for the energy literacy model when the girls' school ($N = 330$) was eliminated: GFI = .941, AGFI = .928, SRMR = .050, RMSEA = .042, NFI = .823, and CFI = .879). The conditional process analysis found that the conditional direct effect of CEI predicted stronger AR for males than females (Males $b_m = 0.14$, $t(1310) = 9.30$, $p < .001$; Females $b_f = 0.10$, $t(1310) = 7.83$, $p < .001$). On the other hand, when the girls' school was eliminated, the coefficient of interaction was not significant ($p = .065$), and the conditional direct effect of CEI predicted a stronger AR for males than females (Males $b_m = 0.14$, $t(986) = 9.45$, $p < .001$; Females $b_f = 0.10$, $t(986) = 6.43$, $p < .001$).

Comparing each observed variable in the CEI and AR by gender, the females scored significantly higher than the males for three question items: No. 42 (the best reason to buy an appliance labeled "energy efficient" $p < .005$), No. 7 (My energy-use contributes no difference to energy problems, $p < .001$), and No. 15 (No worries about saving energy because new technologies solve the problems, $p < .05$), but others were not significant (Reason for global warming; Easing strict laws for environmental protection; No worries about turning off the lights in the classroom).

Since the results cannot identify a characteristic tendency among genders, it is difficult to assume the reason for the males' effect in the mediated moderation model with limited information. However, it is noted that an interaction between CEI and gender on the AR was found. Moreover, in this case, the magnitude of the effect of gender did not necessarily depend on the amount of knowledge of EE issues.

4.4.2 Relation between responsibility and energy-saving behavior

A negative effect of AR on the ESB through the ECB was found in the energy literacy model. Even though students feel responsibility to energy saving on a conceptual basis, if an individual may not know or understand that his/her behavior contributes to solve some of the global EE problems, he/she might ignore or underestimate energy-use consciousness in everyday life. In fact, only 49% students opposed the idea of question item No. 7 in AR, which is "My energy use contributes no difference to energy problems facing our nation (Reverse question)." The relation between AR and ECB may become positive when it is consistent with social norms and pressures, and students feel responsible for and are aware of the adverse consequences for future society [9]. It may be said that lower secondary students in Japan do not necessarily recognize the needs for urgency and importance as an individual matter in addressing global EE issues.

In this moderated mediation model, it was also found that the lower graders predicted the ESB by the ECB stronger than 9th graders (unstandardized coefficient of ECB to ESB: 7th grade $\beta_{7th} = 1.29$, 8th grade $\beta_{8th} = 0.57$, 9th grade $\beta_{9th} = 0.38$, $p < .01$). This was supported by a conditional process analysis that the conditional indirect effect of the AR on the ESB through the ECB seems to decrease with the school year progression. When the girls' school of excellent performance was excluded, the coefficient of interaction was not significant (p = .317), and the conditional indirect effect of AR predicted a stronger negative ESB through the ECB for the 9th graders compared to the 8th graders (8th grade: b_{8th} = -0.034, 95% CI = -0.064 to -0.007; 9th grade: b_{9th} = -0.046, 95% CI = -0.084 to -0.015). It is noted that students who indicated a high responsibility would perform energy-saving somewhat unconsciously. It might be said the habit of ESB, which is often formed partially by home or school discipline or unconscious actions for energy conservation [10], such as turning off lights in unoccupied rooms or turning off the showering during shampooing. A habit also plays an important role in daily energy use [11, 12]; however, a habitual behavior is difficult to change [10]. Hence, it would be better to form proper habits during childhood for energy conservation. Although it is dificult to identify the reason of the decline of indirect effect of AR on the ESB through the ECB with the school year progression, one possible reason can be considered that as students grow, a habit is more fixed in everyday life and they use energy unconsciously.

Despite the fact that Japan is a low self-sufficient with respect to natural resources and energy, only 13% of students know that Japan is almost 100% dependent on imported energy resources (Table B.1, No. 43 in Appendix B) and so do 15% of adults according to a JAERO survey [13] (p. 67). Furthermore, only 39% of adults worry about the depletion of fossil resources or oil shock [13] (p. 115). This is because Japanese people have hardly experienced serious energy-related difficulties, even though most of the nuclear power plants have been shut down since the nuclear accident in 2011. The regional electricity supply is stable, has few blackouts, is quickly back up, and is always restored to support our daily lives (Fig. 4.2). Therefore, even if the student feels responsible for EE problems, they can perform a pro-environmental habitual behavior without specific consciousness for energy use. Gradually, this tendency would become trivial with the school year progression because the students' interests will diversify toward the future.

Although it is difficult to maintain consciousness about energy use in daily life, as Zografakis et al. proposed that energy awareness is formed during childhood [14], family discussion about energy-related issues is more likely to impact students' energy literacy (See Table 3.3). As such, the earlier implementation of energy education regardless formal or informal, which improves students' awareness and values for solving energy-related issues and leads to favorable habits for energy conservation, would be recommended.

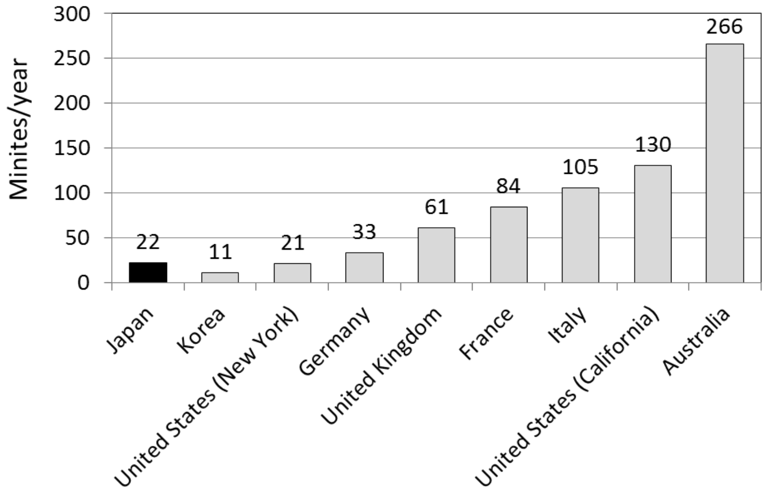

Fig. 4.2. Annual Power Outage Continuity per Household. Average of Japan and the US in 2015; Australia and Korea in 2014; France, Germany, Italy, and the UK in 2013 [15].

4.4.3 Relations between knowledge, awareness of consequences, and energy-saving behavior

Despite the fact that knowledge relevant to EE issues may be a critical component for deriving personal values, beliefs, attitudes toward energy-saving behavior and making a favorable decision for energy-related issues, the lack of a correlation between knowledge and behavior has been frequently reported (e.g., [3,4,16–18]). In the TPB, the most substantial information about behavioral determinants is contained in a person's behavioral, normative, and control beliefs [19]. Knowledge is one of the background factors that may impact the beliefs people hold, and it is expected to affect the intent to act and behavior indirectly [19, 20]. The VBN Theory assumes the relations between a person's values, environmental beliefs, and behavior, which is directly determined by personal norms to be activated by the AR and the AC [21]. If it can be considered that knowledge impacts one's values which in turn forms one's beliefs, "energy-use conscious behavior (ECB)" in the energy literacy conceptual model might be discussed as a behavior with personal norms activated by the AC. On the basis of this idea, the energy literacy model of this study can support the fact that the BEK predicts the ESB through the ECB by being concerned about the adverse consequences of ongoing energy-related problems. Even though indirect experiences such as school learning about EE issues do not impact behavior directly [22, 23], behavioral change requires knowledge contributions to modify values and beliefs to behavior [22, 24, 25]. Knowledge about the adverse consequences of ongoing energy-related problems may touch students' emotions, stimulate resonance, and inspire and foster their understanding of EE issues [26].

A corpus of knowledge, which was identified by Anable et al. – the facts of the issue, the causes and effects of the issue, its urgency and importance, and the individual contribution to a behavioral change – may be effective for improving students' awareness of the current EE situation [26]. Furthermore, "knowledge of the impact of behavioral changes" is also needed to learn the basic principles of energy to make rational behavioral choices [27].

4.4.4 Relation between region and energy-saving behavior

This study found a conditional indirect effect of the AC on the ESB through the ECB for the region (Fukushima and Tokyo). The situations in Fukushima about the academic achievement level, and the circumstances after the natural disasters and the nuclear accident have been explained in Chapter 3.5.1.

On the other hand, students in Tokyo experienced planned power outages after the disasters to avoid massive blackouts in its service area, which affect economic and industrial activities as well as various aspects of daily lives. Energy and power savings were often discussed in mass media, in schools, and at home during the period. In fact, the planned power outage in the early morning of March 14 was postponed owing to the prospect of lower-than-expected demand due to people's electricity saving [28]. Over 90% of the participants in this survey reported that their parents had talked about the discipline in energy and power savings before graduating elementary school. Although there was no interaction of family discussion about energy-related issues in the energy literacy conceptual model, it cannot be denied that it may implicitly have turned into a regional effect for Tokyo, where students experienced strict energy-saving for the planned blackouts. Some possible reasons for the differences between students in Fukushima and Tokyo can be discussed, which are the relatively low academic performance, the disadvantages in daily life due to the natural disasters and the nuclear accident in Fukushima, and the extraordinary experience of energy savings in Tokyo.

According to a recent study in Taiwan, secondary students in a southern region that frequently experiences natural disasters scored higher on energy-conservation-related attitudes and practices than students in a northern urban area that does not directly suffer from environmental disasters in an advanced infrastructure [29]. Such direct experiences have a stronger impact on people's behavior than indirect experiences [23], and personal experiences could foster a student's long-term environmental concerns [30]. Moreover, the impact of natural disasters can be employed as teaching materials in schools since students may be aware of EE issues more closely. In fact, the students of six high schools in Fukushima published their research about the measurement and comparison of individual external doses of high school students living in Japan, France, Poland, and Belarus [31]. They found that the individual external doses in areas where people are allowed to live in Fukushima prefecture and Belarus are within the range of the estimated annual doses of the terrestrial background radiation level of other regions they surveyed. There must have been hardships for students in Fukushima, however, their personal experiences would turn into learning opportunities, and proper teaching materials and timely educational approaches would contribute to enhance students' awareness of the EE issues.

To achieve objectives of EE education within the limited time given to developing an in-depth understanding of EE issues, and cultivating and fostering fundamental knowledge, skills, awareness to contribute to solving energy-related issues [32], the energy literacy conceptual model is effective for developing energy education contents that takes into account the student's conceptual construction of energy-relevant knowledge, attitudes, and energy-saving behavior.

4.5 Conclusion

Applying the results of energy literacy assessment of lower secondary students in Japan, an energy literacy conceptual model has been explored by a factor analysis approach.

The energy literacy conceptual model was explained by six components, where the energy-saving behavior was predicted by both the awareness of consequences and the ascription of responsibility, which were activated by the cognition of environmental issues based on the basic energy knowledge.

The relatively higher knowledge of energy and environment predicted a strong positive effect on the ascription of responsibility than the awareness of consequences. The negative effect of ascription of responsibility on the energy-saving behavior through the energy-use conscious behavior was observed. Even though students feel responsibility to energy-saving on a conceptual basis, they are possibly to ignore or underestimate energy-use consciousness in daily life if they do not know that the contributions of their behaviors are important and urgent to solve energy and environmental issues. In contrast, the positive effect of awareness of consequences predicts the energy-saving behavior through the energy-use conscious behavior. Thus, the awareness of consequences plays a vital role in bonding between energy-relevant knowledge and energy-saving behavior.

A conditional process analysis elucidated that (1) the direct effect of cognition of environmental issues on the responsibility depends on the gender, and the magnitude of its effect did not necessarily depend on the amount of EE knowledge; (2) the indirect effect of responsibility toward energy-related issues on energy-saving behavior through energy-use conscious behavior seems to decrease with the school year progression; and (3) the indirect effect of awareness of consequences on the energy-saving behavior through the energy-use conscious behavior depends on the regions. These findings contribute for developing energy education program on the basis of the construction of students' energy literacy concept.

Reference

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Chapter 5

Integrating energy literacy structural model with the Theory of Planned Behavior and Value-Belief-Norm Theory

5.1 Introduction

The conceptual construction of students' of energy literacy was understood by an exploratory factor analysis (EFA) in the previous chapter. Subsequently, the energy literacy structural model is constructed to explore the relationship between students' EE knowledge and behavioral intentions, by incorporating attitude-behavioral factors and normative factors, which were not extracted by a factor analysis approach. To improve more understanding of the relationship among knowledge, attitudes, and behavior in energy literacy and to identify the elements what should be emphasized in energy education, the hypothesis model approach can be applied by adopting both the TPB and the VBN, which have been verified in social psychology studies in last decades.

Furthermore, the interaction of six attributes are examined by a conditional process analysis, and scientific literacy, critical thinking ability, and environmental values or worldview are also evaluated because these aspects are vitally associated with energy literacy [1]. This may potentially assist in providing informative insights from the perspective of students' knowledge, attitudes, and behaviors regarding EE issues.

Considering the aforementioned perspectives, the objectives of this chapter are (1) to integrate the energy literacy structural model with the TPB and the VBN,

(2) to examine the causal relationship between basic energy knowledge and energy-saving behavior based on the integrated model, and (3) to analyze the interactions of moderators.

5.1.1 Hypothesis model

Wall suggested that there is merit in developing a model incorporating constructs from each model and it is beneficial to apply these theoretical models as complementary [2]. The TPB focuses on external influences (subjective norms), while the VBN focuses on internal normative factors (personal norms) [3]. Furthermore, the TPB explains the personal usefulness of a given behavior, including the intention, which is predicted by perceived control over behavior, whereas the VBN emphasizes the benefit to others (altruism) over self-interest. From the theoretical and practical perspectives, while keeping the existing model framework, extension based on the two theories would help in interpreting the energy literacy structure to identify the potentiality and validity of the components [4, 5]. In the following sections, first, the theories are separately introduced and applied to the structure of energy literacy. Then, the hypothesis model for the energy literacy structure is proposed based on the specified variables and their relations.

5.1.1.1 Theory of Planned Behavior (TPB)

According to the TPB, a person's behavior is driven by the intention to act (INT). The INT is determined by the person's attitudes toward the behavior (ATB), subjective norms (SNs), and perceived behavioral control (PBC). The TPB is a good model for understanding pro-environmental behavior [6, 7] and energy-saving behavior. The theoretical model of energy-saving behavior (ESB) from the TPB is presented in Fig. 5.1. The ATB is determined by the behavioral beliefs and the evaluation of the behavioral outcome or attributes [8]. When students perform ESBs according to their beliefs to contribute to an energy solution or environment protection, positive and preferable ATBs have been formed in advance [9]. The SNs are perceptions of social expectations and pressures regarding actions that an individual's valuable referents think that they should perform. Students' preferable energy-saving behaviors may result from the expectations of important or trusted people. The PBC is a perception of a person's ability and opportunities for behavioral control, which is affected by the presence of factors that promote or hamper a given behavior [10]. Even if students are willing to perform energy-saving behaviors, it may be possible that they do not know what to do or an interference factor prevents them from carrying out the actions.

Anable, Lane, & Kelay pointed out that beliefs are "the ultimate determinants" in the TPB framework, which are influenced by person's values and depend on knowledge, facts and things people believe. Although knowledge may be useful in evaluating which beliefs are more salient and valuable, the TPB will help explain that knowledge alone does not necessarily lead to behavioral changes [3]. On the basis of this idea, basic energy knowledge is considered one of the most important factors in determining beliefs in ATBs. Therefore, according to the TPB, knowledge is assumed to be an antecedent of the ATBs [11].

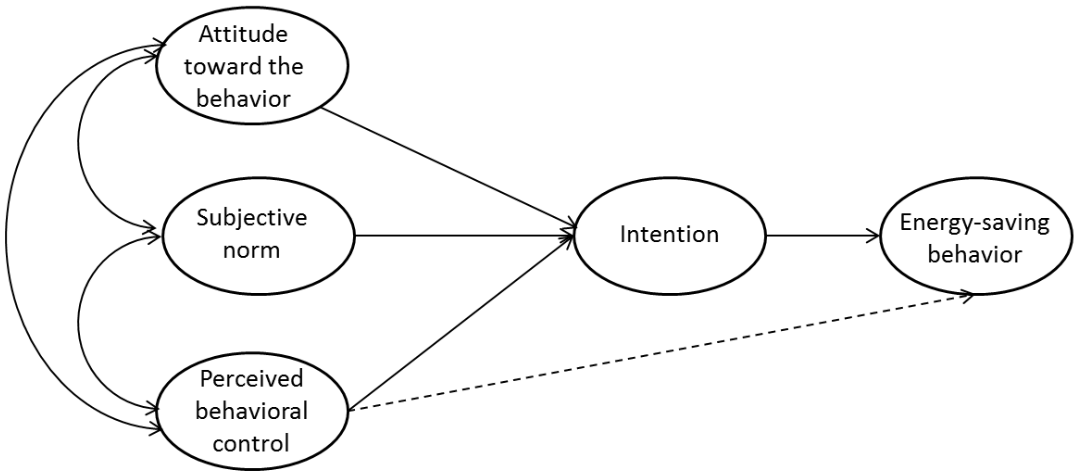

Fig. 5.1. Energy-Saving Behavioral Model Applying the Theory of Planned Behavior [12].

5.1.1.2 Value-Belief-Norm Theory (VBN)

The VBN explains that pro-environmental behavior is predicted by personal norms (PNs) that are activated by the ascription of responsibility (AR) and the awareness of consequences (AC). The AC is connected to the persons environmental worldview, which is assessed by the new ecological paradigm (NEP) [13]. The NEP is related to general values: altruistic values, egoistic values, traditional values, and values regarding openness to changes. When people's behaviors are consistent with their beliefs, which reflect values that are based on the knowledge that they have, the energy-saving behavior model that is adapted from the VBN can be applied, which is presented in Fig. 5.2. It is assumed that the ESB is predicted by the PN through the AR and AC, which are activated by basic energy knowledge.

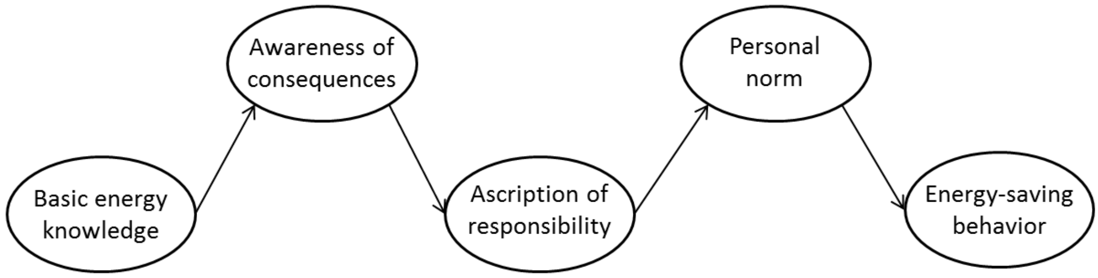

Fig. 5.2. Structure of Energy-Saving Behavior, as Predicted by the Basic Energy Knowledge by Applying the Value-Belief-Norm Theory [14, 15].

5.1.1.3 Hypothesis model integrated with the TPB and the VBN

A normative aspect has been considered in the TPB. The PN is often examined in relation to pro-environmental behaviors, which have many underlying factors [16], thus, it may be more general than the ATB (e.g., [7, 17, 18]). As Klöckner concludes from his meta-analysis research, if each behavior is in line with personal values, parts of the impacts of personal norms on intentions to act are mediated by attitudes [5,17]. Therefore, when assuming that knowledge contributes to modifying attitudes and values toward behavioral changes [19–21], it can be considered that the VBN model that is predicted by basic energy knowledge is antecedent to the ATB in the TPB in the configuration of the energy literacy structural model. Knowledge relevant to EE issues ignites students' interests, touches their emotions, stimulates their awareness and responsibility toward EE problems, and cultivates their norm [3]. Hence, the hypothesis model integrates both the "personal interest aspect" of the TPB and the "social motivation" of the VBN. The hypothesis model of energy literacy structure is shown in Fig. 5.3. The intention toward the ESB is predicted by the ATB, SN, and PBC, and the ESB is predicted by independent contributions from the INT and PBC. The integrated model can examine the links among students' relevant EE knowledge, beliefs, norms, attitudes, intentions, and energy-saving behaviors within a single model. It will facilitate the interpretation of relationships between the distal variables, such as knowledge and behavior, by applying mediation variables and the estimation of a target predictor within the same model [5].

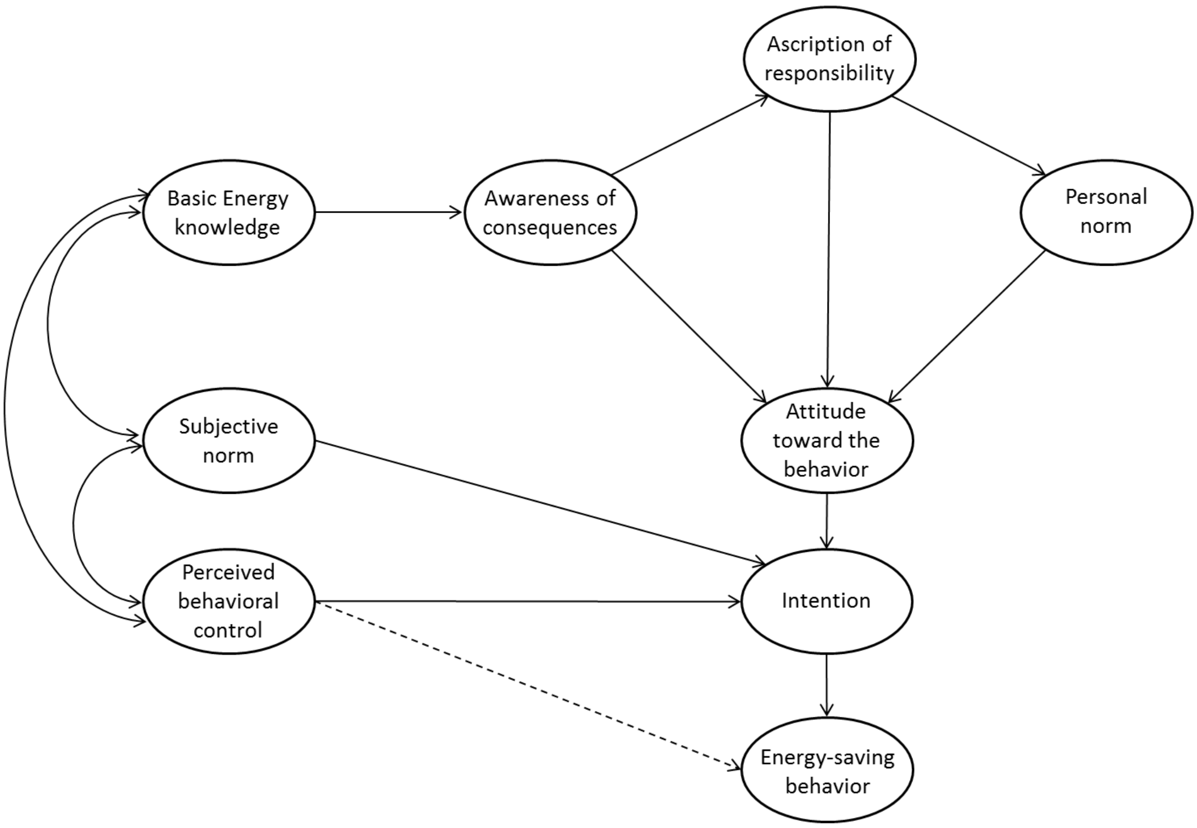

Fig. 5.3. Hypothesis Energy Literacy Structural Model, Which Is Integrated with the Theory of Planned Behavior and Value-Belief-Norm Theory.

5.2 Method

5.2.1 Sampling

In July 2016, eight schools where teachers appreciate the importance of energy education participated in this survey. Those were in Fukushima, Fukui, Tokyo (two schools), Kyoto, Osaka (two schools), and Nagasaki prefectures (Fig. 5.4). Schools were selected in wide areas from northeast to southwest of Japan. The survey was conducted by each teacher in the classroom by a printed questionnaire. Valid responses of 1070 students (60% of the 95% response rate) from the 7th to 9th grades (ages 13–15), without missing values, were analyzed. Gender distribution of the respondents was 33% male and 67% female due to the participation of one private girls' school (Table 5.1).

Fig. 5.4. Locations of Survey Participants in 2016.

Table 5.1. Sample Distribution of the Survey 2016

Schools	N	Male	Female	7th	8th	9th	Collection	Rate of valid %
School_1	310	0	310	139	91	80	427	72.6
School_2	171	90	81	36	58	77	356	48.0
School_3	141	71	70	45	45	51	252	55.9
School_4	132	56	76	40	51	41	221	59.7
School_5	107	41	66	57	0	50	165	64.8
School_6	70	36	34	34	0	36	140	50.0
School_7	12	5	7	1	6	5	14	85.7
School_8	127	49	78	0	0	127	199	63.8
Total	1070	348	722	352	251	467	1774	60.3

5.2.2 Question items and conditional process analysis

5.2.2.1 Question items

A new questionnaire was employed (Chapter 2.2.2). The additional measurements of TPB and VBN were developed according to the literature review. All items were shuffled across domains, except a set of items on basic energy knowledge and civic scientific literacy. To avoid a residual covariance among the observed variables and predictors beyond the domains, the residual covariance was analyzed and eliminated the corresponding items. As a result, 117 question items were extracted from a set of 136 items for nine predictors and three moderators: civic scientific literacy, critical thinking ability, and the new ecological paradigm.

Reliability was evaluated by calculating Cronbach's alpha values of the components. Variables of ABC01, ABC02, and ABC03 for the actual behavioral control in the TPB were eliminated from analysis due to lack of internal consistency (0.21). Applying the Ajzen's conception of ABC, the PBC can be a substituted to the ABC to predict the ESB [22]. As a result, the Cronbach's alpha values ranged from 0.71 to 0.87. These values indicated higher internal consistency relative to the previous energy literacy conceptual model based on a factor analysis approach (with values ranging from 0.52 to 0.70 in Chapter 4.2.1). A summary of twelve components (excluding the ABC beforehand), their abbreviations, number of items employed and Cronbach's alpha coefficient values is shown in Table 5.2.

The results of pilot test by graduate students of the Department of Socio-Environmental Energy Science, Graduate School of Energy Science, Kyoto University are presented in Table 5.3. They scored the ranges from 62% to 84%. It is natural that students majoring in energy science course indicated high score on the BEK (84%), while the score of variables for the TPB tend to be less than 70% except the ATB (SN 62%, PBC 65%, INT 67%, ESB 63%). The CSL, CTA, and NEP were over 70%.

Table 5.2. Summary of Predictors and Moderators of Energy Literacy Structural Model Integrated with the Theory of Planned Behavior and the Value-Belief-Norm Theory.

Predictors/Moderators	Abb.	Number of item	Probability	Items eliminated
Basic energy knowledge	BEK	16	0.756	BEK03, 05, 06, 15
Awareness of consequences	AC	9	0.860	AC01, 02
Ascription of responsibility	AR	6	0.735	AR06
Personal norm	PN	4	0.710	PN05
Attitude toward the behavior	ATB	6	0.734	ATB04
Subjective norm	SN	9	0.793	–
Perceived behavior control	PBC	4	0.784	PBC02, 04 ,05
Intention	INT	4	0.722	INT01
Energy-saving behavior	ESB	11	0.727	ESB07, 11
Actual behavioral control	ABC	0	**0.211**	ABC01, 02, 03
Civic scientific literacy	CSL	18	0.751	–
Critical thinking ability	CTA	22	0.870	–
New ecological paradigm	NEP	8	0.711	NEP04
	Total	117		

Table 5.3. Results of Pilot Test by Graduate Students ($N = 19$).

BEK			AC			AR		
Mean %	SD	SE	Mean %	SD	SE	Mean %	SD	SE
84.21	17.35	3.98	81.40	13.05	2.99	72.63	10.75	2.47
PN			ATB			SN		
83.68	15.97	3.66	82.63	15.93	3.65	61.75	14.43	3.31
PBC			INT			ESB		
64.74	18.52	4.25	67.11	18.81	4.31	63.44	16.10	3.69
CSL			CTA			NEP		
75.36	12.61	2.89	77.08	10.10	2.32	77.50	12.72	2.92

5.2.2.2 Conditional process analysis

A subgroup of six attributes where gender; school years (grades); the energy education experience (Yes/No); the energy-related facility-tour experience (Yes/No); the existence of home discipline in energy-saving (Yes/No), and the existence of family discussion about energy-related issues (a five-Likert scale) was also evaluated as a moderation variable affecting the energy literacy model. A total nine moderators including the civic scientific knowledge, critical thinking ability, and new ecological paradigm was employed to a conditional process analysis.

In response to the previous chapter suggesting the importance of AC in linking between BEK and ESB (Capter 4.3.1), this chapter examined interactions on the following two causal relations: (1) the direct effect of BEK on the AC and (2) the direct and indirect effects of AC on the ATB through the AR.

5.3 Result

5.3.1 Assessment of each components in energy literacy structural model

A summary of the energy literacy assessment by the new questionnaire for lower secondary students in Japan is presented in Table 5.4. To make it easy to compare the mean values, Fig. 5.5 to Fig. 5.11 are presented.

In overall result, students scored 53% on the BEK which is better than the previous study (Cognitive subscale, 39%, $p < .001$, See Table 3.2). However, they failed to meet the ideal criterion of 70% correctness, which was suggested by DeWaters and Powers; students who are considered "energy-literate" met this criterion on the cognitive subscale [23, 24]. Beliefs, norm, and attitude factors (AC, AR, PN, and

ATB) indicated relatively high scores over 76%, while the some factors in the TPB indicated less than 70% (SN, PBC, INT, and ESB). The score of CSL, CTA, and NEP ranged from 52% to 76%. Comparing with the pilot test result of graduate students, similar trends can be observed such as high scores of VBN components and the ATB, and low scores of TPB components (Table 5.3).

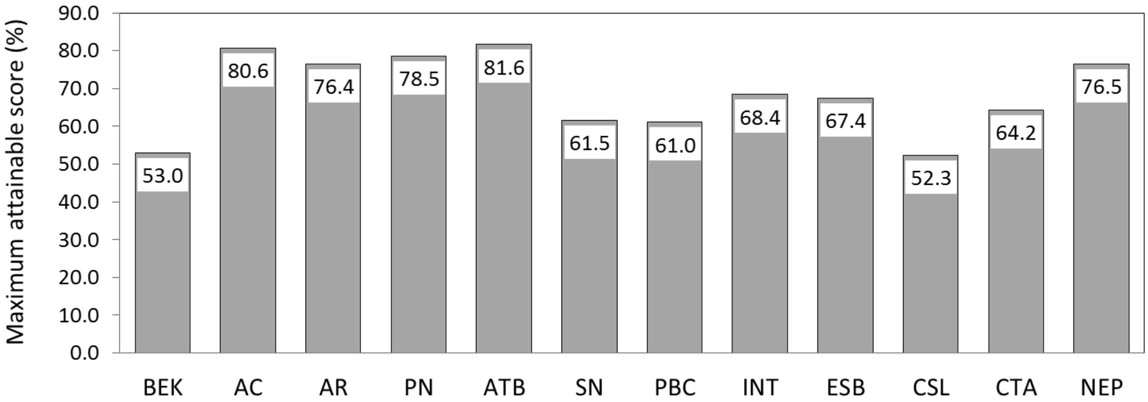

Fig. 5.5. Mean of Overall Components.

The female students scored significantly higher than the males on the BEK, AC, AR, and PN (BEK: Male 46%, Female 56%, $p < .001$; AC: Male 79%, Female 81%, $p < .005$; AR: Male 75%, Female 77%, $p < .01$; PN: Male 77%, Female 79%, $p < .05$), while the males achieved higher scores than the females on the SN and CTA (SN: Male 63%, Female 61%, $p < .05$; CTA: Male 65%, Female 64%, $p < .05$) (Fig. 5.6).

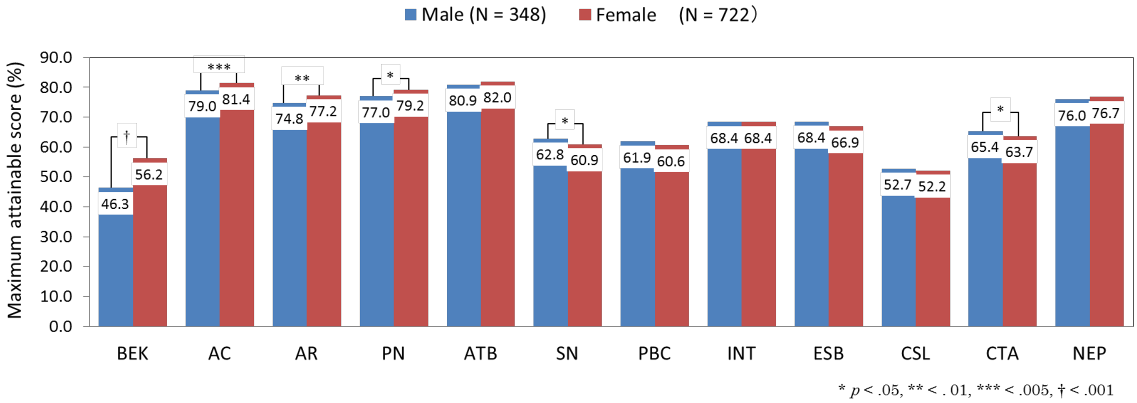

Fig. 5.6. Mean Comparison of Gender.

The 7th grade students scored significantly higher than did those in the 9th grade on the AC, AR, PN, ATB, INT, ESB, CTA, and NEP. Moreover, the actual scores on other predictors seemed to decrease with the school year progression, except the cognitive components: the BEK and CSL (Fig. 5.7).

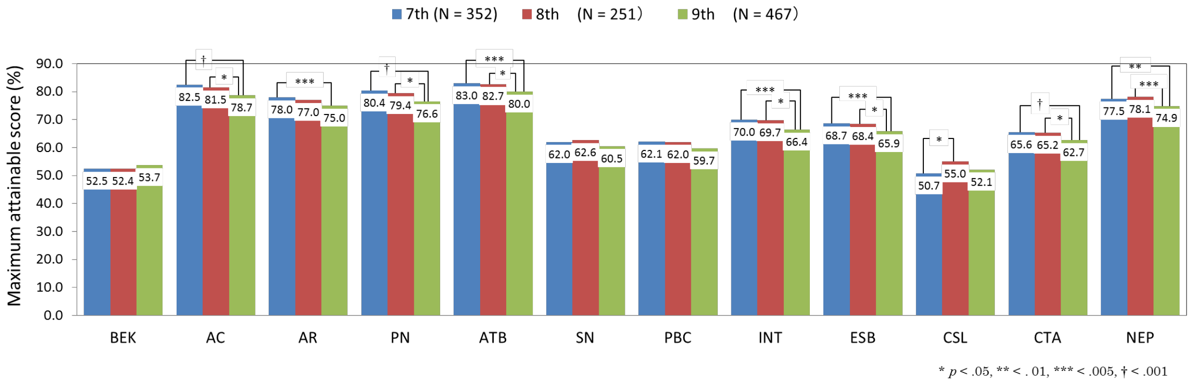

Fig. 5.7. Mean Comparison in the School Years.

Students who responded positively to questions on energy education experience, energy-related facility-tour experience (except BEK), home discipline in energy-saving, and family discussions of energy-related issues achieved higher scores on all predictors than those who responded negatively (Fig. 5.8, 5.9, 5.10, 5.11).

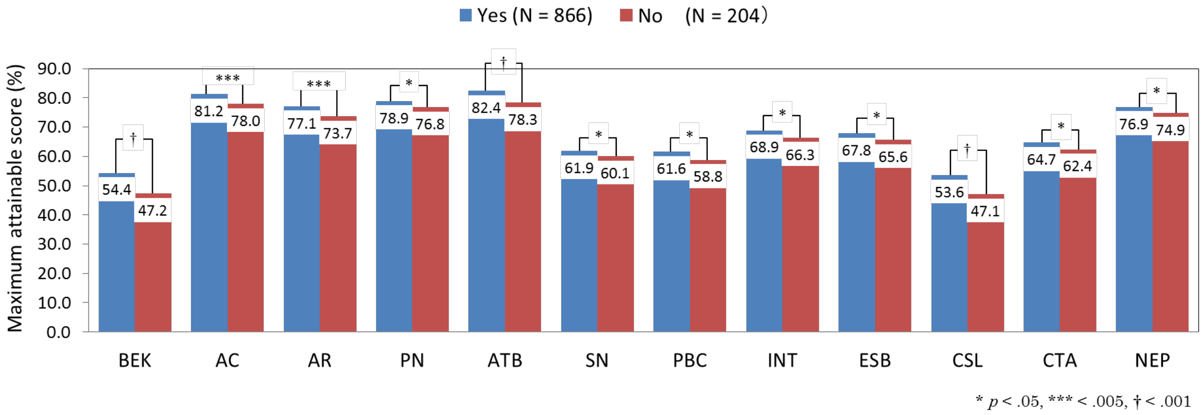

Fig. 5.8. Mean Comparison in the Energy Education Experience.

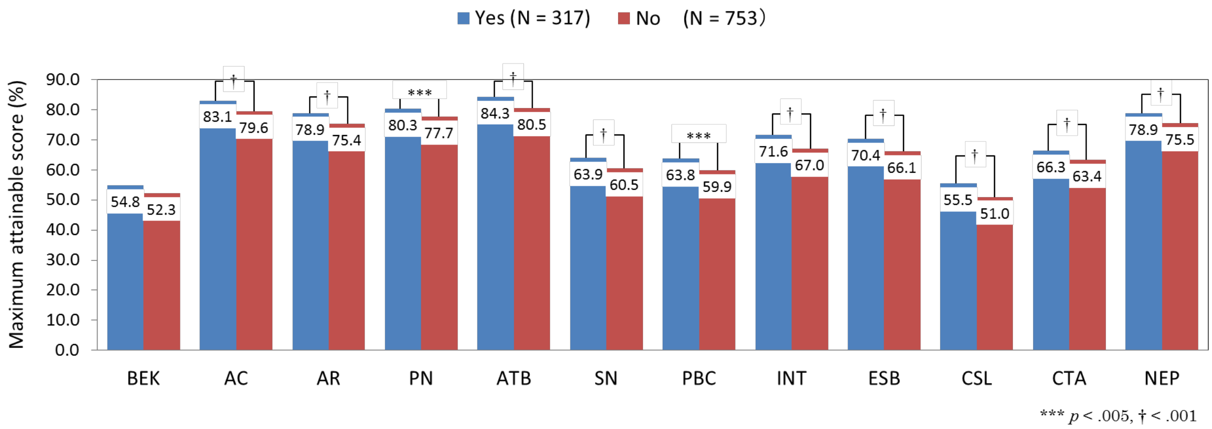

Fig. 5.9. Mean Comparison in the Energy-Related Facility-Tour Experience.

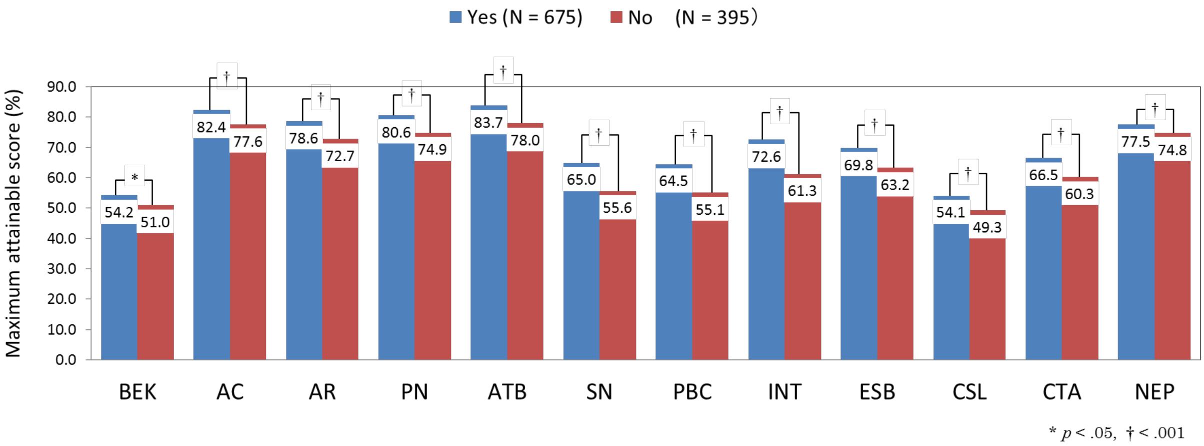

Fig. 5.10. Mean Comparison in the Home Discipline in Energy-Saving.

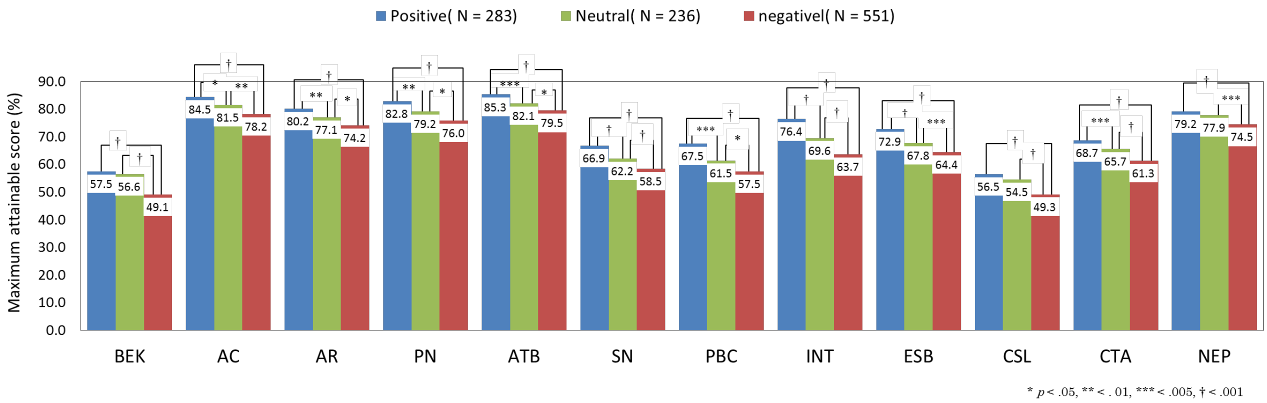

Fig. 5.11. Mean Comparison in the Family Discussions of Energy-Related Issues.

Table 5.4. Descriptive Statistics of Energy Literacy Assessment.

			BEK				AC			
		N	*M* %	*SD* %	*SE* %	*p*	*M* %	*SD* %	*SE* %	*p*
Overall		1070	53.0	22.1	0.68		80.6	13.1	0.4	
Gender	Male	348	46.3	23.3	1.25		79 .0	13.3	0.71	
	Female	722	56.2	20.8	0.78	†	81.4	13.0	0.48	***
Grade	7th	352	52.5	20.1	1.07		82.5	12.8	0.68	†
	8th	251	52.4	22.3	1.41		81.5	13.3	0.84	*
	9th	467	53.7	23.5	1.09		78.7	13.1	0.61	
Education	Yes	866	54.4	22.0	0.75	†	81.2	13.0	0.44	***
	No	204	47.2	21.8	1.52		78.0	13.5	0.95	
Facility tour	Yes	317	54.8	22.2	1.25		83.1	12.7	0.71	†
	No	753	52.3	22.1	0.80		79.6	13.2	0.48	
Discipline	Yes	675	54.2	21.8	0.84	*	82.4	12.2	0.47	†
	No	395	51.0	22.6	1.14		77.6	14.2	0.71	
Discussion	Positive	283	57.5	21.0	1.25	†	84.5	12.0	0.71	†
	Neutral	236	56.6	22.3	1.45	†	81.5	12.7	0.82	*
	Negative	551	49.1	22.0	0.94		78.2	13.4	0.57	**
			AR				PN			
		N	*M* %	*SD* %	*SE* %	*p*	*M* %	*SD* %	*SE* %	*p*
Overall		1070	76.4	13.3	0.41		78.5	14.2	0.43	
Gender	Male	348	74.8	14.0	0.75		77.0	15.1	0.81	
	Female	722	77.2	12.8	0.48	**	79.2	13.6	0.51	*
Grade	7th	352	78.0	12.8	0.68	***	80.4	13.7	0.73	†
	8th	251	77.0	14.0	0.88		79.4	15.0	0.95	*
	9th	467	75.0	13.1	0.60		76.6	13.8	0.64	
Education	Yes	866	77.1	13.2	0.45	***	78.9	14.3	0.49	*
	No	204	73.7	13.3	0.93		76.8	13.5	0.95	
Facility tour	Yes	317	78.9	13.3	0.74	†	80.3	14.2	0.80	***
	No	753	75.4	13.1	0.48		77.7	14.1	0.51	
Discipline	Yes	675	78.6	12.6	0.49	†	80.60	13.4	0.52	†
	No	395	72.7	13.5	0.68		74.9	14.7	0.74	
Discussion	Positive	283	80.2	12.8	0.76	†	82.8	13.1	0.78	†
	Neutral	236	77.1	12.2	0.79	**	79.2	13.4	0.87	**
	Negative	551	74.2	13.5	0.58	*	76.0	14.4	0.62	*
			ATB				SN			
		N	*M* %	*SD* %	*SE* %	*p*	*M* %	*SD* %	*SE* %	*p*
Overall		1070	81.6	11.6	0.36		61.5	12.3	0.38	
Gender	Male	348	80.9	12.0	0.64		62.8	12.5	0.67	*
	Female	722	82.0	11.5	0.43		60.9	12.1	0.45	

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		N	M %	SD %	SE %	p	M %	SD %	SE %	p
Grade	7th	352	83.0	11.6	0.62	***	62.0	12.6	0.67	
	8th	251	82.7	11.4	0.72	*	62.6	11.9	0.75	
	9th	467	80.0	11.6	0.54		60.5	12.2	0.56	
Education	Yes	866	82.4	11.5	0.39	†	61.9	12.4	0.42	*
	No	204	78.3	11.7	0.82		60.1	11.4	0.80	
Facility tour	Yes	317	84.3	11.2	0.63	†	63.9	12.7	0.72	†
	No	753	80.5	11.6	0.42		60.5	11.9	0.43	
Discipline	Yes	675	83.7	10.9	0.42	†	65.0	11.2	0.43	†
	No	395	78.0	12.0	0.60		55.6	11.7	0.59	
Discussion	Positive	283	85.3	10.2	0.61	†	66.9	11.5	0.69	†
	Neutral	236	82.1	11.1	0.73	***	62.2	10.80	0.71	†
	Negative	551	79.5	12.0	0.51	*	58.5	12.2	0.52	†
				PBC				INT		
		N	M %	SD %	SE %	p	M %	SD %	SE %	p
Overall		1070	61.0	18.3	0.56		68.4	15.5	0.47	
Gender	Male	348	61.9	18.4	0.99		68.4	15.6	0.84	
	Female	722	60.60	18.2	0.68		68.4	15.5	0.58	
Grade	7th	352	62.1	19.5	1.04		70.0	15.4	0.82	***
	8th	251	62.0	17.3	1.09		69.7	15.4	0.97	*
	9th	467	59.7	17.8	0.82		66.4	15.6	0.72	
Education	Yes	866	61.6	18.2	0.62	*	68.9	15.7	0.53	*
	No	204	58.8	18.4	1.29		66.3	14.9	1.04	
Facility tour	Yes	317	63.8	18.4	1.04	***	71.6	15.5	0.87	†
	No	753	59.9	18.1	0.66		67.0	15.4	0.56	
Discipline	Yes	675	64.5	17.6	0.68	†	72.6	13.9	0.53	†
	No	395	55.1	17.8	0.9		61.3	15.7	0.79	
Discussion	Positive	283	67.5	17.5	1.04	†	76.4	13.9	0.82	†
	Neutral	236	61.5	16.5	1.07	***	69.6	13.5	0.88	†
	Negative	551	57.5	18.5	0.79	*	63.7	15.4	0.66	†
				ESB				CSL		
		N	M %	SD %	SE %	p	M %	SD %	SE %	p
Overall		1070	67.4	11.7	0.36		52.3	17.3	0.53	
Gender	Male	348	68.4	11.2	0.60		52.7	18.8	1.01	
	Female	722	66.9	11.9	0.44		52.2	16.5	0.61	
Grade	7th	352	68.7	12.1	0.64	***	50.7	17.4	0.93	
	8th	251	68.4	12.1	0.77	*	55.0	17.4	1.10	*
	9th	467	65.9	11.0	0.51		52.1	16.9	0.78	
Education	Yes	866	67.8	11.7	0.4	*	53.6	16.7	0.57	†
	No	204	65.6	11.5	0.81		47.1	18.6	1.30	
Facility tour	Yes	317	70.4	11.7	0.66	†	55.5	17.2	0.97	†

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		N	M %	SD %	SE %	p	M %	SD %	SE %	p
	No	753	66.1	11.5	0.42		51.0	17.1	0.62	
Discipline	Yes	675	69.8	11.3	0.44	†	54.1	16.7	0.64	†
	No	395	63.2	11.1	0.56		49.3	17.8	0.89	
Discussion	Positive	283	72.9	11.2	0.67	†	56.5	16.9	1.00	†
	Neutral	236	67.8	9.90	0.64	†	54.5	16.7	1.09	†
	Negative	551	64.4	11.6	0.50	***	49.3	17.1	0.73	
				CTA				NEP		
		N	M %	SD %	SE %	p	M %	SD %	SE %	p
Overall		1070	64.2	10.9	0.33		76.5	11.8	0.36	
Gender	Male	348	65.4	11.0	0.59	*	76.0	11.8	0.64	
	Female	722	63.7	10.8	0.40		76.8	11.7	0.44	
Grade	7th	352	65.6	10.6	0.56	†	77.5	12.0	0.64	**
	8th	251	65.2	11.0	0.69	*	78.1	11.8	0.75	***
	9th	467	62.7	10.9	0.51		74.9	11.3	0.52	
Education	Yes	866	64.7	10.9	0.37	*	76.9	11.8	0.40	*
	No	204	62.4	10.6	0.74		74.9	11.6	0.81	
Facility tour	Yes	317	66.3	11.5	0.65	†	78.9	11.6	0.65	†
	No	753	63.4	10.5	0.38		75.5	11.7	0.43	
Discipline	Yes	675	66.6	10.4	0.40	†	77.5	11.4	0.44	†
	No	395	60.3	10.7	0.54		74.8	12.2	0.61	
Discussion	Positive	283	68.7	10.8	0.64	†	79.2	11.4	0.68	†
	Neutral	236	65.7	10.4	0.68	***	77.9	11.6	0.76	***
	Negative	551	61.3	10.2	0.44	†	74.5	11.7	0.50	

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

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5.3.2 Intercorrelations between components

To evaluate the validity of the model analysis, a confirmatory factor analysis in which all predictors were interrelated was carried out to construct the energy literacy model. The results indicated that the energy literacy model that is integrated with the TPB and VBN fits the data moderately well: GFI = 0.851; AGHI = 0.839; SRMR = 0.052; NFI = 0.769; CFI = 0.843; RMSEA = 0.039. The correlations among the components were calculated with the non-parametric Spearman's rank correlation (ρ) and reported along with the descriptive statistics in Table 5.5. Correlation coefficients are ranged from 0.18 to 0.75 in the standardized estimates, and are all significant except the intercorrelation between BEK and SN (r = 0.03, p = 0.34).

The relatively low correlation between knowledge (BEK) and TPB components were indicated (ATB $r = .30$, SN $r = .03$, PBC $r = .08$, and INT $r = .15$) (e.g., [25]), while the moderated correlation between BEK and AC (in the VBN) was shown ($r = .41$). Furthermore, the VBN components relatively strongly correlated to the attitude toward the behavior (in the TPB) (AC $r = .73$, AR $r = .68$, AC $r = .69$). It implies that although the BEK does not directly affect behavioral components (TPB), it may possibly to able to explain energy-saving behavior by mediating the VBN components.

Table 5.5. Descriptive Statistics for Predictors and Moderators (CSL, CTA, and NEP) and Spearman's *rho* Correlation Matrix for Path Analysis.

Predictors	M %	SD %	BEK	AC	AR	PN	ATB	SN	PBC	INT	ESB	CSL	CTA
Basic energy knowledge	53.0	22.1	1										
Awareness of consequences	80.6	13.1	.41**	1									
Ascription of responsibility	76.4	13.3	.31**	.76**	1								
Personal norm	78.5	14.2	.32**	.76**	.73**	1							
Attitude toward the behavior	81.6	11.6	.30**	.73**	.68**	.69**	1						
Subjective norm	61.5	12.3	.03 ns	.29**	.39**	.34**	.37**	1					
Perceived behavioral control	61.0	18.3	.08*	.27**	.40**	.34**	.31**	.43**	1				
Intention	68.4	15.5	.15**	.47**	.56**	.54**	.54**	.61**	.59**	1			
Energy-saving behavior	67.4	11.7	.07*	.33**	.43**	.36**	.38**	.53**	.61**	.64**	1		
Civic scientific literacy	52.3	17.3	.51**	.47**	.36**	.39**	.35**	.15**	.09**	.21**	.13**	1	
Critical thinking ability	64.2	10.9	.24**	.45**	.48**	.41**	.45**	.43**	.31**	.52**	.43**	.42**	1
New ecological paradigm	76.5	11.8	.47**	.72**	.58**	.61**	.55**	.15**	.15**	.28**	.18**	.51**	.39**

* $p < .05$, ** $< .01$

5.3.3 Measurement of energy literacy structural model

Estimates of two theoretical models and the hypothesis model measured by the data are shown with each description in Fig. C.1, C.2, and C.3 in Appendix C.

The energy literacy structural model that is integrated with the TPB and VBN, which is presented in Fig. 5.12, obtained acceptable model fitness index values (Table 5.6). While based on the modification indices, the paths with estimated values of less than 0.1 were not employed to avoid changing the model solely to pursue better model fitness indices. The BEK does not predict AR and PN directly and exerts little covariance between SN and PBC (($\beta = 0.04$, $p = .164$).

According to the energy literacy structural model, the INT and PBC explained 50% of the variance in ESB ($\beta = 0.42$, 0.37, $p < .001$, $R^2 = 0.50$). The INT was determined relatively equally by the TPB predictors, namely ATB, SN, and PBC ($\beta = 0.33$, 0.34, 0.31, $p < .001$), before adding the prediction of PN, and these factors explained 58% of the variance in INT. Several studies have examined and proposed introducing the PN as an independent predictor of INT [17, 18, 26, 27]. Harland et al. [16] found that the inclusion of moral (personal) norms increased the proportion of the explained variance of INT by one to ten percentage points. Therefore, this study has adopted the direct prediction of PN to the INT. As a result, the ATB, SN, PBC, and PN were able to explain 60% of the variance in INT.

The SN, AR, PN, and AC were able to explain 61% of the variance in ATB. The AC more strongly predicted the ATB than other predictors ($\beta = 0.38$, $p < .001$). The BEK predicted the AC significantly ($\beta = 0.41$, $p < .001$) and accounted for 26% of the variance in AC, along with the prediction of SN. The AR and PN, which are activated by the AC, predict the ATB, and the prediction of AC to both AR and PN had large estimates in this model ($\beta = 0.66$ and 0.49, $p < .001$). Consequently, it is suggested that the AC is a key determinant in the energy literacy structural model, which interprets between BEK and ESB through the ATB and links the AR, PN and ATB.

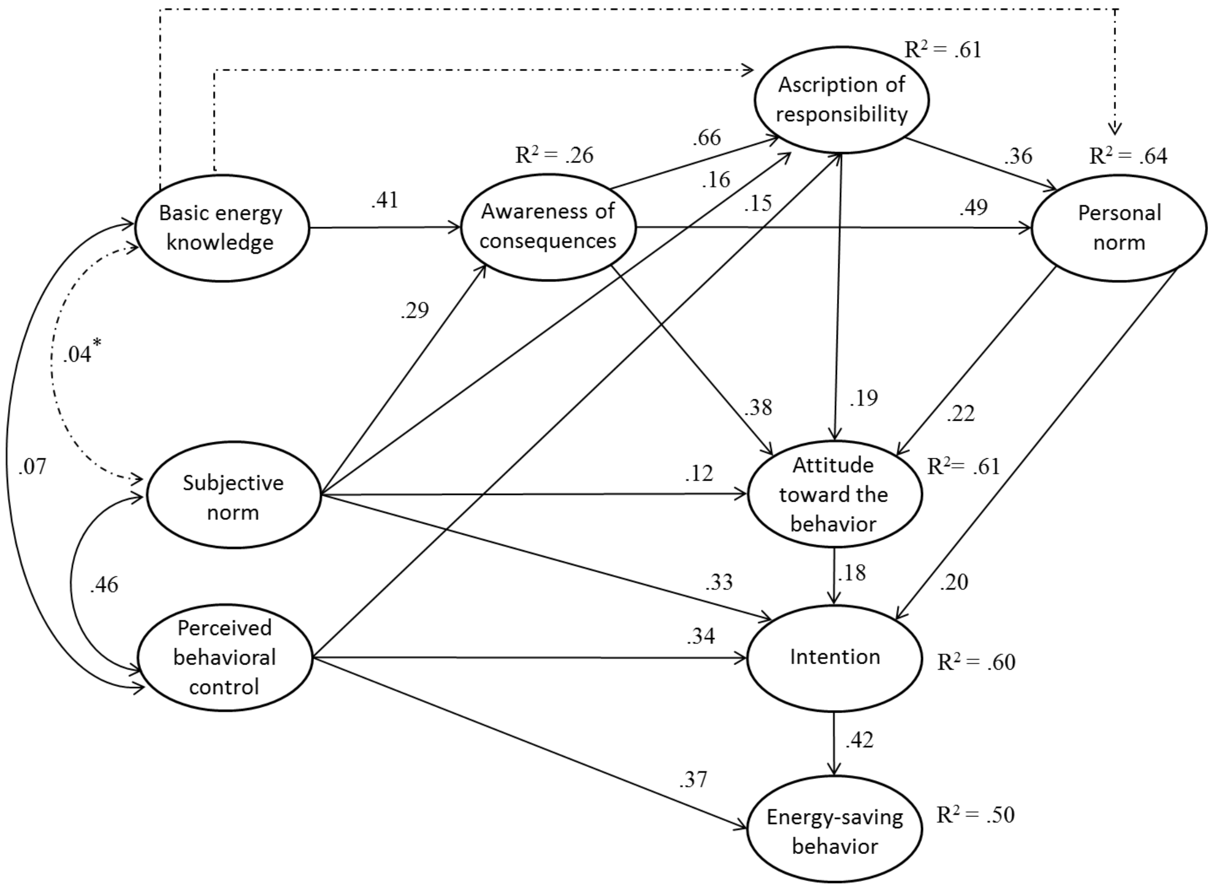

Fig. 5.12. Energy Literacy Structural Model Integrated with the Theory of Planned Behavior and Value-Belief-Norm Theory with Standardized Coefficients. Non-Significant Estimates are Indicated by the * Symbol and Dashed Lines.

Table 5.6. Model Fitness Indices between Hypothesis and Energy Literacy Structual Models.

	χ^2	*df*	GFI	AGFI	SRMR	NFI	CFI	RMSEA	AIC
Energy literacy structural model	116.67	16	0.978	0.937	0.053	0.979	0.982	0.077	174.67
Hypothesis model	751.92	22	0.881	0.756	0.196	0.866	0.869	0.176	797.92

5.3.4 Conditional process analysis

Nine moderators were evaluated in the relation between BEK and AC in the model (See 2.2). As a result, the direct effect of BEK on the AC was moderated by CSL, CTA, and NEP (CSL: $b_{3_{CSL}}$ = -.004, 95% CI = -.006 to -.003, $p < .001$; CTA: $b_{3_{CTA}}$ = -.009, 95% CI = -.012 to -.006, $p < .001$; NEP: $b_{3_{NEP}}$ = -.005, 95% CI = -.007 to -.003, $p < .001$) (Table 5.7). The conditional effect of BEK on the AC decreased as the moderators' scores increased, except for the relatively high level group of NEP, which was not significant. These results indicate that relatively low level group for the BEK is more strongly affected by the moderators: CSL, CTA, and NEP, relative to the high level group (CSL: $b_{high} = 0.07$, $t(1066) = 2.98$, $p < .003$; $b_{average} = 0.14$, $t(1066) = 8.00$, $p < .001$; $b_{low} = 0.22$, $t(1066) = 9.17$, $p < .001$, CTA: $b_{high} = 0.10$, $t(1066) = 14.0$, $p < .001$; $b_{average} = 0.20$, $t(1066) = 13.0$, $p < .000$; $b_{low} = 0.30$, $t(1066) = 14.0$, $p < .001$, NEP: $b_{high} = -0.00$, $t(1066) = -0.05$, $p = .96$; $b_{average} = 0.06$, $t(1066) = 4.15$, $p < .001$; $b_{low} = 0.12$, $t(1066) = 6.36$, $p < .001$).

Table 5.7. Unstandardized OLS Regression Coefficients with Confidence Intervals for Estimating Awareness of Consequences (AC) under Moderation by Civic Scientific Literacy (CSL), Critical Thinking Ability (CTA), and New Ecological Paradigm (NEP). Variables are Mean Centered.

			AC (Y)					AC (Y)					AC (Y)			
			Coeff.	*SE*	95% *CI*	*p*		Coeff.	*SE*	95% *CI*	*p*		Coeff.	*SE*	95% *CI*	*p*
BEK (X)	b_1	→	.142	.018	.107, .177	†	→	.198	.015	.168, .227	†	→	.058	.014	.031, .085	†
CSL (M_1)	b_2	→	.268	.023	.223, .313	†										
CTA (M_2)	b_2						→	.455	.031	.394, .516	†					
NEP (M_3)	b_2											→	.753	.026	.702, .805	†
$X \times M_1$	b_3	→	-.004	.001	-.006, -.003	†										
$X \times M_2$	b_3						→	-.009	.001	-.012, -.006	†					
$X \times M_3$	b_3											→	-.005	.001	-.007, -.003	†
Constant	i_M	→	81.46	.375	80.72, 82.20	†	→	81.12	.336	80.46, 81.78	†	→	81.22	0.3	80.63, 81.81	†
			$R^2 = 0.302$ F (3, 1066) = 153.367, $p < .000$					$R^2 = 0.338$ F (3, 1066) = 181.438, $p < .000$					$R^2 = 0.739$ F (3, 1066) = 428.239, $p < .000$			

† $p < .001$

The conditional effects of AC on the ATB through the AR at values of the moderators in the mediation model were also examined. It was found that the interactions between gender, family discussion about energy issues, CSL, CTA, and NEP. Tables 5.8–5.12 present the estimated regression coefficients for the moderators.

Students with relatively higher AC expressed higher AR ($a_1 = 0.752$, 95% $CI = 0.711$ to 0.792, $p < .001$) (Table 5.8). Holding the AC constant, the effect of AR on the ATB depends on gender ($b_2 = 0.111$, 95% $CI = 0.004$ to 0.217, $p < .05$). Furthermore, the interaction between gender and AC affects the ATB significantly (c_3 = -0.127, 95% CI = -0.236 to -0.018, $p < .05$) and the effect of female gender is stronger than that of male gender (Male: $b_{male} = 0.35$, $t(1064) = 7.69$, $p < .001$; Female: $b_{female} = 0.47$, $t(1064) =$ 14.55, $p < .001$). This result seems that, through moderated mediation, the indirect effect of AC on the ATB through AR depends on gender, however, the index of moderated mediation by employing a 95% bootstrap confidence interval on 10,000 resamples includes zero (-0.008 to 0.211). Thus, it cannot be concluded that the indirect effect of AC on the ATB through the AR depends on gender [28].

Following the same procedure for conditional process analysis, it was found that the direct effect of AC on ATB depends on several moderators: family discussion of energy issues, CSL, CTA, and NEP (Discussion: $c_3 = 0.046$, 95% $CI = 0.004$ to 0.088, $p < .05$; CSL: $c_3 = 0.003$, 95% $CI = 0.000$ to 0.006, $p < .05$; CTA: $c_3 = 0.005$, 95% $CI = 0.001$ to 0.010, $p < .05$; NEP: $c_3 = 0.005$, 95% $CI = 0.000$ to 0.010, $p < .05$) (Tables 5.9–5.12). Furthermore, holding the AC constant, the negative effect of AR on the ATB depends on family discussion of energy issues and the NEP (Discussion: b_2 = -0.074, 95% CI = -0.115 to -0.034, $p < .001$; NEP: b_2 = -0.006, 95% CI = -0.011 to -0.002, $p < .01$) (Tables 5.9 and 5.12). Namely, students with fewer family discussion about energy issues and NEP indicated relatively large indirect effect of AC on the ATB through the AR (Discussion: $b_{high} = 0.14$, 95% $CI = 0.078$ to 0.120; $b_{average} = 0.20$, 95% $CI = 0.161$ to 0.255; $b_{low} = 0.27$, 95% $CI = 0.208$ to 0.344, NEP: $b_{high} = 0.15$, 95% $CI = 0.087$ to 0.216; $b_{average} = 0.20$, 95% $CI = 0.155$ to 0.250; $b_{low} = 0.25$, 95% $CI = 0.180$ to 0.318).

In summary, the conditional direct effect of BEK on the AC depends on the CSL, CTA, and NEP. The mediation model (AC $\rightarrow$ AR $\rightarrow$ ATB) indicates the effect of moderated mediation by family discussion of energy issues and NEP, and the effect of mediated moderation between AC and ATB by gender, family discussion, CSL, CTA, and NEP.

Although significant differences were observed in the mean comparison, there was no interaction of school year grade, energy education experience, energy-related facility tour experience, and home discipline in energy-saving.

Table 5.8. Unstandardized OLS Regression Coefficients with Confidence Intervals for Estimating Ascription of Responsibility (AR) and Attitude toward the Behavior (ATB) with the Moderation by Gender. Variables are Mean Centered.

			AR (M)						ATB (Y)			
			Coeff.	*SE*	95% *CI*	p			Coeff.	*SE*	95% *CI*	p
AC (X)	a_1	$\rightarrow$	.752	.021	.711, .792	†	c'_1	$\rightarrow$	.433	.027	.381, .485	†
AR (M)							b_1	$\rightarrow$	.284	.026	.233, .336	†
Gender (W)	a_2	$\rightarrow$	-.571	.578	-1.705, .563	.323	c'_2	$\rightarrow$	.707	.495	-.264, 1.68	.153
$X \times W$	a_3	$\rightarrow$	.043	.044	-.043, .128	.327	c'_3	$\rightarrow$	-.127	.056	-.236, -.018	*
$M \times W$							b_2	$\rightarrow$	.111	.054	.004, .217	*
Constant	i_M	$\rightarrow$	.023	.270	-.507, .553	.932	i_Y	$\rightarrow$	81.62	.231	81.16, 82.07	†
			$R^2 = 0.560$						$R^2 = 0.583$			
			F (3, 1066) = 451.648, $p < .000$						F (5, 1064) = 296.976, $p < .000$			

* $p < .05$, † $< .001$

Table 5.9. Unstandardized OLS Regression Coefficients with Confidence Intervals for Estimating Ascription of Responsibility (AR) and Attitude toward the Behavior (ATB) with the Moderation by Family Discussion of Energy and Environmental Issues. Variables are Mean Centered.

			AR (M)						ATB (Y)			
			Coeff.	*SE*	95% *CI*	p			Coeff.	*SE*	95% *CI*	p
AC (X)	a_1	$\rightarrow$	.743	.021	.702, .784	†	c'_1	$\rightarrow$	.426	.026	.375, .479	†
AR (M)							b_1	$\rightarrow$	.277	.026	.226, .336	†
Discussion (W)	a_2	$\rightarrow$	.554	.221	.120, .987	.323	c'_2	$\rightarrow$	.506	.189	.135, .876	**
$X \times W$	a_3	$\rightarrow$	.007	.016	-.025, .039	.669	c'_3	$\rightarrow$	.046	.021	.004, .088	*
$M \times W$							b_2	$\rightarrow$	-.074	.021	-.115, -.034	*
Constant	i_M	$\rightarrow$	-.025	.275	-.564, .515	.929	i_Y	$\rightarrow$	81.73	.235	81.26, 82.18	†
			$R^2 = 0.562$						$R^2 = 0.587$			
			F (3, 1066) = 451.103, $p < .000$						F (5, 1064) = 303.074, $p < .000$			

* $p < .05$, ** $< .01$, † $< .001$

Table 5.10. Unstandardized OLS Regression Coefficients with Confidence Intervals for Estimating Ascription of Responsibility (AR) and Attitude toward the Behavior (ATB) with the Moderation by Civic Scientific Literacy. Variables are Mean Centered.

			AR (M)						ATB (Y)			
			Coeff.	*SE*	95% *CI*	p			Coeff.	*SE*	95% *CI*	p
AC (X)	a_1	$\rightarrow$	.756	.024	.709, .803	†	c'_1	$\rightarrow$	.433	.029	.377, .489	†
AR (M)							b_1	$\rightarrow$	.286	.026	.234, .337	†
CSL (W)	a_2	$\rightarrow$	.008	.018	-.028, -.043	.678	c'_2	$\rightarrow$	.006	.018	-.024, .037	.690
$X \times W$	a_3	$\rightarrow$	.001	.001	-.001, -.004	.185	c'_3	$\rightarrow$	.003	.001	.000, .006	*
$M \times W$							b_2	$\rightarrow$	-.003	.001	-.006, .000	.094
Constant	i_M	$\rightarrow$	-.163	.296	-.743, .418	.583	i_Y	$\rightarrow$	81.50	.254	81.01, 82.00	†
			$R^2 = 0.560$						$R^2 = 0.581$			
			F (3, 1066) = 451.466, $p < .000$						F (5, 1064) = 295.239, $p < .000$			

* $p < .05$, † $< .001$

Table 5.11. Unstandardized OLS Regression Coefficients with Confidence Intervals for Estimating Ascription of Responsibility (AR) and Attitude toward the Behavior (ATB) with the Moderation by Critical Thinking Ability. Variables are Mean Centered.

			AR (M)						ATB (Y)			
			Coeff.	*SE*	95% *CI*	p			Coeff.	*SE*	95% *CI*	p
AC (X)	a_1	→	.660	.023	.615, .706	†	c'_1	→	.427	.027	.374, .480	†
AR (M)							b_1	→	.259	.027	.206, .312	†
CTA (W)	a_2	→	.232	.027	.179, .286	†	c'_2	→	.087	.025	.039, .136	†
$X \times W$	a_3	→	-.002	.002	-.005, .001	.220	c'_3	→	.005	.002	.001, .010	*
$M \times W$							b_2	→	-.315	.210	-.726, .097	.134
Constant	i_M	→	.132	.282	-.421, .686	.639	i_Y	→	81.50	.254	81.01, 81.99	†
			$R^2 = 0.587$						$R^2 = 0.588$			
			F (3, 1066) = 505.288, $p < .000$						F (5, 1064) = 303.432, $p < .000$			

* $p < .05$, † $< .001$

Table 5.12. Unstandardized OLS Regression Coefficients with Confidence Intervals for Estimating Ascription of Responsibility (AR) and Attitude toward the Behavior (ATB) with the Moderation by New Ecological Paradigm. Variables are Mean Centered.

			AR (M)						ATB (Y)			
			Coeff.	*SE*	95% *CI*	p			Coeff.	*SE*	95% *CI*	p
AC (X)	a_1	→	.704	.031	.644, .765	†	c'_1	→	.419	.032	.356, .483	†
AR (M)							b_1	→	.283	.026	.232, .335	†
NEP (W)	a_2	→	.079	.033	.013, .144	*	c'_2	→	.024	.029	-.033, .080	.409
$X \times W$	a_3	→	.000	.002	-.003, .004	.826	c'_3	→	.005	.002	.000, .010	*
$M \times W$							b_2	→	-.006	.002	-.011, -.002	**
Constant	i_M	→	-.041	.327	-.683, .601	.900	i_Y	→	81.61	.281	81.06, 82.16	†
			$R^2 = 0.561$						$R^2 = 0.583$			
			F (3, 1066) = 454.400, $p < .000$						F (5, 1064) = 297.147, $p < .000$			

* $p < .05$, ** $< .01$, † $< .001$

5.4 Discussion

This study investigated the proposed energy literacy structural model, which was integrated with the TPB and the VBN, to evaluate the causal relationship between BEK and ESB for lower secondary students in Japan and found that the AC plays an inevitable role in linking these distal predictors. Furthermore, it was determined that interactions of gender, CSL, CTA, NEP, and family discussion of energy-related issues affect the causality between BEK, AC, AR, and ATB. In this section, the status of basic energy knowledge of Japanese students and their energy literacy structure are discussed.

5.4.1 Basic energy knowledge

The BEK of Japanese students is insufficient (53%). In particular, on the scientific items related to energy form, efficiency, and conversion, these students scored lower than the US middle school students whom this study compared in Chapter 3.5.2 (BEK10: JP 31%, US 44%; BEK11: JP 39%, US 41%; BEK13: JP 41%, US 50%, $p < .001$) [29]. In parallel, the CSL, on which the score was similar to that on BEK, can be discussed as a cognitive component (CSL 52%). The result that female students scored significantly higher on the BEK than male students did was supported by the previous chapters (Chapter 3.5.1 and 4.4.1). The females' better achievement is likely due to the fact that the same private girls' junior high school (N = 310) participated again in the survey, which has excellent academic performance in the Kansai area (Western Japan). However, it has been determined that this school does little to affect the gender difference in the BEK (after excluding the results from the girls' private school, female 51%, Male 46%, $p < .005$, Table 5.13) nor the energy literacy model (the model fitness indices without the results from the girls' private school are: N = 310: GFI = .977, AGFI = .934, SRMR = .043, RMSEA = .076, NFI = .979, and CFI = .983). Moreover, there was no longer gender difference in the AC, AR, and PN, and the females' scores decreased significantly on the CSL, CTA, and NEP.

In the current sample, the females scored, however, higher than the males on the basic energy knowledge, it seems that knowledge may not contribute coherently to their beliefs and normative factors (AC, AR, and PN). The potentiality of the effect of academic achievement level on the relation between BEK and belief and normative factors should be further clarified. In addition, the amount of BEK little affect the TPB components (ATB, PBC, INT, and ESB). Further investigation on the relationship between academic achievement level and gender characteristics for energy relevant knowledge, belief and normative factors is required.

Table 5.13. Gender Comparison with Female Groups Before/After Excluding a Private Girls' School.

	N	*M* %	*SD* %	*SE* %	*p*	*M* %	*SD* %	*SE* %	*p*
			BEK				AC		
Male	348	46.3	23.3	1.25		79.0	13.3	0.71	
Female	722	56.2	20.8	0.78	†	81.4	13.0	0.48	***
Female after deleting	412	51.2	20.8	1.03	***	79.4	13.2	0.65	
			AR				PN		
Male	348	74.8	14.0	0.75		77.0	15.1	0.81	
Female	722	77.2	12.8	0.48	**	79.2	13.6	0.51	*
Female after deleting	412	76.6	12.8	0.63		77.5	13.8	0.68	
			ATB				SN		
Male	348	80.9	12.0	0.64		62.8	12.5	0.67	
Female	722	82.0	11.5	0.43		60.9	12.1	0.45	*
Female after deleting	412	80.7	11.8	0.58		61.9	12.2	0.60	
			PBC				INT		
Male	348	61.9	18.4	0.99		68.4	15.6	0.84	
Female	722	60.6	18.2	0.68		68.4	15.5	0.58	
Female after deleting	412	61.9	18.6	0.92		69.2	15.2	0.75	
			ESB				CSL		
Male	348	68.4	11.2	0.6		52.7	18.8	1.01	
Female	722	66.9	11.9	0.44		52.2	16.5	0.61	
Female after deleting	412	67.1	11.7	0.58		47.7	16.0	0.79	†
			CTA				NEP		
Male	348	65.4	11.0	0.59		76.0	11.8	0.64	
Female	722	63.7	10.8	0.40	*	76.8	11.7	0.44	
Female after deleting	412	63.1	10.5	0.52	***	74.0	11.4	0.56	**

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

According to the other group comparison, there was no significant difference between the 7th, 8th, and 9th grades in terms of BEK. Students who are aware of the energy education experience, practice home discipline in energy-saving, and are involved in family discussions of energy issues obtained higher scores than their counterparts (Education: Yes 54%, No 47%, $p < .001$; Discipline: Yes 54%, No 51%, $p < .05$; Discussion: Yes 57%, No 49%, $p < .001$). The family influence on students' energy literacy can be supported by Chapter 3.3.3. To summarize the above, the degree of BEK of Japanese students is relatively low and changes little with the school year progression, and the amount of knowledge seems to affect their beliefs and normative factors.

Although Japanese students ranked 2nd among 72 countries and economies in the OECD Programme for International Student Assessment: PISA 2015 (OECD 2016), the BEK has not dramatically improved to the ideal level of energy literacy (70% correct or more [23]) since this survey began in 2014 (for the same items on the 2014 survey: *M* 44%, *SD* 19.2%; BEK in the current survey: *M* 53%, *SD* 22.1%, $p < .001$). As Chen et al. discussed regarding the situation in Taiwan [30], inter-disciplinary holistic energy learning has been given little emphasis in the teaching curriculum, as the units and subjects that are relevant to the EE topics are dispersed throughout the formal education curriculum in Japan. Although it is recognized that energy education is a part of the environmental education that is recommended in the government curriculum guidelines in Japan [31, 32], neither actual comprehensive teaching materials that focus on energy-related issues nor a measure for evaluating its achievement have been presented. The current situation of energy education in Japan tends to depend on the degree of contribution by teachers who emphasize the need for energy education [33].

5.4.2 Energy literacy structure

On the premise that further study is required for the investigation of implications of the paths beyond the two theoretical models (e.g., SN to AC, AR, PBC to AR), this study has explored the energy literacy structural model integrated with the TPB and VBN. Consistent with the previous model (Fig. 4.1), the AC plays an important role in the energy literacy integrated model and was found to more strongly predict the ATB than other determinants ($\beta = 0.38$, $p < .001$).

A conditional process analysis elucidated that there were interactions between the BEK and CSL, CTA, and NEP in predicting the AC. This indicates that the prediction of AC requires not only EE knowledge but also scientific literacy, critical thinking ability, and an ecological worldview or values to evaluate the relevant EE information. Furthermore, the direct effect of AC on the ATB and indirect effect of AC on the ATB through the AR depend on the NEP and family discussion of energy issues. It can be understand that the conditional effect of AC on ATB depends on the NEP because the correlations between AC and ATB, AC and NEP are relatively strong (ATB $r = 0.73$, NEP $r = 0.72$), and AC is assessed by NEP in the VBN. Family intervention enhances students' awareness of adverse consequences of ongoing energy-related issues, which is of significant importance.

The Schwartz's Norm-Activation Theory holds that AC determines the activation of PNs, which drive pro-environmental behavior [34, 35], and has been supported by substantial evidence for decades (e.g., [36–38]). The score on AC of Japanese students was 81%, which is fairly high among the overall determinants. They are concerned that the progression of global warming due to energy overconsumption will cause environmental destruction and threats to living things (AC05: 87%, AC08: 82%). In addition, they believe that resource depletion will be a serious problem for the country (AC09: 84%). Therefore, they consider people in Japan should save more energy (AC04: 82%). Most of their concern is based on the environmental issues that are derived from the mass consumption of energy and fossil resources, so it is natural that strong intercorrelation is observed between AC and NEP (Table 5.5, $r = 0.72$, $p < .01$). These results can be considered the outcome of environmental education in Japan. Gender difference in the AC (Male 79%, Female 81%, $p < .005$) are supported by previous studies: females tend to be more concerned with EE issues than males (e.g., [30, 39–44]). On the other hand, Black et al. argued that people with greater knowledge (better-educated people) show more concern about energy [36]. Moreover, Lyons & Breakwell found that the amount of knowledge about specific environmental issues is a powerful discriminator between the environmentally concerned group and its counterpart [45]. These claims support the results that the high score of females on the BEK affects the degree of AC. In addition, the females' conditional direct effect of AC on the ATB is stronger than that of the males (Male: $b_{male} = 0.35$, $t(1064) = 7.69$, $p < .001$; Female: $b_{female} = 0.47$, $t(1064) = 14.55$, $p < .001$). AS such, if the high score of BEK may affect the degree of AC, pertinent and factual knowledge about EE issues becomes a powerful predictor for understanding the degree of seriousness of the problems and perceiving the adverse consequences of the current situation for future generations and society.

Although school year progression did not show a significant affect in the energy literacy structural model, it is necessary to discuss the decline in the AC score (AC: 9th grade 79%, 8th grade 81%, $p < .05$; 7th grade 82%, $p < .001$ compared to the 9th grade). However, it is difficult to identify the reason for the score reduction with the school year progression. It may be that lower-grade students responded to the adverse consequences of current energy consumption more simply, intuitively, and honestly, with a feeling of justice. The 7th graders scored significantly higher on two thirds of the AC items than did the 9th graders (AC03, AC04, AC05, AC07, AC09, and AC10). DeWaters & Powers reported that the middle students in the U. S. scored higher than those in high school in response to how effectively they feel they can contribute to solving energy-related problems [42]. The question item of "I believe that I can contribute to solving the energy problems by making appropriate energy-related choices and actions" indicated a significant difference between the middle and high school students (MS: 67%, HS: 66%, $p < .01$). It is conceivable that the motivation of younger students causes higher performance on the affective domain. Although, the school years comparison is needed further research with more random and less bias sampling broadly, for the energy education curriculum development, it is important to elucidate how students' energy literacy depends on school years.

Despite Japan consumes a large amount of energy at low energy self-sufficient rate, many Japanese teachers mention that they do not want to foment or stir up students' sense of crisis toward energy issues [46]. Actually, it is difficult to provide energy education in which learning nuclear energy as same as other energy sources, due to the current controversy over nuclear energy after the severe nuclear accident occurred in 2011. However, the awareness of consequences differs from that other people inflame an individual's sense of crisis. The AC should be promoted and improved by oneself with the actual information, which students obtained from energy education that improve their perception and understanding of the current energy issues. And then, their ability will contribute shaping the future society that is knowledgeable about energy and the environment.

According to a longitudinal study of the age-stability of political attitudes, youth is the period in life when attitudes are most flexible, and attitudes become hardened with age [47]. It is assumed that adolescents' social and political attitudes are already considerably developed by the time they finish secondary school and maintained throughout their lives [48, 49]. The same idea may apply to the energy policy: developing positive attitudes toward EE issues in childhood are important in forming their attitudes and behaviors regarding appropriate energy choices in later life [50–52]. Thus, it is necessary to implement energy education as early as possible to provide basic EE knowledge, encourage students' awareness and attitudes toward engaging in problem-solving, and cultivate preferable energy conservation habits [33].

The energy literacy structural model was able to interpret EE relevant knowledge, belief, norms, attitudes, and behavior in the energy literacy of Japanese lower secondary students. The students may be aware of the adverse consequences of ongoing energy-related issues by attaining basic energy knowledge, along with the CSL, CTA, and NEP. Furthermore, their responsibility for global problem-solving may be enhanced by the interaction of NEP and family discussion of energy-related issues. These implications activate their attitudes toward energy-saving behavior. By incorporating collaboration with students' families into the energy learning program, the implementation of energy education at an earlier educational stage is recommended.

In a tight school curriculum, the time allocated for energy education is limited, so energy education should be provided in the most effective way possible [44]. The energy literacy structural model provides a theoretical contribution to the development of an effective energy education program that considers the structure of students' energy literacy.

5.5 Conclusion

This chapter has explored an energy literacy structural model, which was integrated with the Theory of Planned Behavior and Value-Belief-Norm Theory through the survey of lower secondary students in Japan, and the interactions of moderators in the model were also analyzed.

The following findings were obtained: energy-saving behavior was predicted by the intention to perform energy-saving behavior and the perceived behavioral control, and the intention was determined by the attitude toward the behavior, the subjective norms, the perceived behavioral control, and the personal norms. The awareness of consequences plays a critical role in the link between basic energy knowledge and attitude toward the behavior. The interactions between basic energy knowledge and civic scientific literacy, critical thinking ability, and environmental value or worldview are important in predicting the awareness of consequences. Furthermore, the conditional direct and indirect effects of awareness of consequences on the attitude toward the behavior depend on environmental values or worldview and family discussion of energy and environmental issues.

The energy literacy structural model proposed would contribute theoretically to the development of an effective energy education program by adapting the concept of energy literacy to link basic energy knowledge and energy-saving behavior.

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Chapter 6

Energy literacy assessment

6.1 Introduction

In the previous chapter, the energy literacy structural model has been constructed by integrated with social psychology models, and succeeded in applying it to lower secondary students in Japan. Subsequently, to assess the applicability of energy literacy model, and to provide empirical data of a cross-cultural perspective on energy literacy that have implications for understanding of students' energy literacy in Japan, the international assessment was planned. The key points of country selection are: the low energy self-sufficiency country, the island country, and the Asian countries where have been developing rapidly and consuming a large amount of energy. This study suggested France, Taiwan, Malaysia, Indonesia, and Thailand as candidate countries and prepared the questionnaires in each language. As a result, since the sample size in Thailand was acceptable to compare, the assessment focused on Thailand and compared with the result of Japan.

Thailand has been playing an important role in the promotion of regional economic integration, economic growth, and harmonious cooperation in energy and other sectors through APEC [1]. Recent years, they have recognized that sound society requires well-informed public participations in the solution of energy-related issues.

As it has been introduced in literature reveiws section in Chapter 1.3, the Yuenyong & Jones comparative study between Thai and New Zealand students [2] indicates that students' idea about energy-related issues varies at their attributes which are influenced by the socio-cultural perspective. People's beliefs and values depend on social norms. The evaluative predispositions are formed by social backgrounds and experiences produced by diversity of religious, artistic, political, economy, and other attitudes within and between cultures [3]. Education reflects values, norms, beliefs, culture, and science and technology, that are shaped by the time and social background, and learning involves knowledge construction and taking a stand on the culture of one's community [2]. Through the energy literacy structural model, it has been proposed that students' attitudes are produced by their beliefs and values which underlie informative knowledge, and that attitudes activate their intention to energy-saving behavior. Since studying differences in attributes will characterize energy literacy of Japanese students and give some implications for the development of energy education, it is worthwhile comparing Thai and Japanese students in energy literacy.

Thai identity stems from national religion. With more than 93% of the nation being Theraveda Buddhism, the belief system and values of Buddhism play a major role in daily life. The most important values that Thai people hold throughout the country are: respect, self-control, and non-contrary attitudes. Thai children is expected humility and to respect senior people [2, 4–6]. While in Japan, Shinto and Buddhism are major religions, however, religion is not emphasized in everyday life like in Thai. Religion is free, separated from the country, and rarely discussed in daily life. The majority of Japanese do not claim to be religious or worship regularly. Instead, it can be hardly distinguishable from Japanese social and cultural values, a code of moral, and way of living. The average Japanese people follow the religious rituals occasion as birth, weddings, funerals, New Year, and Matsuri (local festival), the Western ceremonial style is also embraced [7–9]. Considering another perspective of normative factor, Japan is perceived one of the representatives of a collectivistic culture in the world and those respect their group memberships, decisions, and expectations [10–13]. Subjective norms which are formed by social pressures and expectations may affect both students' energy literacy.

The goal of Thai science education is set to develop those who can make decisions about issues entwined with science, technology, and society with a multidimensional scientific and technological literacy [14]. Thus, as Yuenyong has suggested, learning energy issues is a good opportunity for Thai science education to explore their challenges to improve the school science program more practical to foster students' skills of understanding, analysis, decision-making, and values to deal with science, technology and social issues [4]. Education in Japan has achieved major success the rich economic society and securing lifestyles by the efforts of every individual through the ideal of equal education opportunity, raises the academic standards of nation, and contributing development of society [15]. On the other hand, the country has been facing with serious issues in a rapid change and globalization as hollowing out the industry, declining of the working-age population, and ageing society [16]. It is also concerned that declining children's motivation to learn, declining norm consciousness in society as a whole, and value changes in family and local community [16]. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) requires both academic and moral education in the Course of Study [16]. The moral education focuses on values in justice and responsibility, mutual respect and cooperation, gender equality, a civic spirit for nurturing the country and community to enable children to foster a zest for living. Learning EE issues is perceived as a part of character formation [17]. Its objective is grounded on the essence where learning social problems encourages a zest for living that enables individuals to identify social challenges and to engage problem-solving by sound skills, values, actions, and ability to decision-making [17]. It may be considered that Thailand and Japan resemble in the context of social norms and the perception of EE education.

Thailand is located in South-East Asia bounded by Myanmar, Lao People's Democratic Republic, and Cambodia, and has a land area of about 513 square kilometers (km^2), and had a population of approximately 69 million at the end of 2017 [18]. Thailand is the second largest economy in the Association of South East Asian Nations (ASEAN) and its gross domestic product (GDP) is projected to a 152% grow from 2013 to 2040, while population is expected to increase 8% [19]. Thailand depends on energy imports accounting for 46% of the total primary energy imports. Oil is the main imports energy, which depends on the Middle East. Thailand has limited resources so that 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 [1, 19]. The Thai Ministry of Energy recognizes the need of energy security and conservation for sustainable energy management, economic growth, and mitigating greenhouse gases emissions [20]. However, in 2016, the anti-coal groups protested against the current energy policy of the transition to clean coal technology for power generation and diversification of resources due to the reason of that most coal produces air pollution and emits greenhouse gases [19]. Reflecting this experience, Thai's energy policy also seeks to build a knowledge-based society to promote harmonized cooperation in energy and other sectors [1]. Both the Ministry of Energy and Ministry of Education emphasize the need of public awareness and participation in energy-related issues [21].

6.1.1 Overview of energy education in Thailand

The Ministry of Energy and Ministry of Education have launched the project of promotion of teaching about energy in basic education in Thailand in 2009 [21]. Because energy literacy is indispensable for people in Thailand and lack of knowledge and understanding relevant to energy is more likely to affect various field in society. With the cooperation of the National Energy Education Development Project (NEED) in the U. S. [22], teachers' trainings and teaching materials developments have been implemented. The energy textbooks and handbooks for both students and teachers titled "*Fuel for Transportation*" and "*Alternative Energy and their uses*" were developed in 2012 and 2013, respectively. These educational materials have been widely introduced throughout the country and over 2000 teachers have participated in the workshops which provide the effective manner of using teaching materials. Some of teachers participated in a tour to the hydroelectric power plant for capacity building. It was reported that 94% of teachers who participated were satisfied with this project. In 2014, the Energy STEM (Science, Technology, Engineering and Mathematics) Project has been launched and they have developed four STEM Energy Activity Handbooks to be introduced in the science curriculum targeting from the 7th to 9th grade [23]. Currently, this project are exploring an evaluation manner of students' energy literacy to assess the outcome of the project [21].

The purpose of this Chapter is to assess the applicability of energy literacy structural model. Furthermore, it is to provide empirical data of a cross-cultural perspective on energy literacy that have implications for the development of energy education in Japan. The interaction effects of Thai and Japan are further analyzed in conjunction with the energy literacy structural modeling.

6.2 Materials and Method

6.2.1 Questionnaire preparation

The survey in Thailand employed the same questionnaire as Chapter 5 (Table 2.4). It was translated into Thai language and modified to meet domestic energy-related circumstances by working with Thai researchers in Kyoto University and Chiang Mai University. With advices of Thai researchers, it was considered to mitigate the burden of working on the survey on Thai students. As a result, the items of civic scientific literacy (CSL), critical thinking ability (CTA), and new ecological paradigm (NEP) were omitted. A set of nine components with eighty-three items was carried out for the survey, where: basic energy knowledge (BEK), awareness of consequences (AC), ascription of responsibility (AR), personal norm (PN), attitude toward the behavior (ATB), subjective norm (SN), perceived behavioral control (PBC), intention to act (INT), and energy-saving behavior (ESB). The item ESB03 in the ESB regarding room temperature control in summer and winter has been deleted beforehand because it is not suit for the custom in Thai tropical climate. The self-rating question items of the experience of energy education and energy facility-tour, the presence of home discipline in energy-saving were conducted in conjunction with demographics. The questionnaire which was used in school is presented in Fig. E.3 in Appendix E.3.

6.2.2 Sampling

A total seven schools which were selected by researchers of Chiang Main University participated in the survey. They are located in Chiang Mai, Udon Thani (two schools), Udon Ratchathani, Bangkok, Pathum Thani, and Trang (Fig. 6.1). The printed questionnaires were distributed and the surveys were conducted in the classroom by each school teacher in March, 2017. The completed questionnaires were sent back in PDF, and the responses were input by the author. The valid responses of 635 with no missing values that is 58% valid response rate from 1066 samples, that were collected from students in the 7th, 8th, and 9th grades (ages 13-15), were analyzed. Table 6.1 presents of the sample distribution of both countries (Japan's sample information is reshown, see Table 5.1). The samples of serial number Thai_2 ($N = 20$) was removed because these ages are high school students. The sample size can characterize the entire population of lower secondary students in Thailand that is 2,579,804 UIS 2015 (UNESCO Institute for Statistics) [24] at the margin of error which is plus or minus four percentage points at the 95% confidence level. While taking into account of uneven samples between gender and school years, this study have compared subgroups.

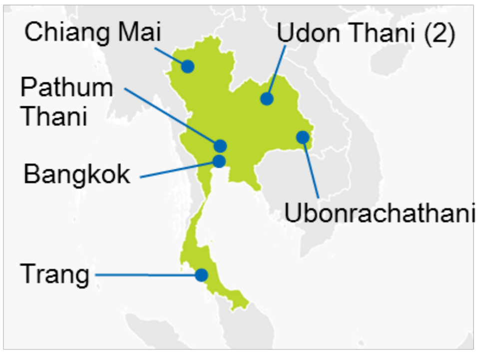

Fig. 6.1. Locations of Survey Participants in Thailand in 2017.

Table 6.1. Sample Distribution of Thailand and Japan.

Country	N	Male	Female	7th	8th	9th	Collection	Rate of valid %
Thai_1	191	64	127	1	12	178	291	65.6
Thai_3	74	20	54	0	0	74	99	74.7
Thai_4	70	14	56	39	30	1	152	46.0
Thai_5	45	25	20	0	45	0	81	55.6
Thai_6	67	25	42	29	15	23	94	71.3
Thai_7	155	48	107	52	46	57	299	51.8
Thai_8	33	13	20	0	11	22	50	66.0
Thai_Total	635	209	426	121	159	355	1066	59.6
JPN_1	310	0	310	139	91	80	427	72.6
JPN_2	171	90	81	36	58	77	356	48.0
JPN_3	141	71	70	45	45	51	252	55.9
JPN_4	132	56	76	40	51	41	221	59.7
JPN_5	107	41	66	57	0	50	165	64.8
JPN_6	70	36	34	34	0	36	140	50.0
JPN_7	12	5	7	1	6	5	14	85.7
JPN_8	127	49	78	0	0	127	199	63.8
JPN_Total	1070	348	722	352	251	467	1774	60.3
Grand Total	1705	557	1148	473	410	822	2840	60.0

6.2.3 Questionnaire reliability

Both samples of Thailand (N = 635) and Japan (N = 1070) were integrated and measured internal consistency and validity, Cronbach's alpha values to evaluate reliability how closely related a set of items in each component. As a result, a total of seventy-eight items was selected. Table 6.2 presents reliability of each predictor raging from 0.69 to 0.82 which are acceptable.

Table 6.2. Reliability of Each Predictor in the Integrated Sample with Thailand and Japan.

Predictors	No. of items	Reliability	Items eliminated
Basic energy knowledge	20	0.712	–
Awareness of consequences	11	0.822	–
Ascription of responsibility	6	0.713	AR06
Personal norm	5	0.693	–
Attitude toward the behavior	7	0.730	–
Subjective norm	9	0.818	–
Perceived behavioral control	5	0.718	PBC02, 05
Intention	4	0.718	INT01
Energy-saving behavior	11	0.708	ESB05
Total	78		

6.3 Result

6.3.1 Energy literacy results

6.3.1.1 Overall

Both students performance are summarized in Table 6.3. To aid in visually comparing, a bar chart is presented in each subgroup comparison.

The mean comparison between two countries is shown in Fig. 6.2 and the sample ratio of Japan is 63% and Thai, 37%. Students in Japan scored significantly higher on the BEK than those in Thai (48%, 41%, $p < .001$). Although, the item difficulty should be in the range of 0.4 to 0.8 [25], the performance of both students on the BEK was still unsatisfactory for the 70% correct answer rate which is the ideal difficulty level of five multi-choice items [26]. While, Thai students indicated significantly higher on other components than those counterparts ($p < .001$) except the AC. In particular, they scored higher than Japan on the SN (73%, 61%, $p < .001$). Even if students in Japan have a large amount of knowledge with respect to EE issues, it does not necessarily lead to the entire energy literacy.

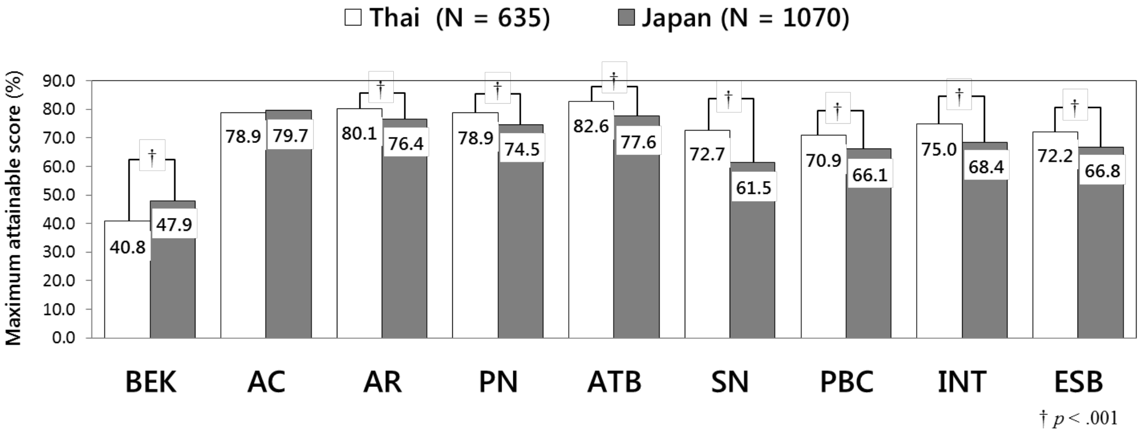

Fig. 6.2. Mean Comparison between Thailand and Japan.

6.3.1.2 Subgroups comparison

Gender

Fig. 6.3 presents gender mean comparison between both countries. Both gender distributions of Thailand and Japan were same as 33% for males and 67% for females. Thai female students indicated significantly higher scores than those in Japan on almost all components except the BEK and AC. For Japanese students, there were significant gender differences on the BEK (Males 42%, Females 51%, $p < .001$), AR (Males 75%, Females 77%, $p < .05$), and ESB (Males 68%, Females 66%, $p < .005$). On the other hand, no gender differences in Thai students were observed.

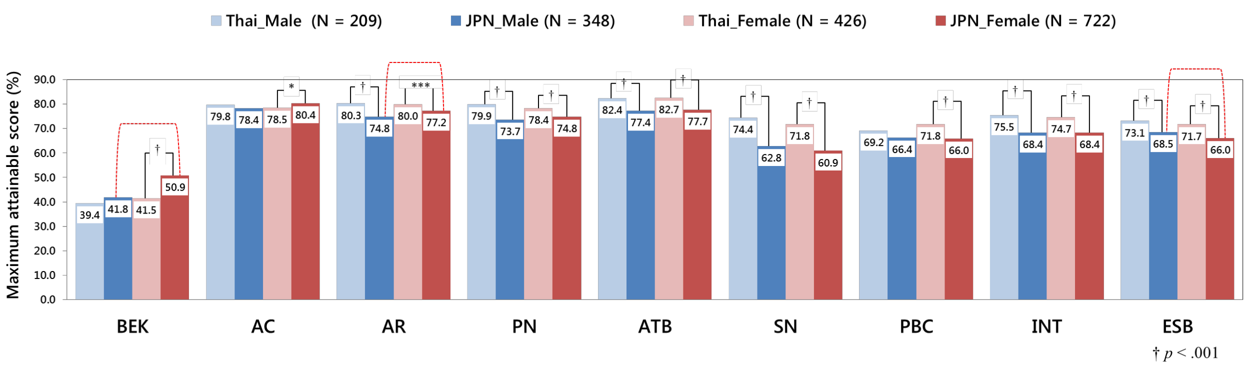

Fig. 6.3. Mean Comparison of Gender between Thailand and Japan.

School years

Fig. 6.4 presents mean comparison in the school years between both countries. Thai grade distributions were 19%, 25%, and 56% in the 7th, 8th, and 9th grade, and those of Japan were 33%, 23%, and 44%. There was no grade difference on the BEK in both countries. The 9th grade of Thai scored significantly higher than those in Japan on almost all components except the BEK and AC. In particular, Thai students scored significantly higher on the SN than those in Japan among all grades. Interestingly, scores of Japanese students seem to decline with the school year progression. In fact, the 7th grade of Japan scored higher than 9th grade on the AC (82%, 78%, $p < .001$), AR (78%, 75%, $p < .01$), PN (76%, 73%, $p < .005$), ATB (79%, 76%, $p < .005$), INT (70%, 66%, $p < .01$), and, ESB (68%, 65%, $p < .001$). On the contrary, overall Thai's actual scores tend to increase according to the school year progression, in details, a statistical test found that the 9th graders scored higher than the 7th graders on the PBC (73%, 67%, $p < .01$) and ESB (72%, 68%, $p < .05$).

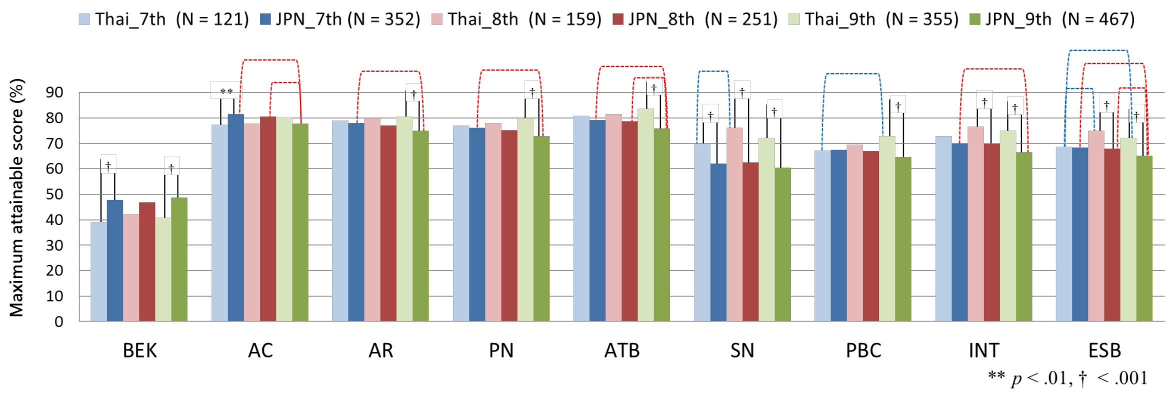

Fig. 6.4. Mean Comparison in the School Years between Thailand and Japan.

Experience of energy education

Fig. 6.5 presents mean comparison between both countries in the students' energy education experience. The proportion of students who have experienced energy education was 91% for Thai and 81% for Japan. For both countries, students who have experienced energy education scored significantly higher than their counterpart on the BEK (Thai: Yes 41%, No 34%, $p < .05$, Japan: Yes 49%, No 43%, $p < .001$), AC (Thai: Yes 79%, No 74%, $p < .05$, Japan: Yes 80%, No 77%, $p < .01$), and ATB (Thai: Yes 83%, No 79%, $p < .05$, Japan: Yes 78%, No 74%, $p < .001$). Furthermore, Japanese students who have experienced the energy education indicated significant high scores on the AR (Yes 77%, No 74%, $p < .01$), PBC (Yes 67%, No 63%, $p < .05$), and ESB (Yes 67%, No 65%, $p < .05$). While for Thai students, there was a significant difference on the PN (Yes 80%, No 72%, $p < .001$). Interestingly, despite the difference of the mean values of two countries on the SN was significant, the energy education experience did not affect the students' SN in both countries.

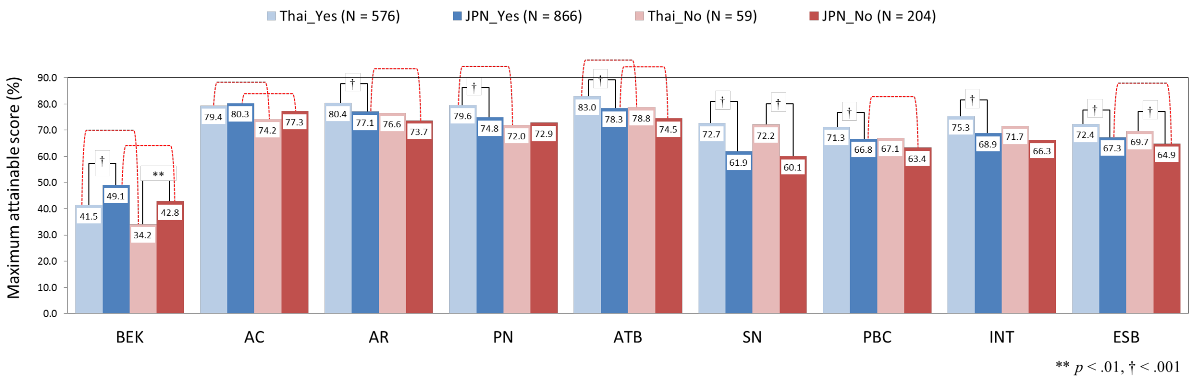

Fig. 6.5. Mean Comparison in the Energy Education Experience between Thailand and Japan.

Experience of tour of energy-related facility

Fig. 6.6 presents mean comparison between both countries on students' experience of energy-related facility tour. Approximately 30% of students of both countries have visited energy-related facility. There were significant differences on the SN (Yes 75%, No 71%, $p < .001$) and ESB (Yes 74%, No 71%, $p < .005$) for the Thai students. On the other hand, Japanese students who have experienced the tour of energy-related facility scored significantly higher than those counterparts on all components except the BEK (AC: Yes 82%, No 79%, $p < .001$; AR: Yes 79%, No 75%, $p < .001$; PN: Yes 76%, No 74%, $p < .01$; ATB: Yes 80%, No 76%, $p < .001$; SN: Yes 64%, No 60%, $p < .001$; PBC: Yes 69%, No 65%, $p < .001$; INT: Yes 72%, No 67%, $p < .001$; ESB: Yes 70%, No 65%, $p < .001$). Therefore, it can be claimed that the experience of energy-related facility-tour affects the students' energy literacy in Japan. Moreover, this experience is likely to affect the SN and ESB for students in both countries.

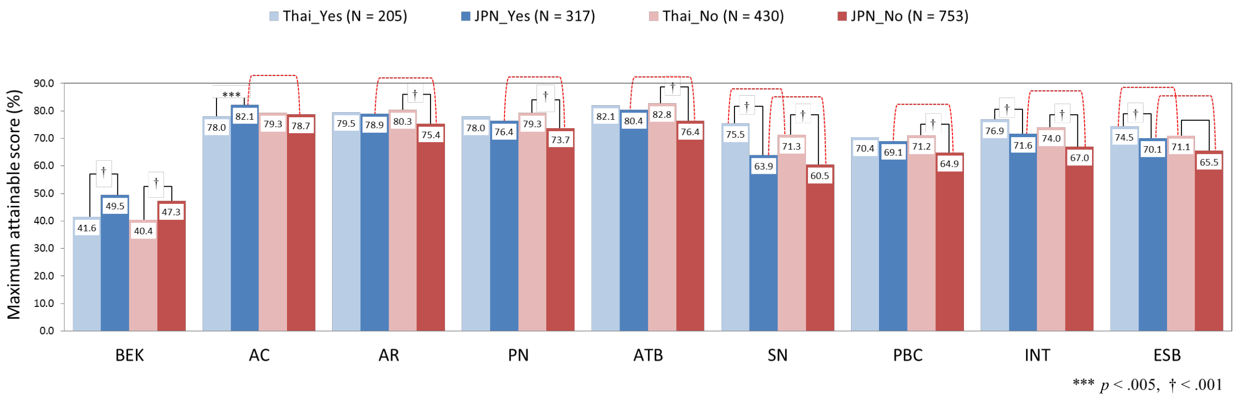

Fig. 6.6. Mean Comparison in the Experience of Energy-Related Facility Tour between Thailand and Japan.

Home discipline in energy-saving

Fig. 6.7 presents mean comparison between both countries on home discipline in energy-saving. The proportion of students who respond "Yes" to the presence of home discipline in energy-saving was 61% for Thai and 63% for Japan. The significant difference was indicated on the SN (Yes 74%, No 71%, $p < .05$) and INT (Yes 76%, No 73%, $p < .05$) for Thai students. Meanwhile, Japanese students who answered that their parents train their son(s)/daughter(s) for energy-saving scored significantly on all components than those counterparts except the BEK (AC: Yes 82%, No 76%, $p < .001$; AR: Yes 79%, No 73%, $p < .001$; PN: Yes 77%, No 71%, $p < .001$; ATB: yes 80%, No 74%, $p < .001$; SN: Yes 65%, No 56%, $p < .001$; PBC: Yes 69%, No 60%, $p < .001$; INT: Yes 73%, No 61%, $p < .001$; ESB: Yes 69%, No 63%, $p < .001$). As a whole, it can be assumed that the energy literacy of Japanese students is more likely to be influenced by their home discipline in energy-saving than students in Thai.

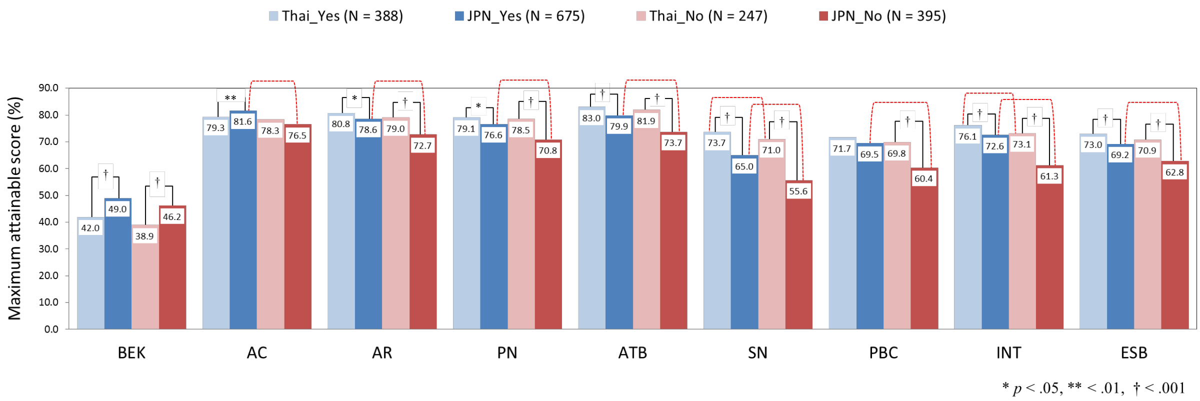

Fig. 6.7. Mean Comparison in the Home Discipline in Energy-Saving between Thailand and Japan.

In summary, Thai students indicated higher score than Japanese students in energy literacy except knowledge, no gender differences, and a tendency of score increasing with the school year progression. Thai SN is significantly higher than Japan, however, it is not affected by the energy education experience. While, students in Japan indicated that the amount of BEK does not alone lead their energy literacy, which can be supported by Chapter 3.6. The gender differences were observed in the BEK, AR, and ESB and the scores tend to decrease with the school year progression. The experiences of energy education and tour of energy-related facility and home discipline in energy-saving influenced energy literacy of Japanese students. In addition, this survey reported that ESB of both students was influenced by the experience of tour of energy-related facility.

Table 6.3. Mean Comparison of Subgroups between Thailand and Japan.

			BEK				AC				AR			
		N	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	204	42.82	19.13	1.34	**	77.32	12.68	0.89		73.69	13.27	0.93	
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	317	49.46	19.15	1.07	†	82.14	11.50	0.65	***	78.93	13.25	0.74	
	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	

			PN				ATB				SN			
		N	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	10.8	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	204	72.86	12.47	0.87		74.51	11.68	0.82		60.06	11.43	0.80	
Tour														
Thai	Yes	205	77.95	13.87	0.97		82.09	12.37	0.86		75.50	12.52	0.87	†

to be continued

Continued from the previous page

		N	Mean (%)	*SD*	*SE*	*p*	Mean (%)	*SD*	*SE*	*p*	Mean (%)	*SD*	*SE*	*p*
	No	430	79.31	12.27	0.59	†	82.80	11.65	0.56	†	71.31	10.87	0.52	†
Japan	Yes	317	76.38	13.17	0.74		80.44	11.30	0.63		63.93	12.75	0.71	
	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	11.8	0.59		55.62	11.73	0.59	
				PBC				INT				ESB		
		N	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	0.5		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	†	71.7	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	204	63.39	16.69	1.17		66.35	14.89	1.04		64.89	11.01	0.77	
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	317	69.07	16.08	0.90		71.64	15.49	0.87		70.09	11.37	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

End of the table

6.3.1.3 Item analysis

The results of item analysis were summarized in Appendix D Table D.1. The item asking about definition of energy in the BEK, both students' scored discouragingly low and so was the discrimination index, less than 0.01 (BEK06: Japan overall 13%, D = 0.08; Thai overall 24%, D = 0.02). Energy definition should be learned at the beginning of energy education because it becomes essential knowledge to understand the energy. Both students also indicated low score on the question about a degree of dependence on imported energy resources in the country (BEK03: Japan 20%, D = 0.22; Thai 17%, D = -0.01). Energy self-sufficiency rate of the country is a pivotal knowledge in considering the energy choice. Japanese students indicated a low score on the item about photosynthetic products (BEK05: Japan 20%, D = 0.08), whereas, the forms of energy seemed to be an unlearned item for Thai students (BEK10: Thai 9%, D = -0.01). Japanese students scored well for the items of nuclear energy and energy conservation (BEK02 and BEK12) and Thai students showed a well performance for the items regarding scientific basic knowledge relevant to energy (BEK01, BEK05, BEK06, BEK15).

The question item in the AR section that statement is "the authorities, not the public, are responsible for energy saving and the environment (reverse question)" could not discriminate the performance of Thai students (AR06: Thai overall 48%, D = -0.05). Finally, this item was eliminated according to the internal consistency evaluation.

Due to the high score of both highest- and lowest-scoring groups on the item of ATB for Japanese students, the discrimination index of "For me energy saving is important" was 0.16 (ATB01: Japan overall 82%).

In the SN section, the high perception of Thai students to fulfil the expectations of significant others was observed (in the range of 65%–79%). In particular, Thai students indicated strong perception of the expectations of their family, people who are important to him/her, and their classmates, and these discrimination indices were all well. Conversely, the response of Japanese students to the SN section was relatively lower than those of Thai (in the range of 50%-68%).

The item of "energy-saving is up to me" (PBC02) and "how often do you encounter unanticipated events that you cannot do energy-saving (reverse question)" (PBC05) indicated the low discrimination indices (PBC02: Japan D = 0.18, Thai D = 0.19; PBC05: Japan D = 0.15). These items were eliminated by evaluating the internal consistency. Students in both countries indicated a high score on the item of "when I leave a room, I turn off the light" (ESB01: Japan 90%, D = 0.16; Thai 84%, D = 0.18) so that this item could not discriminate the highest- and lowest-scoring groups.

Students' item selection on all items is presented in Fig. D.1–D.5 in Appendix D.

6.3.2 Intercorrelations between components

The Spearman's rank correlation coefficients between each component are given, and overall were positive and significant ($p < .05$) except the Japan's intercorrelation between BEK and SN ($r = 0.03$, no significant) and BEK and ESB ($r = 0.05$, no significant) (Table 6.4). Fig. 6.8 shows clearly to see that Thai's intercorrelation between components tends stronger than Japan. In particular, the intercorrelations between the SN, ESB, and other components were significantly stronger than those of Japan. Both countries showed high correlation coefficients between AC and AR, PN, and ATB ($r = 0.71$–0.78). Moreover, the significant differences between Thai and Japan on the intercorrelation between the SN and other components are likely to be produced by the fact that Thai scored higher mean value than Japan on the SN (mean of SN: Thai 73%, Japan 61%, $p < .001$, Table 6.3). Thus, it can be considered that the AC in both countries and the SN in Thai play an important roles in both students' energy literacy.

Table 6.4. Results of A Test of the Difference of Correlation Coefficient between Thai and Japan.

	BEKthai	BEKjpn	p	ACthai	ACjpn	p	ARthai	ARjpn	p	PNthai	PNjpn	p
BEK	1	1										
AC	.404**	.377**	ns	1	1							
AR	.426**	.304**	***	.712**	.776**	***	1	1				
PN	.454**	.271**	†	.753**	.765**	ns	.692**	.732**	ns	1	1	
ATB	.383**	.291**	*	.752**	.754**	ns	.706**	.699**	ns	.673**	.706**	ns
SN	.213**	.026 ns	†	.521**	.336**	†	.524**	.394**	***	.508**	.412**	*
PBC	.400**	.098**	†	.384**	.378**	ns	.396**	.464**	ns	.383**	.456**	ns
INT	.313**	.135**	†	.607**	.518**	**	.594**	.560**	ns	.623**	.594**	ns
ESB	.295**	.053 ns	†	.560**	.422**	†	.552**	.456**	*	.540**	.459**	*
	ATBthai	ATBjpn	p	SNthai	SNjpn	p	PBCthai	PBCjpn	p	INTthai	INTjpn	p
BEK												
AC												
AR												
PN												
ATB	1	1										
SN	.579**	.441**	†	1	1							
PBC	.483**	.447**	ns	.285**	.450**	†	1	1				
INT	.660**	.609**	ns	.635**	.607**	ns	.414**	.628**	†	1	1	
ESB	.570**	.482**	*	.728**	.559**	†	.322**	.581**	†	.675**	.663**	ns

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

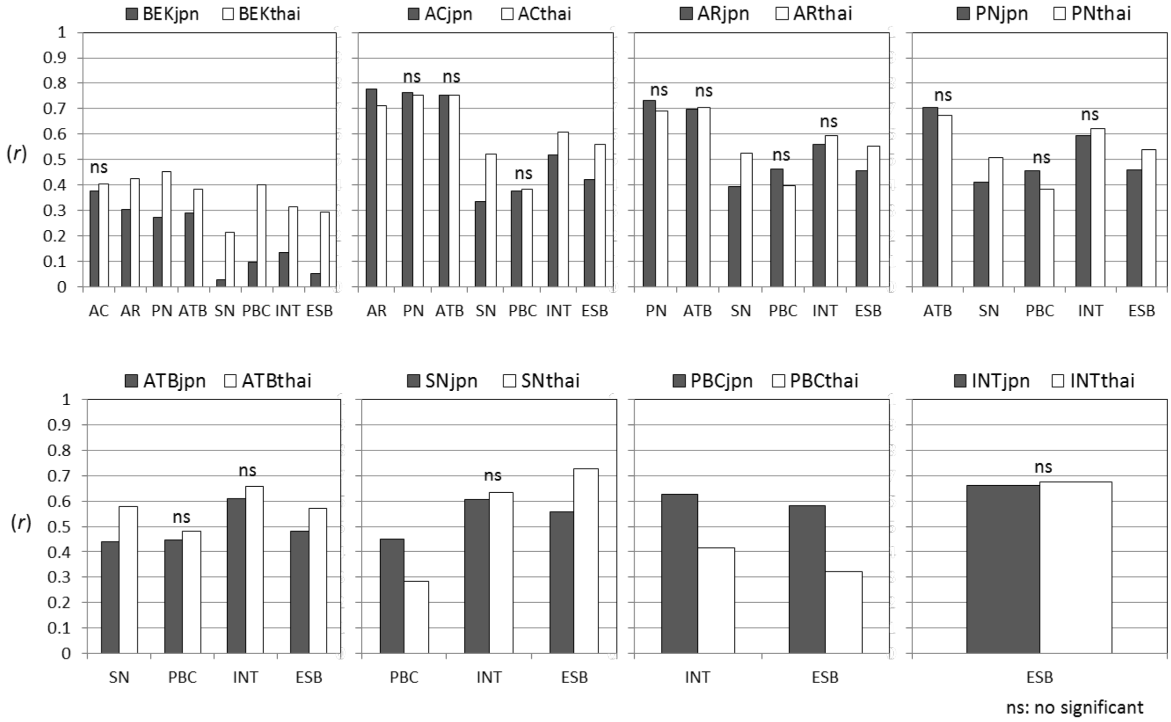

Fig. 6.8. Results of A Test of the Difference of Correlation Coefficient between Thailand and Japan.

6.3.3 Energy literacy structural model for the integrated samples of Thailand and Japan

To apply the integrated samples of Thailand and Japan ($N = 1705$) to the energy literacy model, the correlations among the predictors were calculated with the non-parametric Spearman's rank correlations (ρ). The summary is reported with the descriptive statistics in Table 6.5. All correlation coefficients were significant ($p < .01$) except between the BEK and SN ($r = .002$).

Table 6.5. Descriptive Statistics for Predictors and Spearman's *rho* Correlation Matrix for Path Analysis of Thailand and Japan.

	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	.002 ns	.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	11.40	.092**	.447**	.505**	.509**	.543**	.635**	.512**	.681**

** $p < .01$

The energy literacy structural model for students in Thai and Japan was depicted as Fig. 6.9. Two paths were added to the original integrated model, which were from the SN to PN and from the PBC to AC. The model fitness indices indicated relatively acceptable values: GFI = 0.958; AGHI = 0.865; SRMR = 0.045; NFI = 0.963; CFI = 0.964; RMSEA = 0.120. All factor loadings ranged from 0.14 to 0.62 in the standardized estimates, and were significant except covariance between the BEK and SN ($\beta = 0.02$, $p = 0.513$).

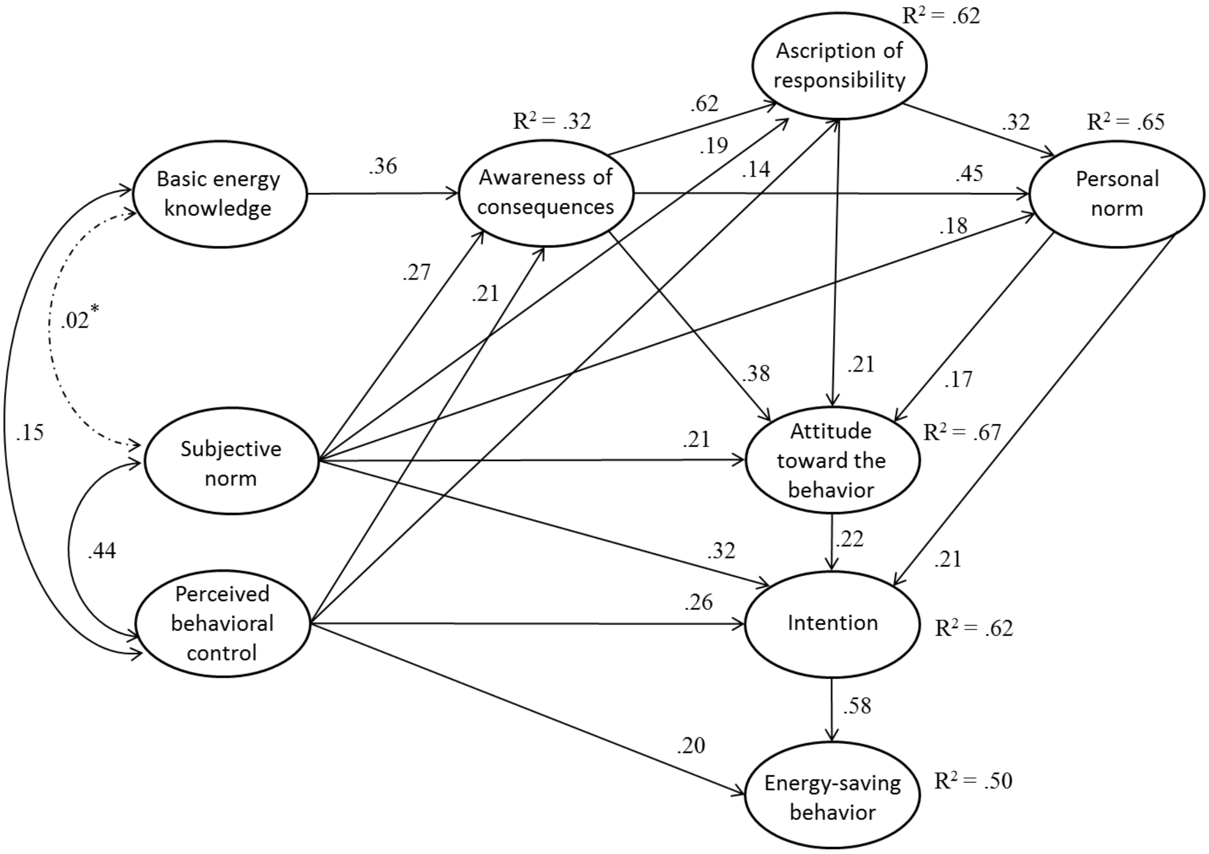

Fig. 6.9. Energy Literacy Structural Model for the Integrated Sample of Thailand and Japan with Standardized Coefficients. A Non-Significant Estimate is Indicated by the * Symbol.

According to the energy literacy structural model, the INT and PBC were able to explain 50% of the variance in ESB ($\beta = 0.58$ and 0.20, $p < .001$, $R^2 = 0.50$). The ATB, SN, PBC, and PN accounted for 62% of the variance in the INT. The SN, AR, PN, and AC explained 67% of the variance in the ATB. The AC predicts

ATB stronger than other predictors ($\beta = 0.38$, $p < .001$). The BEK predicts AC significantly ($\beta = 0.36$, $p < .001$) and accounted for 32% of the variance in AC along with the prediction by the SN and PBC. Whereas, both the AR and PN were predicted by the AC larger than the estimated values in this model ($\beta = 0.62$ and 0.45, $p < .001$). Thus, it can be suggested that the AC is a critical determinant in explaining the relationship between the BEK and ESB mediated by the ATB in the energy literacy model of Thailand–Japan integrated sample.

The standardized regression coefficients of both countries are presented in Fig. 6.10. The model fit indices of Japan are well, whereas those of Thai indicates that Thai model could be further improved. It will be explained in the discussion section. All estimates are significant except that the covariance between BEK and SN of Japan is non-significant ($p = 0.19$).

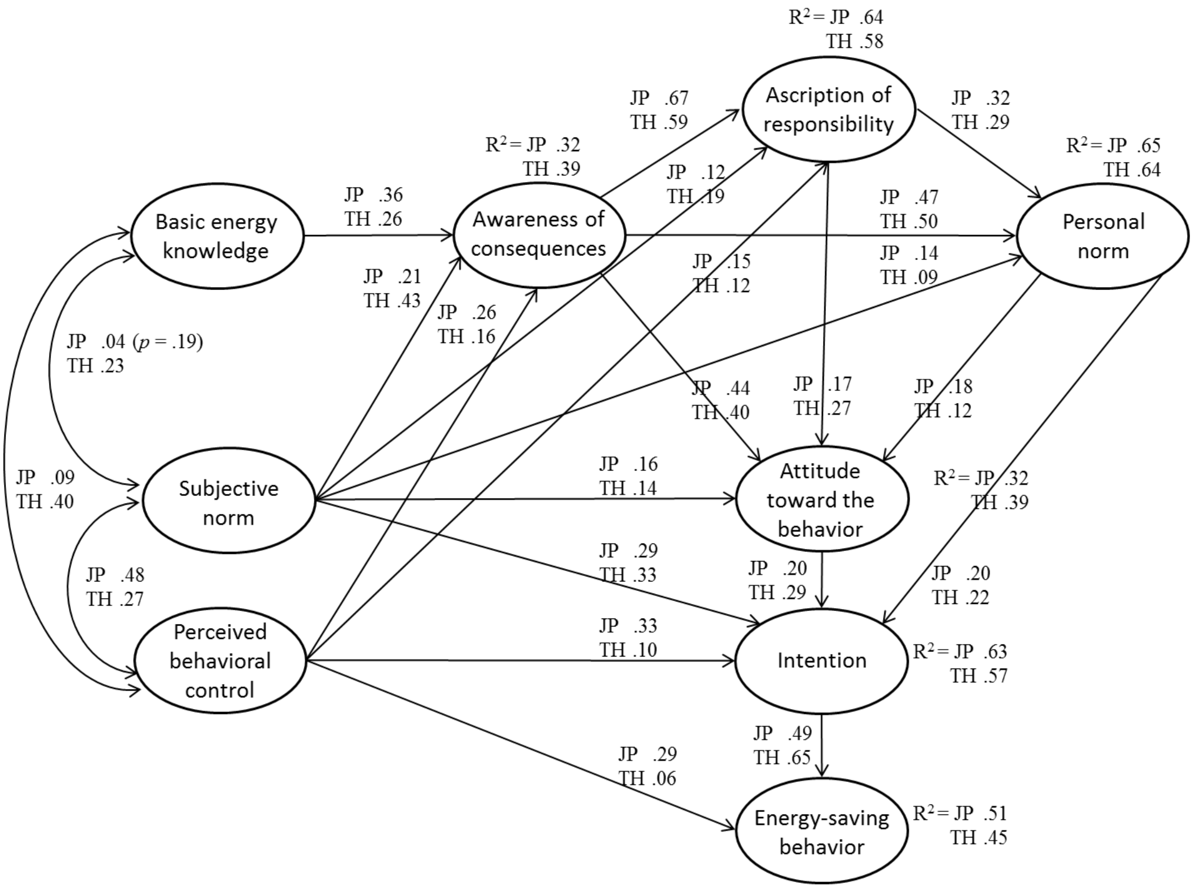

Fig. 6.10. Standardized Regression Coefficients of Japan and Thailand on Energy Literacy Model. Japan: GFI = 0.976; AGHI = 0.924; SRMR = 0.033; NFI = 0.980; CFI = 0.982; RMSEA = 0.084, Thai: GFI = 0.908; AGHI = 0.705; SRMR = 0.075; NFI = 0.909; CFI = 0.912; RMSEA = 0.189.

6.3.4 Conditional process analysis

A conditional process analysis were conducted to examine whether the interaction of country can be found in the energy literacy model. The moderator was coded as zero for Japan and one for Thai. Table 6.6 presents the results of analysis whether the moderator (country) affects the relationship between a predictor (X) on an outcome (Y). As a result, the direct effects of SN on the AC, PN, and ATB, and three mediation models which are No. 2, 10, and 16 in Table 6.6, depended on the moderator: country.

Table 6.6. Summary of conditional process Analysis.

	Predictor (X)	Outcome (Y)	Mediator (M)	Results
1	BEK	AC	–	ns
2	AC	ATB	AR	Moderated
3	AC	ATB	PN	ns
4	AC	PN	AR	ns
5	SN	AC	–	Moderated
6	SN	AR	–	ns
7	SN	PN	–	Moderated
8	SN	ATB	–	Moderated
9	SN	INT	–	ns
10	SN	ATB	AC	Moderated
11	SN	ATB	AR	ns
12	SN	ATB	PN	ns
13	SN	INT	ATB	ns
14	AR	ATB	PN	ns
15	PN	INT	ATB	ns
16	PBC	ESB	INT	Moderated

First, the direct effects of SN on outcomes were investigated by simple moderation analysis (See, Fig. 2.2). Table 6.7 shows that the interaction of SN on the AC, PN, and ATB are significant (AC: $b_3 = 0.166$, 95% $CI = 0.076$ to 0.255, $p < .001$; PN: $b_3 = 0.103$, 95% $CI = 0.009$ to 0.197, $p < .05$; ATB: $b_3 = 0.139$, 95% $CI = 0.054$ to 0.223, $p < .005$). Evidence of interaction between the SN and country has established that the direct effects of SN on AC, PN, and ATB depend on country. Furthermore, the conditional effects of the SN at value of Thai indicated larger than those of Japan (AC: $b_{thai} = 0.51$, $t(1701) = 13.95$, $p < .001$, $b_{japan} = 0.35$, $t(1701) = 13.01$, $p < .001$, PN: $b_{thai} = 0.57$, $t(1701) = 14.58$, $p < .001$, $b_{japan} = 0.46$, $t(1701) = 16.41$, $p < .001$, ATB: $b_{thai} = 0.58$, $t(1701) = 16.65$, $p < .001$, $b_{japan} = 0.44$, $t(1701) = 17.41$, $p < .001$). It was concluded that the direct effects of SN on the AC, PN, and ATB depend on the country, Thai is larger than Japan.

Table 6.7. 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	.123
$X \times M$	b_3	→	.166	.046	.076, .255	†	→	.103	.048	.009, .197	*	→	.139	.423	.054, .223	***
Constant	i_Y	→	78.995	.287	78.432, 79.558	†	→	75.837	.303	75.244, 76.431	†	→	79.084	.269	78.556, 79.613	†
			$R^2 = 0.177$ F (3, 1701) = 122.158, $p < .001$					$R^2 = 0.242$ F (3, 1701) = 180.594, $p < .001$					$R^2 = 0.285$ F (3, 1701) = 225.740, $p < .001$			

* $p < .05$, *** $< .005$, † $< .001$

Subsequently, Table 6.8 presents the estimated regression coefficients of AR and ATB in the mediation model by country. Students with relatively higher AC expressed higher AR (a_1 = 0.808, 95% CI = 0.775 to 0.842, $p < .001$). Moreover, holding AC constant, the effect of AR on the ATB depends on country (b_2 = 0.099, 95% CI = 0.013 to 0.185, $p < .05$). The conditional indirect effect of AC on the ATB through the AR, there was a significant difference at country, and effect of Thai was larger than Japan. (b_{thai_i} = 0.275, 95% CI = 0.216 to 0.339, b_{japan_i} = 0.220, 95% CI = 0.171 to 0.270).

For the reason that the evidence of moderation of one of the paths in a mediation model is sufficient to claim mediated moderation, this analysis supports the conclusion that the indirect effect of AC on ATB through AR depends on country. In this case, however, the 95% bootstrap confidence intervals for 10,000 resamples for the index of moderated mediation includes zero (-0.021 to 0.137). Thus, this model cannot be defined that the indirect effect of AC on the ATB through the AR depends on country.

Table 6.8. Unstandardized OLS Regression Coefficients with Confidence Intervals Estimating Ascription of Responsibility (AR) and Attitude Toward the Behavior (ATB) with the Moderation by Country. Variables are Mean Centered.

			AR (M)						ATB (Y)			
			Coeff.	SE	95% CI	p			Coeff.	SE	95% CI	p
AC (X)	a_1	→	.808	.017	.775, .842	†	c'_1	→	.515	.022	.471, .558	†
AR (M)							b_1	→	.300	.021	.259, .341	†
Country (W)	a_2	→	4.290	.416	3.474, 5.107	†	c'_2	→	4.235	.373	3.503, 4.966	†
$X \times W$	a_3	→	-.076	.036	-.146, -.006	*	c'_3	→	.026	.046	-.065, .116	.580
$M \times W$							b_2	→	.099	.044	.013, .185	*
Constant	i_M	→	-.015	.201	-.410, .380	.942	i_Y	→	79.366	.179	79.016, 79.717	†
			$R^2 = 0.582$						$R^2 = 0.644$			
			F (3, 1701) = 788.930, $p < .001$						F (5, 1699) = 614.323, $p < .001$			

* $p < .05$, † $< .001$

Table 6.9 presents that results of conditional precess analysis of which the SN predicts the ATB through the AC. The interaction between the SN and the country was significant for the AC (a_3 = 0.166, 95% CI = 0.076 to 0.255, $p < .001$). However, both direct and indirect effects of SN on the ATB were non-significant (c'_3 = 0.013, 95% CI = -0.056 to 0.081, p = .716; b_2 = 0.035, 95% CI = -0.034 to 0.105, p = .321).

Table 6.9. Unstandardized OLS Regression Coefficients with Confidence Intervals Estimating Awareness of Consequences (AC) and Attitude Toward the Behavior (ATB) with the Moderation by Country. Variables are Mean Centered.

			AC (M)						ATB (Y)			
			Coeff.	SE	95% CI	p			Coeff.	SE	95% CI	p
SN (X)	a_1	→	.411	.022	.369, .454	†	c'_1	→	.217	.016	.185, .248	†
AC (M)							b_1	→	.663	.016	.631, .695	†
Country (W)	a_2	→	-5.890	.609	-7.084, -4.656	†	c'_2	→	3.069	.426	2.256, 3.927	†
$X \times W$	a_3	→	.166	.046	.076, .255	†	c'_3	→	.013	.035	-.056, .081	.716
$M \times W$							b_2	→	.035	.035	-.034, .105	.321
Constant	i_M	→	-.432	.287	-.995, .255	.132	i_Y	→	79.419	.198	79.031, 79.808	†
			$R^2 = 0.177$						$R^2 = 0.639$			
			F (3, 1701) = 122.158, $p < .001$						F (5, 1699) = 601.190, $p < .001$			

† $p < .001$

Last, Table 6.10 shows that results of conditional process analysis of which the PBC predicts the ESB through the INT. The interactions between the PBC and the country were significant (a_3 = -0.194, 95% CI = -0.277 to -0.112, $p < .001$; $b_2 = 0.151$, 95% CI = 0.087 to 0.215, $p < .001$). The conditional direct and indirect effects of PBC on the ESB at values of Japan were larger than that of Thai (Direct effect: Thai: $b_{thai_d} = 0.051$, $t(1699) = 1.967$, $p < .05$; Japan: $b_{japan_d} = 0.201$, $t(1699) = 10.391$, $p < .001$; Indirect effect: Thai: $b_{thai_i} = 0.214$, 98% CI = 0.169 to 0.261; Japan: $b_{japan_i} = 0.222$, 98% CI = 0.191 to 0.252).

However, a 95% of bootstrap confidence interval for the index of moderated mediation on the basis of 10,000 bootstrap samples includes zero (-0.063 to 0.049). Hence, it cannot conclude the indirect effect of PBC on the ESB through the INT depend on the country.

Table 6.10. Unstandardized OLS Regression Coefficients with Confidence Intervals Estimating Intention (INT) and Energy-Saving Behavior (ESB) with the Moderation by Country. Variables are Mean Centered.

			INT (M)						ESB (Y)			
			Coeff.	SE	95% CI	p			Coeff.	SE	95% CI	p
PBC (X)	a_1	→	.539	.019	.501, .577	†	c'_1	→	.145	.015	115, .175	†
INT (M)							b_1	→	.419	.016	.387, .450	†
Country (W)	a_2	→	4.215	.613	3.012, 5.418	†	c'_2	→	1.803	.411	.997, 2.610	†
$X \times W$	a_3	→	-.194	.042	-.277, -.112	†	c'_3	→	-.150	.032	-.213, -.087	†
$M \times W$							b_2	→	.151	.033	.087, .215	†
Constant	i_M	→	.220	.295	-.359, .798	.457	i_Y	→	68.766	.197	68.379, 69.152	†
			$R^2 = 0.370$						$R^2 = 0.520$			
			F (3, 1701) = 332.909, p < .001						F (5, 1699) = 368.387, p < .001			

† p < .001

In summary, in this energy literacy model, the interaction between SN and Thailand is larger than that of Japan. The same results also can be found the relationship between AR and ATB in the mediation model of the AC on the ATB through the AR. On the other hand, for the prediction of PBC to the ESB through the INT strongly depends on Japan than Thai.

6.4 Discussion

This study has assessed the applicability of the energy literacy model, and investigated the differences in attributes on energy literacy through lower secondary students in Thailand and Japan by a questionnaire survey. The findings should be discussed at least four aspects that they are: (1) the gap of basic energy knowledge between two countries; (2) the importance of awareness of consequences; (3) the school-year differences among Japanese students, and (4) the interactions of country on energy literacy model.

6.4.1 Gap of basic energy knowledge

A significant difference in the BEK between Thailand and Japan can be discussed based on the achievement of the OECD Programme for International Student Assessment, PISA 2015, which around 540,000 students participated in the assessment on science, mathematics and reading, representing approximately 29 million 15-year-old in the schools of the 72 participating countries and economies [27]. The latest evaluation in 2015 focused on science. Japanese students were outstanding performance and ranked the 2nd among the participating countries and economies, and this trend has not changed in recent surveys. On the contrary, the Thai overall performance was far below the OECD average and other Asian countries, ranked the 54th. The scientific education performance may affect their energy literacy, which includes broad topics regarding energy, environment, and science. Mathematics and reading comprehension are also necessary to understand the data and trend of the global climate issues. The outcome of PISA 2015 is of help for understanding of significant differences on the BEK between Thai and Japan.

Yuenyong J. and Yuenyong C. discussed that school science teachings and learnings in Thailand did not seem to provide students that they can connect science concepts they have learned for applying to their events or activities in their communities [28]. According to the authors, in the recent trends in Thai education, learners value education as a goal to enter well-known schools and universities, rather than as a basis for lifelong learning. To achieve high scores and apply for well-known schools and universities, students have to take supplementary study outside of formal school schedule. The gap of education opportunity for students has expanded according to the household income.

The Japanese school system ensures equality in education opportunities and its level has been keeping stable since 2006, and the relationship between student socioeconomic status and performance is weaker than the OECD average [27]. However, fewer Japanese students in PISA 2015 reported that they enjoy learning science in comparison with 2006 and the level of enjoyment of science is below the OECD average. Even though it is difficult for 15-year-olds to decide their future, 25% students across OECD countries reported that they expect to work in science-related occupation, while 18% in Japan. Furthermore, PISA 2006 reported that 39% of Japanese students are enrolled in schools where school principals reported constant pressure from many parents who expected the school to set high academic standards and to have the students achieve them [29]. Namely, although Japanese students perform outstanding achievement on science assessment under high pressure of their parents expectations, their motivations tend to be low in learning science and in choosing future occupation relevant to science. If the parents expectations may cause students to pursue only high level of academic achievement to pass the exams of famous schools and universities, it is difficult to improve their energy literacy with only gaining basic energy knowledge which is provided in school education. Evidently, the results of energy literacy of Japanese students can support previous studies which claim that the amount of knowledge dose not alone lead to altering people's behavior and lifestyles toward energy conservation nor does it affect attitude-behavioral consistency (e.g., [30–38]).

6.4.2 Importance of awareness of consequences

In the energy literacy structural model, the AC is a powerful predictor to the ATB ($\beta = 0.38$) and plays a pivotal role in the energy literacy model to mediate the causal relationship between knowledge and energy-saving behavior (Fig. 6.9).

There was no significant difference on the AC between two countries (Thai: 79%, Japan:80%, non-significant), and the intercorrelations between the AC and AR, PN, and ATB indicate very strong correlation coefficients in both countries (Table 6.4, Thai: $r = 0.71$, 0.75, 0.75, Japan: $r = 0.78$, 0.76, 0.75).

Examining the details of response, Thai students tend to expect more than Japanese students on government leadership and energy-saving (A01,03,04, and 07, $p < .01$). It can be supported by Yuenyong & Yutakom report that Thai students believe in country's development and scientific application into society for solving energy-related problems, and that are under controlled by government [2]. Moreover, according to the study of the relationship between values and decision making for the energy issues of Thai students in schools that are located in rural and urban in Khon Kaen, the northeast of Thailand, students' decision making varies somewhat at areas where they live in, but they concerned the energy issues from the perspectives of social economy, environmental damage, and individual's action for energy-saving [4]. For example, one school of participants in the study in Khon Kaen has discussed about employing nuclear power, they concluded that Thailand has still immature technology on nuclear power and Uranium should be imported. However, it was not described the risk about nuclear accident [4].

While, students in Japan scored higher than Thai students on the items of AC05, 08, 09, 10, and 11 ($p < .001$), and concerned environmental destructions such as global warming by large amount of energy consumption, resource depletion, and deforestation, that are serious problems. These results reflect that the most valuable contexts have been provided into their EE education in each country. In Japan, the environmental issues tend to be emphasized in EE education rather than social economic aspects (Chapter 1.1.2, [39]). As aforementioned in Chapter 5.4.2, Japan has experienced severe nuclear accident in 2011, and been still in the process of reconstruction in Fukushima and efforts to overcome misunderstanding and ignorance about radiation. Needless to say, it may be, however, difficult for teachers and students in Japan to discuss about nuclear power for the perspective of the social economy, it is of significant importance of understanding that Japan has been facing declining in the energy self-sufficiency ratio, increasing in electric power costs, and increasing in the amount of CO_2 emissions [40] (Chapter 1.1).

Japanese students who responded positively to experiences of energy education and energy-related facility-tour, and home discipline in energy-saving scored higher than the negative respondents on the AC. Thus, for Japanese students, it can be recommended that energy education should be provided with practical and informative contents including ongoing EE issues, which will emerge adverse consequences for the future generation and society. Providing experience learning and incorporating family participation in EE learning will be further effective to foster students' AC.

6.4.3 School year differences among Japanese students

It was indicated that scores of Japanese students decrease with the school year progression on the AC, AR, PN, ATB, INT, and ESB ($p < .01$ or less, Chapter 6.3.1.2). To ascertain this tendency, the mean values were compared between school years by schools with samples in all school years (Thai_6, Thai_7, JPN_2, JPN_3, JPN_4) (Table 6.11). The trend of mean values of Thai students showed relatively high scores in the 9th grade, while the lower grades in Japan tended to indicate higher mean values than the 9th grade except the BEK. Furthermore, this study have employed results of high school students (HS), and compared with those of lower secondary (LS). Students of 10th grade (age of 16) of private high school in Kanagawa prefecture adjacent to Tokyo were assessed (N = 242). Blank and vague responses of both LS and HS in each components were eliminated case-wise from the analysis. Table 6.12 presents mean comparison between the LS and HS. The HS students indicated higher score on the BEK than the LS, while the LS students scored significantly higher than those in HS on the AR, SN, PBC, INT, and ESB ($p < .05$). There was little difference on the AC, PN, and ATB. A conditional process analysis also uncovered that there was no significant interaction of the BEK and academic levels (LS and HS) on the AC (b_3 = -0.006, $t(1587)$ = -0.183, 95% CI = -0.072 to 0.060, p = 0.85). Namely, even if knowledge relevant to EE issues indicates high score (LH 51%, HS 75%, $p < .001$), it does not necessarily activate individual values and norms nor lead the preferable attitudes and behaviors toward the EE issues. This trend, the cognitive dissonance, has already emerged at the stage of lower secondary education in Japan. If so, the EE education should be provided to the proper target age. The earlier secondary education stage may be important period to implement energy education to enhance students' awareness to global EE issues as an individual matter, and form values and beliefs for problem-solving toward a sustainable development society.

Table 6.11. Mean Comparison between School Years by Schools with Samples in All School Years (Thai_6, Thai_7, JPN_2, JPN_3, and JPN_4)

		BEK				AC				AR			
	N	M (%)	*SD*	*SE*	*P*	M (%)	*SD*	*SE*	*P*	M (%)	*SD*	*SE*	*P*
Thai_7th	81	38.64	13.53	1.50		79.84	11.19	1.24	** 8th<7th	81.07	11.74	1.30	
Thai_8th	61	31.48	14.36	1.84		72.97	12.56	1.61		75.68	12.19	1.56	
Thai_9th	80	41.81	12.28	1.37	*** 8th<9th	79.50	9.87	1.10	* 8th<9th	79.83	10.82	1.21	
JPN_7th	121	38.35	15.96	1.45		77.39	11.78	1.07		74.21	13.94	1.27	
JPN_8th	154	41.59	18.13	1.46		79.60	12.73	1.03		76.65	14.10	1.14	
JPN_9th	169	47.90	21.58	1.66	*** 7th<9th	77.71	12.96	1.00		75.19	13.42	1.03	
		PN				ATB				SN			
	N	M (%)	*SD*	*SE*	*P*	M (%)	*SD*	*SE*	*P*	M (%)	*SD*	*SE*	*P*
Thai_7th	81	78.77	11.62	1.29		83.49	10.34	1.15	*** 8th<7th	71.11	11.01	1.22	
Thai_8th	61	73.18	13.73	1.76		75.36	14.83	1.90		70.42	11.38	1.46	
Thai_9th	80	78.90	12.29	1.37		84.21	9.92	1.11	*** 8th<9th	71.47	10.10	1.13	
JPN_7th	121	73.26	12.55	1.14		76.32	11.81	1.07		63.20	12.84	1.17	
JPN_8th	154	74.62	14.13	1.14		78.20	12.18	0.98		63.95	12.28	0.99	* 9th<8th
JPN_9th	169	72.78	13.68	1.05		76.33	12.58	0.97		59.49	11.80	0.91	
		PBC				INT				ESB			
	N	M (%)	*SD*	*SE*	*P*	M (%)	*SD*	*SE*	*P*	M (%)	*SD*	*SE*	*P*
Thai_7th	81	68.69	13.10	1.46		75.00	11.51	1.28		69.70	9.95	1.11	
Thai_8th	61	64.72	13.57	1.74		69.26	12.21	1.56		67.69	9.84	1.26	
Thai_9th	80	74.75	11.71	1.31	*** 8th<9th	73.38	13.31	1.49		72.34	9.20	1.03	
JPN_7th	121	68.03	17.06	1.55		70.54	12.78	1.16		67.59	11.65	1.06	
JPN_8th	154	68.47	15.35	1.24		70.88	15.29	1.23		68.34	12.08	0.97	
JPN_9th	169	64.19	16.45	1.27		67.66	15.54	1.20		64.67	10.58	0.81	

Table 6.12. Mean Comparison of Students between Lower Secondary and High Schools in Japan.

	BEK					AC					AR				
	N	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	

* $p < .05$, † $< .001$

6.4.4 Country effect on energy literacy model

People are not born with fixed attitudes toward all matters in society. Our attitudes are shaped by social backgrounds [3]. Thai students indicated a greater performance on the SN than those in Japan, and were all significant (SN01–09, $p < .001$). The SN is the perception of social pressure to perform or not to do a given behavior, and "it is assumed that SN is determined by the total set of accessible normative beliefs concerning the expectations of important referents" [41]. Thai identity stems from the Buddhist view, and the values are also underlying in the education [2]. Thai children are taught that a good child must obey parents, teachers, and adults who have a better understanding [2]. Therefore Thai norms can be said to respect seniority [4] and it may cause high SNs. While, Ando, Yorifuji, Ohnuma, Matthies, & Kanbara reported that meeting others' expectation is more important in interdependent cultures and this normative element, namely, the SN plays a critical role in determining the environmental behavior for Japanese children [42]. Their suggestion can support that this study found the parental influence on energy literacy of Japanese students through the comparison regarding home discipline in energy-saving. Although both students in Thai and Japan imply the effect of SN, it was elucidated that Thai students performed stronger than those in Japan on the effect of SN in this study. This also can be supported by results of conditional process analysis that uncovered that the effect of Thai was larger than Japan in the relationships between the SN and AC, PN, and ATB.

Considering a model improvement for Thai (Fig. 6.10), the direct prediction of SN to the ESB is interesting. Its regression coefficient estimated 0.51, and the estimation of regression coefficient of INT to the ESB decreased from 0.65 to 0.33. The variance in ESB explained by the INT, PBC, and SN increased from 45% to 61%. The model fitness has improved as: GFI = 0.962; AGHI = 0.868; SRMR = 0.043; NFI = 0.968; CFI = 0.972; RMSEA = 0.112. Although, the Theory of Planned Behavior assumes that person's behavior is controlled by the intention to act that behavior, in Thai case, it would be possible that students unconsciously take actions which are expected by their important referents. If so, it may imply unconscious energy-saving behavior, a kind of obedience which is expected by social pressure. Thai social norms expect children to be humility and to respect senior people. Not only children but people accept the potential requests of someone who we respect or like [43]. Information and values from a recognized seniority and important referents can provide children a valuable short-cut for deciding how to act toward a given behavior. Once children realize that obedience to social norms are valuable, it is easy to allow themselves to act a given behavior with automatic obedience [43]. Behaviors are usually activated by the intention to act the given behavior, and the intention stronger correlates with the critical thinking ability than other components according to the Japan survey in this study (r = 0.52, Table 5.5). Although the CTA has not been surveyed in Thai assessment, investigating their CTA is required for future, and it is important to evaluate whether education intervention alter their structure of energy literacy.

In summary, the BEK of Japanese students is likely to be derived by academic performance level, while the AC is influenced by various aspects such as experiences of energy education and tour of energy-related facility, and students' family attitudes and behaviors toward the energy conservation. Considering a score decline of energy-related attitudes of students in Japan with the school year progression, it would be more effective to implement energy education into earlier stage of education as possible. On the other hand, in Thai case where the SN is strong, it may be effective to emphasize students directly the way of energy conservation, adverse consequences of ongoing energy issues for future generation, and need of their contribution and responsibility for developing sustainable society. Adult people are of course required to show them ideal samples through their values, norms, and behaviors for solving energy-related issues.

Applying the same energy literacy structural model and a comparative assessment can emphasize each characteristic of energy literacy, and obtaining these implications contributes to develop and provide energy education in more effective manner.

6.5 Conclusion

Employing integrated sample of Thai and Japan, the applicability of energy literacy structural model and the difference in attributes in energy literacy have been assessed.

Thai students indicated higher scores than those in Japan in energy literacy except the basic energy knowledge and awareness of consequences, no gender differences, and a tendency of score increasing with the school year progression. In particular, their subjective norm indicated significantly high scores.

While, the results of Japanese students suggested that the amount of basic energy knowledge did not necessarily affect the increasing their entire energy literacy. Furthermore, the scores of Japanese students tend to decrease with the school year progression and it was further supported by comparing with high school students in Japan.

The energy literacy model has succeeded in explaining the energy literacy structure of integrated samples of Thailand and Japan. The intention and perceived behavioral control were able to explain 50% of the variance in energy-saving behavior. The awareness of consequences predicted the attitude toward the behavior stronger than other predictors, and it played a vital role to linking the relationship between basic energy knowledge and energy-saving behavior.

A conditional process analysis has uncovered that (1) the conditional direct effects of subjective norm on the awareness of consequences, personal norm, and (2) the prediction of ascription of responsibility on the attitude toward the behavior in the mediation model, were moderated by country, that the interaction effect of Thai were larger than those of Japan. Social expectations surrounding Thai students' is more likely to affect their attitudes toward the energy-saving behavior than those in Japan.

For energy education in Japan, it is recommended that the implementation of energy education as early as possible to build students' awareness of consequences and to make students recognize the importance of their contributions to problem-solving for EE issues.

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Chapter 7

Conclusion

7.1 Summary

It is necessary for human society to perceive the irreversible threat of climate change and make efforts to reduce greenhouse gases emissions through international cooperation. A solution to the energy and environmental issues depends on technology development, policy administration, and public participation. Energy literacy is a minimum required capacity for developing a sustainable society that participates in and discusses on energy and environmental issues, makes decisions, and takes actions for the solutions. Although, energy literacy is fostered through formal and informal energy education, in a tight school curriculum, the time that is allocated for energy education is limited. Hence, energy education should be provided in the most effective manner possible. To do so, understanding the status of people's energy literacy and its conceptual structure is indispensable. It is particularly worthwhile to gain knowledge of adolescents' energy literacy that affects future society through their energy selection, consumption and conservation.

This study has investigated energy literacy of lower secondary students in Japan (ages 13–15) through the surveys of their current status of energy literacy, the construction of energy literacy structural model, and the assessment of the model applicability and the difference in attributes in energy literacy. The results and discussion about these studies have summarized as follows.

In Chapter 3, a set of 1316 samples was measured with a written closed-item questionnaire modifying the DeWaters & Powers survey instrument. Knowledge relevant to energy and environment of Japanese students was low, while the females showed better achievement than the males on the cognitive subscale and self-efficacy. Students in the 8th and 9th grade scored higher on the cognitive subscale than those of the 7th, however, it did not necessarily affect the affective and behavior subscales with the school year progression. On the other hand, students who positively responded to the existence of family discussion about energy issues and of home discipline in energy-saving indicated higher scores on all subscales than the negative groups. In the regions comparison, Fukushima showed low score among participating schools in this study. The intercorrelation between behavioral and affective subscales was close, whereas little correlation between behavioral and cognitive subscales was observed.

In a comparison with the U. S. middle students results, Japanese students, however, scored higher on the cognitive subscales than the U. S. students, this result did not relate with the degree of attitudes, self-efficacy, and behavior. The U. S. students showed well performance on the affective subscales, and it derived stronger intercorrelation than Japanese students between the affective and behavioral subscales.

To lead preferable behavior for energy-saving, energy education would be required enhancing the interests and attitudes toward the energy related issues as well as knowledge.

In Chapter 4, utilizing results of Chapter 3, an energy literacy conceptual model was explored by a factor analysis approach to understand the causality of knowledge, attitudes, and behavior. Furthermore, the boundary conditions were investigated whether a moderator affects in the model. The energy literacy conceptual model interpreted students' energy literacy that the energy-saving behavior is predicted by both the awareness of consequences and ascription of responsibility, which are activated by the cognition of environmental issues based on the basic energy knowledge. The high percentage of the variance in energy-saving behavior (63%) was explained by the awareness of consequences, ascription of responsibility, and energy-use conscious behavior. Although knowledge predicted the ascription of responsibility larger than the awareness of consequences, the negative effect of ascription of responsibility on the energy-saving behavior through the energy-use conscious behavior was shown. While, the awareness of consequences positively predicts the energy-saving behavior through the energy-use conscious behavior. As such, it can be discussed that the awareness of consequences plays a critical role to link between knowledge and behavior factors in the energy literacy conceptual model.

The conditional direct effect of cognition of environmental issues on the ascription of responsibility depended on gender and the effect of males was larger than the females. This result indicates that the amount of knowledge does not necessarily affect on this relationship. The conditional indirect effect of ascription of responsibility on the energy-saving behavior through the energy-use conscious behavior was likely to decline with the school year progression. It implies that the timing of implementation of energy education should be considered. Finally, the conditional indirect effect of awareness of consequences on energy-saving behavior through energy-use conscious behavior depended on the region. It was mediated moderation. Some possible reasons of the difference between Fukushima and Tokyo can be considered, which are differences of academic performance level, the disadvantages in daily life after the natural disasters and nuclear accident in Fukushima in 2011, and the extraordinary energy-saving experience to reduce electricity demand after the disasters in Tokyo. Students' experiences in daily life may affect their awareness of consequences in energy literacy.

In Chapter 5, to investigate the relationship between energy relevant knowledge, belief and normative factors, intention to act, and energy-saving behavior with adopting common theoretical models which have been verified for last decades, the energy literacy structural model was constructed by integrating with the Theory of Planned Behavior and Value-Belief-Norm Theory. A new questionnaire and sample data ($N = 1070$) were employed. The energy literacy structural model has succeeded in explaining the relationship between the distal variables: knowledge and behavior, which have been frequently reported little correlation. The intention to act and perceived behavioral control were able to explain 50% of the variance in energy-saving behavior. The attitude toward the behavior, subjective norm, perceived behavioral control, and personal norm were able to explain 60% of the variance in intention. The awareness of consequences predicted the attitude toward the behavior larger than other predictors: subjective norm, ascription of responsibility, and personal norm, and it played a vital role in linking the relationship between the basic energy knowledge and the energy-saving behavior.

The effect of basic energy knowledge on the awareness of consequences depended on the degree of civic scientific literacy, critical thinking ability, and environmental values or worldview. While, the direct and indirect effect of awareness of consequences on the attitude toward the behavior depended at values of environmental values or worldview and family discussion about energy and environmental issues. Family attitudes and ecological worldview or values may enhance students' awareness of adverse consequences of ongoing energy-related issues.

The energy literacy structural model can provide a theoretical contribution to the development of effective energy education program adapting the concept of energy literacy to link basic energy knowledge and energy-saving behavior.

In Chapter 6, the applicability of the energy literacy structural model and the difference in attributes in energy literacy have been assessed.

First, the integrated sample of Thai ($N = 635$) and Japan ($N = 1070$) was assessed. Thai students indicated better performance than Japanese students on almost all components except the basic energy knowledge and awareness of consequences. There was no gender difference and scores tended to increase with the school year progression. While, Japanese students, however, scored higher than those in Thai on the basic energy knowledge, it did little to affect other components of energy literacy. Moreover, their scores tended to decline with the school year progression. Namely, it can be discussed that the amount of energy relevant knowledge of Japanese students does not necessarily contribute to the entire energy literacy and rather it may be more effective to implement energy education to the early stage of education as possible.

Next, applying the data to the energy literacy structural model was represented. The intention and perceived behavioral control were able to explain 50% of the variance in energy-saving behavior. The estimate of awareness of consequences was largest among other predictors to the attitude toward the behavior. It was dependent at values of the country: the direct effect of subjective norm on (1) the awareness of consequences, (2) the personal norm (3) the attitude toward the behavior, (4) the effect of subjective norm on the awareness of consequences in the mediation model between subjective norm, awareness of consequences, and attitude toward the behavior, and (5) the effect of ascription of responsibility on the attitude toward the behavior in the mediation model between awareness of consequences, ascription of responsibility, and attitude toward the behavior. These interactions of Thai were larger than those of Japan. It can be discussed that social pressures and expectations on Thai students are more likely to influence on their awareness of consequences and attitude toward the behavior than those on Japanese students. The strength of subjective norm may be able to derive obedience that makes students act easily a given behavior without critical thoughts. Since only comparing the degree of energy-saving behavior cannot uncover its background, it is of significance of understanding the energy literacy structure while associating with other literacy, ability, culture, and so forth which may affect the structure of energy literacy.

We are required to meeting our needs at this time without compromising the ability of future needs. For that, proper energy choices and conservation behaviors are required. Energy issues should be argued with well energy-literate citizens. These citizens are cultivated by formal and informal energy education. In particular, school education is highly expected to develop energy-literate citizens, but the given times are limited. The knowledge obtaining through energy education must contribute to understand the de facto energy and environmental situation in the country and the world. Energy education is expected to provide informative knowledge that activates individual's awareness of adverse consequences of one's acts for values or valued objects. That awareness is not forced by someone but perceived by oneself. If we can decrease consuming energy and fossil fuels, if we do choose appropriate energy sources, if we do change our values, lifestyles, and behaviors, it will mitigate the irreversible adverse consequences for the future.

7.2 Limitations and recommendations

Although this study reveals a number of interesting relations among energy-related knowledge, attitudes, and behavior, there are at least five limitations and their recommendations that should be acknowledged in this study.

1. This survey has been accomplished by the contribution of teachers who appreciated the importance of energy literacy assessment in spite of the controversy over nuclear energy since the severe nuclear accident occurred. Although the number of samples would be able to infer to some extent of energy literacy of Japanese students, more randomly, equally, and a wide range of survey will be required to characterize the status of energy literacy for the perspective of differences in attributes. Because people perceptions about energy and environmental issues depend on their culture and lifestyles that are closely related to geographical condition and economic capacity. The investigations for different generations, a variety of regions (e.g., coast/mountain, urban/rural, warm/cool climate, energy production/consumption region, and so forth), local communities where take different energy policy, and so forth will give us tips for energy education and public relations. Japanese people have experienced the nuclear bomb attacks and severe nuclear accident, they are considerably sensitive to discuss about energy issues including nuclear energy even though it is a significant baseload power source in Japan. Therefore, it is necessary to conduct energy literacy survey with the consent of as many people as possible, such as school principal, teachers colleagues, board of education, parents, and so forth. In particular, to increase participants to the energy literacy survey, highly supports for the research will be needed, for example, by government, board of education, local communities, academic associations, and any agent that concern energy issues. Sharing significance of the improvement of citizens energy literacy will become the ultimate strategy for energy policy.

2. On the premise that energy education has been little progressing in Japan, this study did not specifically compare the accomplishment of energy literacy of each school participated in the survey. While promoting introduction of energy education in the future, it is of critical importance of understanding which energy education causes the increase in students' energy literacy. And then, energy literacy assessment before/after educational intervention contributes to further development of an effective energy education. Moreover, it is expected that comparing with different educational stages would give us the effective timing of the implementation of energy education. In particular, obtaining the insights about the score decline with the school year progression is critical to understand the relationships among age, learning manners, and students' motivations.

3. The study employed students' self-reports to infer the relationship between their energy literacy and family influences through the home discipline in energy-saving and family conversation about energy issues. However, it has not investigated parents' occupation, education level, ideology, religion, the household income, or others which may affect students' energy literacy. Because taking these privacy information is more likely to hinder the successful investigation in Japan. In case of using these parameters, it would be better to use national statistical data.

4. The survey tools should be considered carefully. Although the printed questionnaire is of help for teachers who cooperates an external request and for researchers who want to increase a response rate, if a wide range of surveys are planned in Japan, a web questionnaire may be useful. It is free, collects with no blanks, and aggregates the basic responses automatically. On the other hand, this study had prepared the internet survey of energy literacy for Taiwan, Indonesia, and France though, they could not accomplish it in spite of the efforts by cooperating researchers. One of possible reasons can be considered that the internet environment would be unstable or PC or tablet devices have not been used or disseminated in school as they have been done in Japan. Another reason may be considered that the research objective and its necessity might not have been well shared between researchers and school teachers. The key to the success of Thai survey was that there was a coordinator who appreciated to meet the demands of researchers in both countries.

5. This study carried out a considerable number of question items. According to several teachers' comments, it has taken about 30 to 50 minutes to complete

152 items (Fig. E.2). The energy literacy survey, unlike the consumer behavior survey in market research, also includes contents on energy relevant knowledge, attitudes, and behavior that need to be fostered in energy education. Although the number of items can be selected at survey objectives while keeping the reliability and validity, the author encourages to implement a set of items of the BEK, AC, ATB, and ESB from Table 2.4 at a minimum requirement.

Appendix A

Energy literacy framework

Table A.1. Instrument Development Framework adopted from DeWaters & Powers [1].

I. Cognitive Outcomes	
A. Knowledge of Basic Scientific Facts	
I–A–1	Definition of energy
I–A–2	Forms of energy
I–A–3	First and second laws of energy (concepts of energy conservation, entropy)
I–A–4	Transfer of energy through living and nonliving systems
I–A–5	Relationship between energy and power
I–A–6	Units of energy and power
B. Knowledge of issues related to energy sources and resources	
I–B–1	Sun as primary energy source, other sources of energy used by humans
I–B–2	Renewable and nonrenewable resources
I–B–3	Relationship between supply and demand, and energy resource discovery, development and use
I–B–4	Advantages and disadvantages of developing and using different energy resources (technical, environmental, economic, societal)
I–B–5	Limitations of particular energy resources for various end-use applications
I–B–6	Importance of fossil fuels for meeting energy needs of todays society and as components in many valuable products
C. Awareness of the importance of energy use for individual and societal functioning	
I–C–1	Societys need for energy
I–C–2	Uses of energy in societies and households
D. Knowledge of general trends in U.S. and Global energy resource supply and use	
I–D–1	Relationship between fossil fuel consumption patterns and quantity of remaining reserves
I–D–2	Relative abundance of existing energy resources, in the U.S. and globally
I–D–3	Use and management of various energy resources, in the U.S. and globally
E. Understanding of the impact energy resource development and use can have on society	

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I–E–1	Influence of energy resource supply and demand on relationships between states, regions, and nations
I–E–2	Societal and economic problems related to shortages in nonrenewable energy resources
I–E–3	Societal impacts related to energy resource development and use
I–E–4	Personal and community health and safety factors associated with energy resource development and use
F. Understanding of the impact energy resource development and use can have on the environment	
I–F–1	Impact of developing and using energy from various renewable and nonrenewable resources on all spheres of the environment
I–F–2	Relationship between fossil fuel combustion and increasing levels of carbon dioxide in the atmosphere
I–F–3	Global climate change
G. Knowledge of the impact individual and societal decisions related to energy resource development and use can have on the ability of societies to effectively satisfy future energy needs	
I–G–1	Importance of energy conservation and improved efficiency of energy use
I–G–2	Need for developing alternatives to fossil fuel based energy resources
I–G–3	Importance and effectiveness of personal decisions and actions for reducing energy consumption
I–G–4	Connection between todays energy-related decisions and the future availability of energy resources
H. Skills	
I–H–1	Ability to assimilate and interpret current events relevant to energy issues
I–H–2	Ability to analyze and assess objective, reliable information relevant to energy issues
I–H–3	Ability to evaluate pros and cons related to energy consumption and energy resource development from various renewable and nonrenewable energy resources
I–H–4	Ability to evaluate costs and benefits related to energy when making consumer purchases
I–H–5	Ability to examine ones own beliefs and values in light of new information
II. Affective Outcomes	
A. Awareness/Concern with respect to Global Energy Issues	
II–A–1	Values energy education
II–A–2	Acknowledges seriousness of energy problem
II–A–3	Interested in current energy-related events
II–A–4	Concerned with potential debates with respect to sensitive energy-related issues and options that relate to the environment, economics, personal choices and freedoms, personal responsibility, and technical developments
B. Positive Attitudes and Values Regarding:	
II–B–1	Prevention and remediation of societal problems related to energy resource development and use
II–B–2	Prevention and remediation of environmental problems related to energy resource development and use

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II–B–3	Economic responsibilities related to sustainable energy resource development and use
II–B–4	The potential for adapting our lifestyles in ways that contribute to solving global energy problems
C. Strong Efficacy Beliefs	
II–C–1	Internal locus of control
II–C–2	Assumption of personal responsibility in contributing, as an individual and collectively with others, toward sustainable energy resource development and use
II–C–3	Assumption of personal responsibility in contributing, as an individual and collectively with others, toward mitigating negative impacts associated with energy resource development and use
III. Behavioral Outcomes	
Predispositions to Behave	
A. Willingness to Work toward Energy Conservation	
III–A–1	Considers energy-related impacts of everyday decisions, choices, and actions
B. Thoughtful, Effective Decision-Making	
III–B–1	Assesses objective, reliable information relevant to energy issues
III–B–2	Evaluates pros and cons related to energy consumption and energy resource development from various renewable and nonrenewable resources
III–B–3	Remains open to new ideas
III–B–4	Evaluates costs and benefits related to energy when making consumer purchases
C. Change Advocacy	
III–C–1	Remains open to new ideas
Behaviors	
D. Willingness to Work toward Energy Conservation	
III–D–1	Importance of energy conservation and improved efficiency of energy use
E. Change Advocacy	
III–E–1	Encourages others to make wise energy-related decisions and actions

End of the table

Reference

[1] J. E. DeWaters, "Instrument Development Framework for Energy Literacy," *Clarkson University (U. S.) Energy Literacy Assessment Project*, 2011.

Appendix B

Item analysis for basic survey of energy literacy

Symbol (Se) is self-efficacy items embedded in the affective subscale, (R) is reverse item which was converted reverse score, and symbol * is the item which was eliminated on the comparative survey between the U. S. and Japan.

Table B.1. Cognitive Items Difficulty (*Df*) and Discrimination Index (*D*).

No.	Items of cognitive subscale	Total (*Df*)	H_27% (*Df*)	L_27% (*Df*)	Disc. (*D*)
36	Each and every action on Earth involves ...	0.442	0.510	0.328	0.182
37	The amount of ELECTRICAL ENERGY (ELECTRICITY) we use is measured in units called ...	0.366	0.538	0.260	0.278
38	Which uses the MOST ENERGY in the average Japanese home in recent year?	0.498	0.546	0.399	0.147
39	One advantage to using nuclear power instead of coal or petroleum for energy is that ...	0.625	0.788	0.508	0.280
40	Which of the following energy resources is NOT renewable?	0.584	0.788	0.410	0.378
41	Which resource provides about 85% of the energy used in developed countries like Japan, the United States, and Europe?	0.328	0.524	0.158	0.365
42	The best reason to buy an appliance labeled "energy efficient" is ...	0.831	0.947	0.631	0.316
43 *	The percentage of our energy consumption depends on imported energy resources is	0.133	0.192	0.098	**0.094**
44	It is impossible regarding energy to	0.439	0.582	0.350	0.232
45	When you turn on an incandescent light bulb, some of the energy is converted into light and the rest is converted into ...	0.758	0.919	0.596	0.324

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No.	Items of cognitive subscale	Total *(Df)*	H_27% *(Df)*	L_27% *(Df)*	Disc. *(D)*
46 *	Correct description about methane hydrate development in Japan	0.349	0.552	0.175	0.377
47 *	Correct description about the CO_2 emission increasing which causes global warming	0.691	0.942	0.344	0.597
48	If a person travelled alone to work 10km every day and wanted to save gasoline, which one of the following options would save the MOST gasoline?	0.290	0.398	0.221	0.177
49	Proper description about the amount and cost of petroleum imported to Japan over the past decade	0.280	0.237	0.290	**-0.053**
50	Which energy resource was made by photosynthesis?	0.110	0.123	0.107	**0.016**
51 *	Incorrect description about radiation	0.534	0.638	0.429	0.209
52 *	The sector that consume oil MOST in Japan	0.459	0.518	0.377	**0.141**
53	Which of the following statements best DEFINES energy?	0.155	0.223	0.093	**0.130**
54	Proper description about renewable energy resources	0.153	0.170	0.109	**0.061**
55	Which two things determine the amount of ELECTRICAL ENERGY (ELECTRICITY) an electrical appliance will consume?	0.443	0.682	0.232	0.450
56	Scientists say the single fastest and most cost-effective way to address our energy needs is to ...	0.511	0.596	0.391	0.205
57	Which resource provides MOST of the ENERGY used in Japan in 2010?	0.398	0.471	0.268	0.203
58	Many scientists say the Earths average temperature is increasing. They say that one important cause of this change is	0.489	0.772	0.238	0.534
59 *	Correct description about energy	0.453	0.655	0.254	0.400
60	Which of the following energy-related activities is LEAST harmful to human health and the environment?	0.585	0.819	0.284	0.535
61 *	Which of the following correctly describes oil depletion?	0.144	0.162	0.145	**0.017**
62	Which uses the LEAST ENERGY in the average Japanese home in recent year?	0.193	0.281	0.115	0.167
63	How do you know that a piece of wood has stored chemical potential energy?	0.471	0.599	0.342	0.257
64	Most of the RENEWABLE ENERGY used in Japan comes from	0.267	0.409	0.178	0.232
65 *	Incorrect description about nuclear power plant operating safely	0.267	0.415	0.134	0.281

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No.	Items of cognitive subscale	Total *(Df)*	H_27% *(Df)*	L_27% *(Df)*	Disc. *(D)*
66	Which one of the following sources generates the most ELECTRICITY in Japan in the past few years?	0.082	0.033	0.112	**-0.079**
67	All of the following are forms of energy EXCEPT ...	0.165	0.214	0.139	**0.075**
68	What does it mean if an electric power plant is 35% efficient?	0.359	0.604	0.189	0.416
69 *	Correct description about energy resources development alternative to fossil fuels	0.165	0.192	0.148	**0.045**
70	Appropriate description about energy choice in Japan	0.577	0.710	0.437	0.273
71	Which lifestyle of the following choices ALWAYS SAVES energy?	0.663	0.855	0.467	0.388
72	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?	0.362	0.557	0.202	0.355
73 *	The MOST appropriate description about energy choices in current situation in Japan?	0.403	0.549	0.246	0.303
74 *	The MOST appropriate description about the environmental impact by energy resource development and use	0.404	0.630	0.232	0.397
75 *	Correct description about petroleum that Japan consumes most	0.454	0.727	0.238	0.489
76 *	Appropriate description about abandoning nuclear power in Japan	0.285	0.279	0.306	**-0.027**
77 *	Appropriate description about renewable and non-renewable energy	0.318	0.518	0.178	0.341
78	The original source of energy for almost all living things on earth is ...	0.514	0.638	0.372	0.266
	Total average of cognitive subscale	0.395	0.523	0.273	0.251

End of the table

Table B.2. Item Selection Trend of Affective Subscale.

No.	Items of affective subscale	Extremely agree %		Neutral %		Extremely disagree %
5	We should make more of our electricity from renewable resources	36.6	28.5	29.7	4.3	1.0
6	(Se) I believe that I can contribute to solving energy problems by working with others	6.1	16.7	44.1	22.9	10.2
7	(Se) The way I personally use energy does not really make a difference to the energy problems that face our nation (R)	2.8	9.0	39.6	32.2	16.4
8	More wind farms should be built to generate electricity, even if the wind farms are located in scenic valleys, farmlands, and wildlife areas (R)	13.7	18.0	31.7	22.7	13.9
9	All electrical appliances should have a label that shows the resources used in making them, their energy requirements, and operating costs	8.3	18.6	47.3	17.6	8.1
10	Saving energy is importan	61.9	25.0	10.3	2.1	0.8
11	Efforts to develop renewable energy technologies are more important than efforts to find and develop new sources of fossil fuels.	17.6	26.2	46.6	7.2	2.4
12	The government should have stronger restrictions about the gas mileage of new cars	16.3	27.7	41.2	11.2	3.6
13	(Se) I dont need to worry about turning the lights or computers off in the classroom, because the school pays for the electricity (R)	4.5	5.6	20.1	31.0	38.8
14 *	Burden on general public by strict energy-saving is poor reality in everyday life even if energy issues are critical	15.8	23.9	37.2	16.9	6.2
15	We don’ t have to worry about conserving energy, because new technologies will be developed to solve the energy problems for future generations (R)	2.4	6.5	33.8	38.1	19.2
16	Japanese should conserve more energy.	31.2	32.4	29.0	5.6	1.7
17	Laws protecting the natural environment should be made less strict in order to allow more energy to be produced (R)	3.4	6.5	45.4	29.3	15.3
18	I would do more to save energy if I knew how	25.2	29.9	33.6	8.6	2.7
19	More Geothermal power generation should be developed as they are discovered to increase energy self-sufficiency ratio, even if they are located in areas protected by environmental laws (R)	9.7	19.9	49.8	15.3	5.2

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No.	Items of affective subscale	Extremely agree %		Neutral %		Extremely disagree %
20	Japan should develop more ways of using renewable energy, even if it means that energy will cost more (R)	7.8	16.5	45.2	21.8	8.7
21	(Se) I believe that I can contribute to solving the energy problems by making appropriate energy-related choices and actions	16.5	29.1	43.2	8.1	3.0
22	Energy education should be an important part of every school's curriculum	16.8	26.8	41.2	10.5	4.7
23 *	Need for the Energy-best-mix policy which develops both nuclear power and renewable sources in Japan as an energy insufficient country.	11.4	17.9	52.6	11.9	6.2

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Table B.3. Item Selection Trend of Behavioral Subscale.

No.	Items of behavioral subscale	Always %		Neutral %		Not at all %
24	Many of my everyday decisions are affected by my thoughts on energy use	2.3	9.3	32.1	32.1	24.1
25	I am willing to buy fewer things in order to save energy	3.2	9.9	40.6	30.1	16.3
26	I always sort household waste according to the regulations	38.9	29.0	22.0	7.3	2.9
27	I am willing to encourage my family to turn the heat down at night or the air conditioner temperature up when were not home to save energy	19.8	29.5	29.4	13.5	7.8
28	I always keep on running water when washing my teeth, face or shampooing (R)	8.8	7.8	18.2	24.2	41
29 *	I may change own idea if I understand that the energy choice is for sustainable society	7.3	21.0	59.7	9.0	3.0
30	When I leave a room, I turn off the light and computer	54.8	21.3	14.1	7.1	2.8
31	My family buys energy efficient compact fluorescent light bulbs	24.6	27.5	31.8	11.1	5.0
32 *	Development of renewable energy is important, but the policy to become a burden on the economic and industrial activities should be considered carefully	22.7	28.4	41.3	5.3	2.3

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No.	Items of behavioral subscale	Always %		Neutral %		Not at all %
34	For energy-saving, my family sets the temperatures on the air-conditioners higher in summer, lower in winter	25.5	25.2	32.5	11.6	5.1
35	I am willing to encourage my family to buy energy efficient compact fluorescent light bulbs and home appliance	7.2	13.4	36.4	21.1	21.9

End of the table

Table B.4. Effective Information Sources for Energy Literacy.

Information sources	N	M(%)	SD(%)	SE(%)
Cognitive				
1. Science class	394	38.95	13.38	0.67
2. Social studies class	34	40.08	16.86	2.89
3. Technical course & Home economics class	75	37.83	13.88	1.60
4. Integrated studies class	17	42.82	16.67	4.04
5. Museum, Exhibition	74	41.45	13.52	1.57
6. TV, Radio	363	39.69	13.73	0.72
7. Books	45	46.41	17.75	2.65
8. Newspaper, Magazine	38	43.57	15.54	2.52
9. Internet	208	38.36	14.74	1.02
10. Conversation with family	21	42.97	16.04	3.50
11. Conversation with friends	10	39.30	15.75	4.98
12. Others	3	18.60	6.15	3.55
Affective				
1. Science class	394	69.21	7.13	0.36
2. Social studies class	34	69.97	9.06	1.55
3. Technical course & Home economics class	75	67.13	7.60	0.88
4. Integrated studies class	17	68.36	8.48	2.06
5. Museum, Exhibition	74	71.54	6.79	0.79
6. TV, Radio	363	68.96	6.88	0.36
7. Books	45	71.20	8.64	1.29
8. Newspaper, Magazine	38	72.80	6.53	1.06
9. Internet	208	67.92	8.05	0.56
10. Conversation with family	21	67.22	7.30	1.59
11. Conversation with friends	10	70.84	10.05	3.18
12. Others	3	56.14	5.99	3.46
Self-efficacy				
1. Science class	394	69.16	12.99	0.65
2. Social studies class	34	66.76	14.82	2.54
3. Technical course & Home economics class	75	66.20	9.69	1.12
4. Integrated studies class	17	63.53	11.15	2.70
5. Museum, Exhibition	74	72.30	14.12	1.64
6. TV, Radio	363	69.46	11.42	0.60
7. Books	45	70.33	12.40	1.85
8. Newspaper, Magazine	38	75.26	11.97	1.94
9. Internet	208	66.66	13.23	0.92
10. Conversation with family	21	65.48	12.54	2.74
11. Conversation with friends	10	75.50	14.23	4.50
12. Others	3	60.00	5.00	2.89
Behavior				
1. Science class	394	66.78	10.51	0.53

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Information sources	N	M(%)	SD(%)	SE(%)
2. Social studies class	34	66.20	9.45	1.62
3. Technical course & Home economics class	75	65.70	10.60	1.22
4. Integrated studies class	17	68.13	9.12	2.21
5. Museum, Exhibition	74	70.54	9.65	1.12
6. TV, Radio	363	67.28	10.43	0.55
7. Books	45	66.34	9.49	1.42
8. Newspaper, Magazine	38	71.53	9.03	1.46
9. Internet	208	65.30	11.10	0.77
10. Conversation with family	21	67.01	12.98	2.83
11. Conversation with friends	10	66.55	12.13	3.83
12. Others	3	53.94	12.38	7.15

End of the table

Table B.5. Multiple Comparison between Effective Information Sources and Energy Literacy.

Level 1	Level 2	Mean 1(%)	Mean 2(%)	Difference (%)	*SE*	*p*	
Cognitive							
1. Science class	7. Books	38.95	46.41	7.46	2.23	0.040	*
7. Books	9. Internet	46.41	38.36	8.05	2.33	0.028	*
7. Books	12. Others	46.41	18.60	27.80	8.45	0.048	*
Affective							
3. Tech.& Home	5. Museum, Exhibition	67.13	71.54	4.41	1.21	0.014	*
3. Tech.& Home	8. Newspaper, Magazine	67.13	72.80	5.67	1.47	0.007	***
5. Museum, Exhibition	9. Internet	71.54	67.92	3.62	1.00	0.016	*
5. Museum, Exhibition	12. Others	71.54	56.14	15.40	4.34	0.021	*
7. Books	12. Others	71.20	56.14	15.06	4.39	0.031	*
8. Newspaper, Magazine	9. Internet	72.80	67.92	4.88	1.30	0.010	**
8. Newspaper, Magazine	12. Others	72.80	56.14	16.66	4.42	0.009	**
Self-efficacy							
3. Tech.& Home	8. Newspaper, Magazine	66.20	75.26	9.06	2.48	0.014	*
5. Museum, Exhibition	9. Internet	72.30	66.66	5.64	1.69	0.041	*
8. Newspaper, Magazine	9. Internet	75.26	66.66	8.60	2.20	0.005	**
Behavior							
5. Museum, Exhibition	9. Internet	70.54	65.30	5.24	1.42	0.012	*
8. Newspaper, Magazine	9. Internet	71.53	65.30	6.23	1.85	0.037	*

$^{*}p < .05$, $^{**} < .01$, $^{***} < .005$

Appendix C

Theoretical models with standardized coefficients for exploring energy literacy structural model

Standardized regression coefficients of the Theory of Planned Behavior, Value-Belief-Norm Theory, and the hypothesis energy literacy structural model before model improvement are presented in Fig. C.1, C.2, and C.3 with model fitness indices. All coefficients are significant except the covariance between basic energy knowledge and subjective norm in the hypothesis model ($\beta = 0.04$, $p = 0.164$).

The TPB explains 51% of the variance in energy-saving behavior with the intention and perceived behavioral control. Furthermore, the attitude toward the behavior, subjective norm, and perceived behavioral control were able to explain relatively equally 59% of the variance in intention (Fig. C.1). While in the VBN, only 15% of variance in energy-saving behavior was explained by personal norm which is activated by the ascription of responsibility and awareness of consequences, which is predicted by basic energy knowledge. Students' belief which is hypothesized to cultivate by basic energy knowledge provided by energy education cannot explain sufficiency forming energy-saving behavior by the VBN (Fig. C.2). The hypothesis model integrated with the TPB and VBN explained 48% of the variance in energy-saving behavior with the intention and perceive behavioral control. Fifty-two percent (52%) of the variance in intention was explained by subjective norm, perceived behavioral control, and attitude toward the behavior. The attitude toward the behavior was predicted by the awareness of consequences predicted by the basic energy knowledge, larger relative to the ascription of responsibility and personal norm (Fig. C.3).

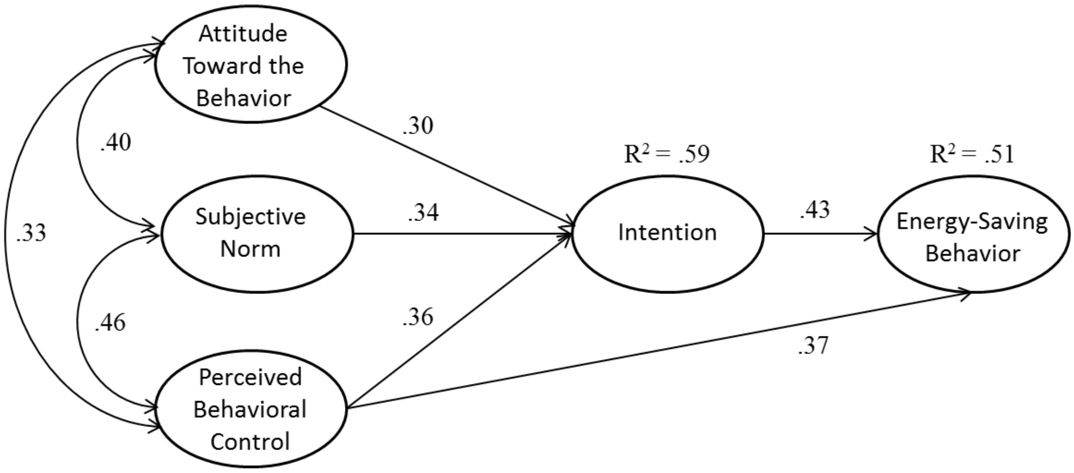

Fig. C.1. Standardized coefficients of the Theory of Planned Behavior. GFI = 0.985; AGHI = 0.889; SRMR = 0.0281; NFI = 0.982; CFI = 0.983; RMSEA = 0.135

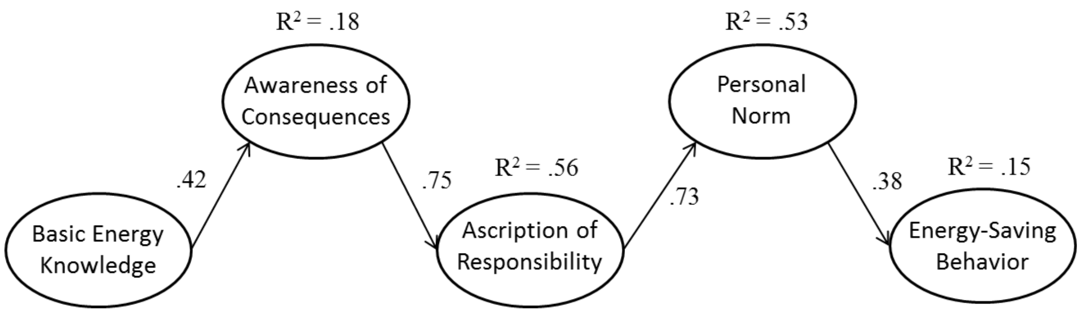

Fig. C.2. Standardized coefficients of the Value-Belief-Norm Theory. GFI = 0.883; AGHI = 0.708; SRMR = 0.0856; NFI = 0.846; CFI = 0.848; RMSEA = 0.241

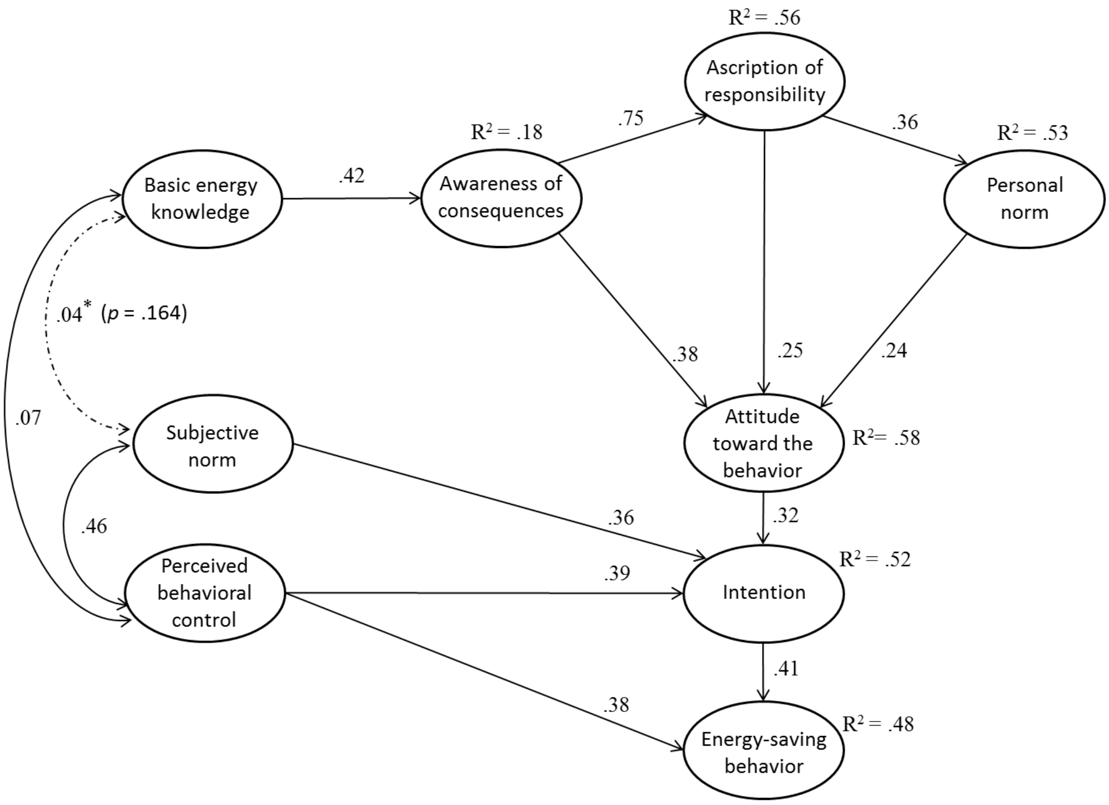

Fig. C.3. Standardized coefficients of the hypothesis Energy Literacy Structural Model. GFI = 0.881; AGHI = 0.756; SRMR = 0.1958; NFI = 0.866; CFI = 0.869; RMSEA = 0.176

Appendix D

Item analysis of survey for Thailand and Japan

The low discrimination index (D) less than 0.2 is emphasized in bold. The items with "α" were eliminated by evaluating internal consistency and with the (R) symbol is a reverse question which is converted into the reversed point.

Students item selections of Thai and Japan are presented in Fig. D.1 to Fig. D.5. The correct answers choice in the BEK is marked with square (Fig. D.1).

Table D.1. Item Discrimination (D) Analysis of Thailand and Japan.

	Question items	Thai (N = 635)				Japan (N = 1070)			
		Overall	Upper %	Lower %	D	Overall	Upper %	Lower %	D
	Basic energy knowledge N	635	154	209		1070	356	336	
	BEK Total	40.8	63.7	21.9	0.42	47.9	69.3	25.2	0.44
BEK01	Each and every action on Earth involves . . .	70.7	96.8	38.8	0.58	59.8	78.9	35.7	0.43
BEK02	One advantage to using nuclear power instead of coal or petroleum for energy is that . . .	39.2	48.1	20.1	0.28	53.5	73.0	38.1	0.35
BEK03	How much does our energy consumption depend on imported energy resources? (change to Local content)	17.2	14.3	14.8	**-0.01**	20.0	32.9	11.0	0.22
BEK04	It is impossible to . . .	24.9	35.1	20.1	**0.15**	39.2	58.1	26.5	0.32
BEK05	Which of the following is produced by photosynthesis?	37.6	50.0	17.7	0.32	19.9	25.3	13.7	**0.12**
BEK06	Which of the following statements best DEFINES energy?	23.9	23.4	21.5	**0.02**	12.8	18.5	11.0	**0.08**
BEK07	Which two things determine the amount of ELECTRICAL ENERGY (ELECTRICITY) an electrical appliance will consume?	44.4	82.5	18.2	0.64	47.0	75.6	23.5	0.52
BEK08	Which of the following description is correct about energy? Energy . . .	49.8	81.2	17.2	0.64	49.7	72.8	20.8	0.52
BEK09	How do you know that a piece of wood has stored chemical potential energy?	43.9	69.5	29.2	0.40	47.6	68.0	27.4	0.41
BEK10	All of the following are forms of energy EXCEPT . . .	9.1	9.7	11.0	**-0.01**	31.2	54.2	12.8	0.41
BEK11	What does it mean if an electric power plant is 35% efficient?	34.5	57.8	14.8	0.43	39.4	66.6	14.9	0.52
BEK12	Which of the following choices ALWAYS SAVES energy? (change to local contents)	30.2	64.3	11.0	0.53	79.0	96.9	45.2	0.52
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?	32.6	76.0	7.7	0.68	40.8	69.9	16.7	0.53
BEK14	Which of the following description is correct about petroleum that our country consumes most? (change to Local content)	30.2	59.1	17.2	0.42	53.2	86.0	19.3	0.67
BEK15	The original source of energy for almost all living things on earth is . . .	60.8	89.6	34.0	0.56	48.9	60.4	34.5	0.26
CEI01	The best reason to buy an appliance labeled “energy efficient” is . . . (change to Local content)	82.4	97.4	56.0	0.41	83.1	98.0	55.4	0.43

to be continued

Continued from the previous page

		Thai (N = 635)				Japan (N = 1070)			
	Question items	Overall	Upper %	Lower %	D	Overall	Upper %	Lower %	D
CEI02	Which of the following description is correct about the CO_2 emission increasing as the cause of global warming?	42.8	89.0	10.0	0.79	67.5	97.2	23.5	0.74
CEI03	Many scientists say the Earth's average temperature is increasing. They say that one important cause of this change is . . .	49.4	85.7	22.5	0.63	50.8	84.8	15.5	0.69
CEI04	Which of the following energy-related activities is LEAST harmful to human health and the environment?	26.5	58.4	14.8	0.44	66.9	93.5	32.4	0.61
CEI05	Which of the following is MOST appropriate description about the environmental impact by energy resource development and use?	65.4	85.7	41.1	0.45	48.5	75.6	25.9	0.50
	Awareness of consequences N	635	174	194		1070	315	331	
	AC Total	78.9	92.0	65.3	0.27	79.7	93.6	65.0	0.29
AC01	All electrical appliances should have a label that shows the resources used in making them, their energy requirements, and operating costs	85.6	96.0	71.4	0.25	62.9	75.2	53.8	0.21
AC02	Saving energy is important	87.7	97.0	74.1	0.23	88.8	98.0	77.4	0.21
AC03	The government should have stronger restrictions about the gas mileage of new cars	77.7	90.6	65.5	0.25	68.6	82.7	56.1	0.27
AC04	People in our country should save more energy	85.9	95.9	73.1	0.23	82.2	95.1	67.7	0.27
AC05	If the global warming progresses by energy mass consumption, thousands of plant and animal species will become extinct	77.2	91.4	61.5	0.3	87.3	98.6	72.5	0.26
AC06	If the global warming progresses by energy mass consumption, environmental threats to public health are serious	80.1	94.7	64.8	0.3	81.3	97.7	64.2	0.33
AC07	Energy saving is beneficial for environmental protection and for my health	78.6	94.3	63.1	0.31	76.6	92.8	62.7	0.30
AC08	Massive consumption of fossil fuel causes global warming, environmental damage, and affects people all over the world	76.2	91.3	62.3	0.29	81.7	97.6	65.0	0.33
AC09	Resource depletion by massive energy consumption will be a very serious problem for the country as a whole	79.3	93.3	66.4	0.27	84.5	98.2	67.3	0.31

to be continued

Continued from the previous page

	Question items	Thai (N = 635) Overall	Upper %	Lower %	D	Japan (N = 1070) Overall	Upper %	Lower %	D
AC10	Climate change will be a very serious problem for me and my family	65.6	79.5	55.3	0.24	80.3	95.7	64.4	0.31
AC11	The destruction of tropical forests for meeting humans' demand will be a very serious problem for me and my family	73.8	88.6	60.6	0.28	82.8	97.9	64.3	0.34
	Ascription of responsibility N	635	178	171		1070	312	337	
	AR Total	75.6	86.2	63.2	0.23	76.3	91.0	61.4	0.30
AR01	Even if the school pays for the electricity, I should worry about turning the lights or computers off in the classroom	82.5	96.4	63.9	0.33	83.8	97.5	67.1	0.30
AR02	Even if new technologies will be developed to solve the energy problems for future generations, we should continue energy saving	86.3	97.6	69.1	0.29	78.5	94.0	62.3	0.32
AR03	Even if it would be produced more energy for future, the laws of protecting the natural environment should be made strictly	83.6	95.3	67.4	0.28	78.7	96.0	62.0	0.34
AR04	The way I personally use energy does really make a difference to the energy problems that face our nation up	75.4	87.6	61.1	0.27	70.0	83.1	57.4	0.26
AR05	Every member of the public should accept responsibility for energy saving to protect the global environment	83.9	95.7	67.3	0.28	79.4	94.9	62.5	0.32
AR06 α	The authorities, not the public, are responsible for energy saving and the environment (R)	48.5	48.1	53.6	**-0.05**	75.6	90.4	63.4	0.27
AR07	I am not worried about energy saving and the global environment (R)	68.8	82.6	59.9	0.23	68.3	81.5	55.3	0.26
	Personal norm N	635	204	201		1070	327	405	
	PN Total	78.9	92.3	63.4	0.29	74.5	89.5	61.3	0.28
PN01	I feel guilty when I squander energy	72.8	85.9	60.4	0.25	74.0	90.8	60.6	0.30
PN02	I feel I ought to save energy for solving climate change and protecting global environment	83.8	95.4	69.1	0.26	86.1	98.3	72.2	0.26
PN03	Business and industry should conserve energy consumption to reduce greenhouse gas emissions to help prevent climate change	82.7	96.2	65.2	0.31	80.2	95.7	65.0	0.31

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Continued from the previous page

	Question items	Thai (N = 635) Overall	Upper %	Lower %	D	Japan (N = 1070) Overall	Upper %	Lower %	D
PN04	The government should take a strong leadership for energy policy to reduce greenhouse gas emissions and prevent global climate change	81.6	96.7	63.7	0.33	73.7	91.8	58.7	0.33
PN05	I feel a personal obligation to do whatever I can contribute including energy saving to prevent climate change	73.4	87.2	58.7	0.28	58.4	70.6	49.8	0.21
	Attitude toward the behavior N	635	187	202		1070	343	363	
	ATB Total	82.6	95.0	68.3	0.27	77.6	90.6	64.7	0.26
ATB01	For me energy saving is important	81.5	93.4	67.7	0.26	92.2	99.3	83.2	**0.16**
ATB02	For me saving energy is valuable	88.9	98.8	75.1	0.24	85.0	97.7	70.1	0.28
ATB03	For me saving energy is effective	89.4	98.1	75.5	0.23	78.3	94.6	63.4	0.31
ATB04	For me saving energy is interesting	77.4	93.0	62.4	0.31	53.4	69.3	39.1	0.30
ATB05	Energy saving will help us to reduce greenhouse gas emission	81.0	95.1	66.6	0.28	75.2	89.3	62.4	0.27
ATB06	Energy saving will help us to save money	83.9	97.0	68.2	0.29	88.1	97.7	76.9	0.21
ATB07	Energy saving will give us an opportunity to consider new values of life style	75.8	89.3	62.5	0.27	71.1	86.1	57.6	0.28
	Subjective norm N	635	195	178		1070	312	336	
	SN Total	72.7	86.2	58.7	0.28	61.5	75.4	47.9	0.28
SN01	My family thinks that I should save energy	78.8	89.7	64.9	0.25	68.3	84.7	53.5	0.31
SN02	Most people who are important to me think that I should save energy	77.4	90.9	59.9	0.31	63.3	78.6	48.9	0.30
SN03	Most of the students in this class think that I should save energy	72.6	88.3	55.6	0.33	50.4	63.4	35.9	0.28
SN04	My family has saved energy	76.1	86.8	63.3	0.24	68.8	83.3	52.9	0.30
SN05	Most people who are important to me have saved energy	70.1	83.3	55.7	0.28	63.0	77.3	50.0	0.27
SN06	Most of the students in this class have saved energy	69.0	81.4	58.1	0.23	52.8	61.9	42.7	**0.19**
SN07	Most people who I respect appreciate my energy saving behavior	65.4	81.2	51.6	0.30	60.2	75.6	46.0	0.30
SN08	When it comes to energy saving, I want to do what the important people expect to me	71.0	87.4	58.0	0.29	64.6	77.9	52.8	0.25
SN09	Generally speaking, how much do you care what the people around you think you should save energy?	73.4	86.9	60.8	0.26	62.2	75.8	48.3	0.27
	Perceived behavioral control N	635	181	173		1070	296	333	
	PBC Total	71.7	85.5	57.2	0.28	67.7	83.9	52.7	0.31
PBC01	For me saving energy is difficult (R)	66.7	85.7	46.0	0.40	62.6	82.8	44.2	0.39

to be continued

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	Question items	Thai (N = 635)				Japan (N = 1070)			
		Overall	Upper %	Lower %	D	Overall	Upper %	Lower %	D
PBC02 α	Energy saving is up to me	87.9	95.7	77.0	**0.19**	77.6	86.8	68.6	**0.18**
PBC03	I am confident that I can save energy	81.1	92.3	69.4	0.23	61.1	80.3	42.8	0.38
PBC04	For me saving energy is possible	82.0	93.5	68.4	0.25	86.4	97.9	73.5	0.24
PBC05 α	How often do you encounter unanticipated events that you cannot do saving-energy? (R)	59.4	70.8	48.0	0.23	65.5	73.9	58.9	**0.15**
PBC06	How often do you forget to do saving-energy? (R)	60.6	76.0	45.5	0.30	58.9	81.0	39.3	0.42
PBC07	How often do you feel troublesome to do saving-energy? (R)	64.3	84.4	46.1	0.38	61.5	84.7	42.0	0.43
	Intention N	635	181	196		1070	344	318	
	INT Total	68.0	82.7	54.2	0.28	61.2	75.4	45.2	0.30
INT01 α	If there were ten people around you, what do you think how many people save energy? (choose the number of persons)	54.0	70.3	39.7	0.31	46.9	59.6	33.2	0.26
INT02									
INT03	I am always thinking about the way of energy saving	67.3	82.7	53.4	0.29	57.9	73.5	39.4	0.34
INT04	I will make an effort to save energy	73.8	87.1	61.6	0.25	70.3	86.5	49.3	0.37
INT05	I will do more to save energy if I knew how	80.4	93.7	66.8	0.27	72.1	88.1	55.1	0.33
INT06	I believe that I can contribute to solving the energy problems by making appropriate energy-related choices and actions (e.g. buy an energy efficient electric appliance, use one thing for a long time)	78.3	91.9	63.9	0.28	73.2	84.9	60.8	0.24
	Energy-saving behavior N	635	185	174		1070	300	333	
	ESB Total	71.9	84.2	59.3	0.25	67.8	81.2	55.2	0.26
ESB01	When I leave a room, I turn off the light	84.2	91.7	73.6	**0.18**	90.1	97.1	81	**0.16**
ESB02	I regularly separate the waste according to the regulations	60.2	74.5	47.8	0.27	81.1	92.0	67.5	0.24
ESB04	I turn off the computer when it is not being used	83.2	93.1	68.9	0.24	87.6	97.4	77.1	0.20
ESB05 α	I always keep on running water when washing my teeth, face or shampooing (R)	68.6	79.4	58.0	0.21	78.5	89.9	66.3	0.24
ESB06	I try to choose the 'ENERGY STAR' appliances/products (change to Local content)	84.6	93.1	73.6	0.20	47.2	62.9	35.0	0.28
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	63.5	74.1	52.5	0.22	61.8	75.5	50.9	0.25

to be continued

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	Question items	Thai (N = 635)				Japan (N = 1070)			
		Overall	Upper %	Lower %	D	Overall	Upper %	Lower %	D
ESB08	I cut down on my consumption of disposal items whenever possible (e.g. Plastic bags from the supermarket, excessive packaging at the department store)	63.1	77.8	52.3	0.26	62.5	80.5	45.3	0.35
ESB09	I try to reduce the waste	72.2	87.0	56.2	0.31	64.6	82.4	49.7	0.33
ESB10	In the past six months, I have made an effort for energy saving	66.6	81.2	53.2	0.28	54.6	72.3	38.7	0.34
ESB11	For me to gain a better understanding of energy saving is important	75.1	90.1	59.2	0.31	74.2	86.3	62.6	0.24
ECB01	Many of my everyday decisions are affected by my thoughts on energy use	70.5	83.8	59.3	0.24	63.6	76.4	52.0	0.24
ECB02	I am willing to buy fewer things to save energy	70.8	85.2	57.0	0.28	48.1	61.5	36.0	0.25

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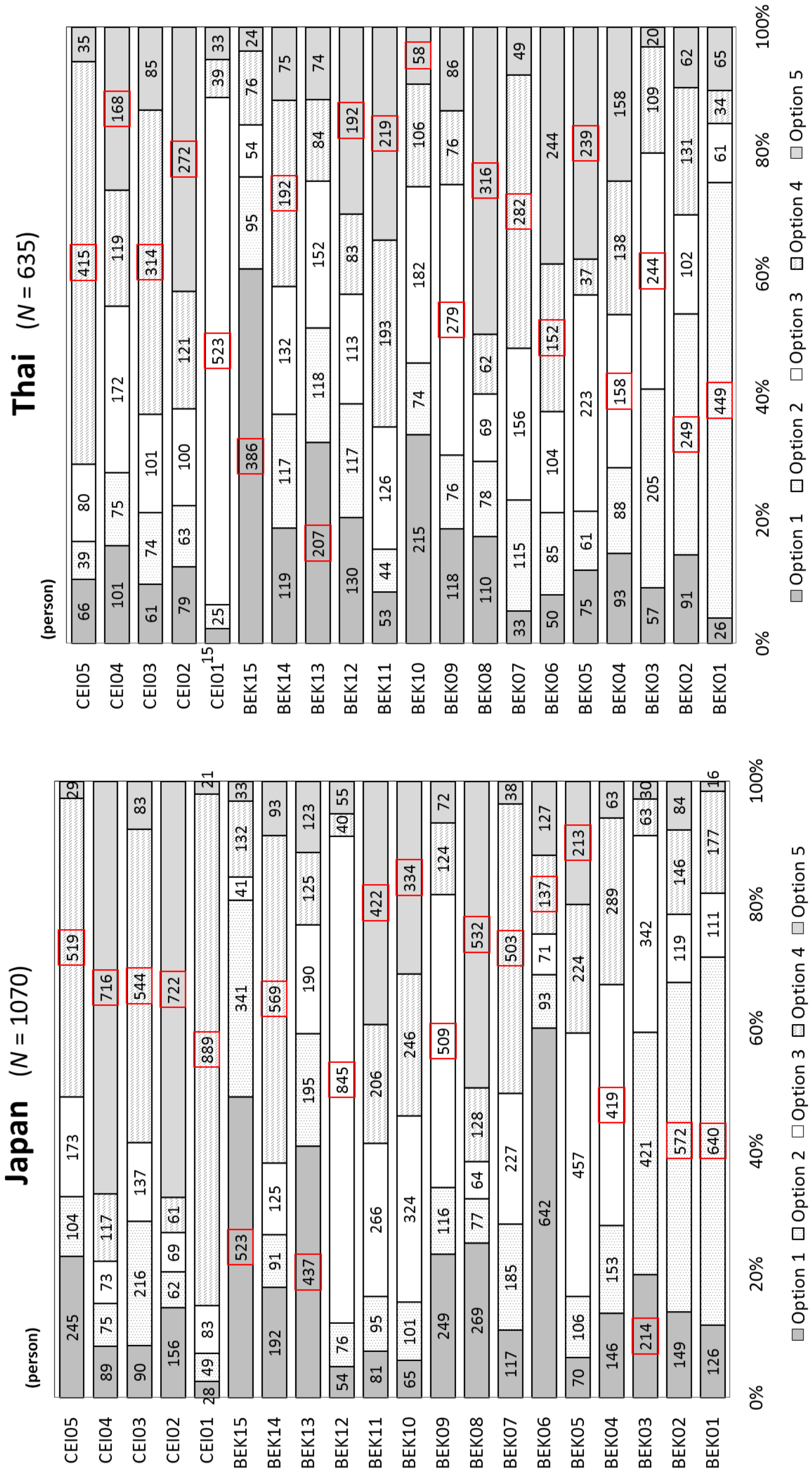

Fig. D.1. Students' Selection on Basic Energy Knowledge.

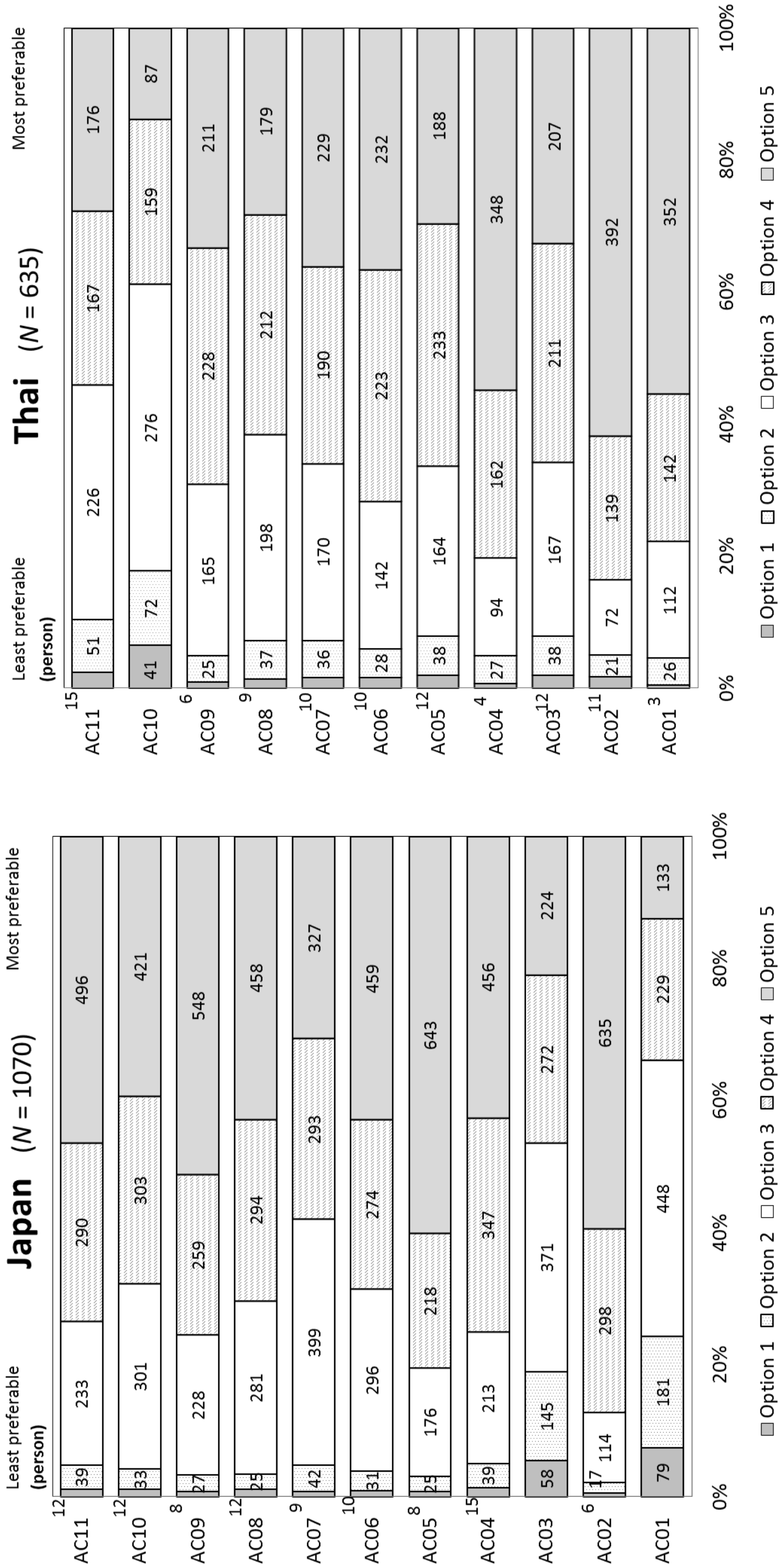

Fig. D.2. Students' Selection on Awareness of Consequences.

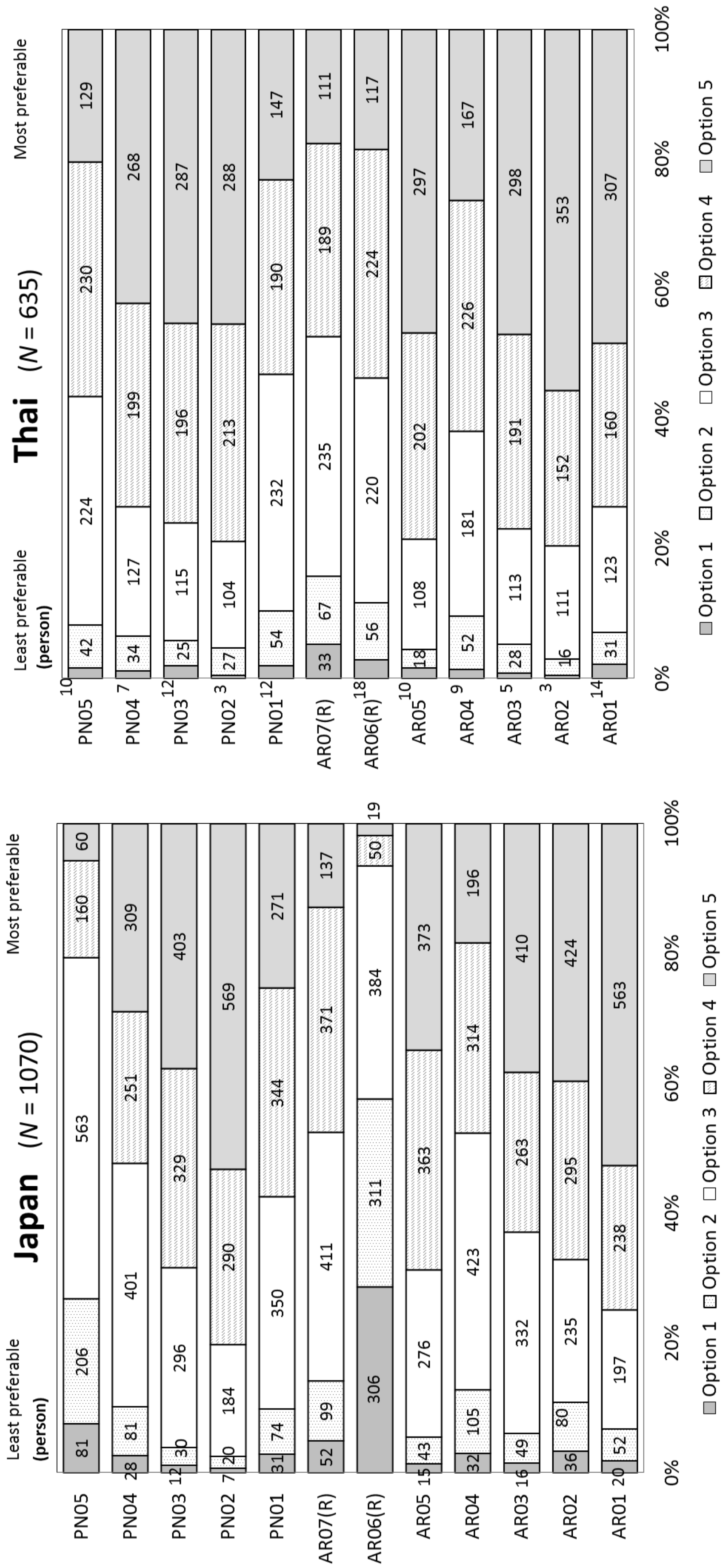

Fig. D.3. Students' Selection on Ascription of Responsibility and Personal Norm.

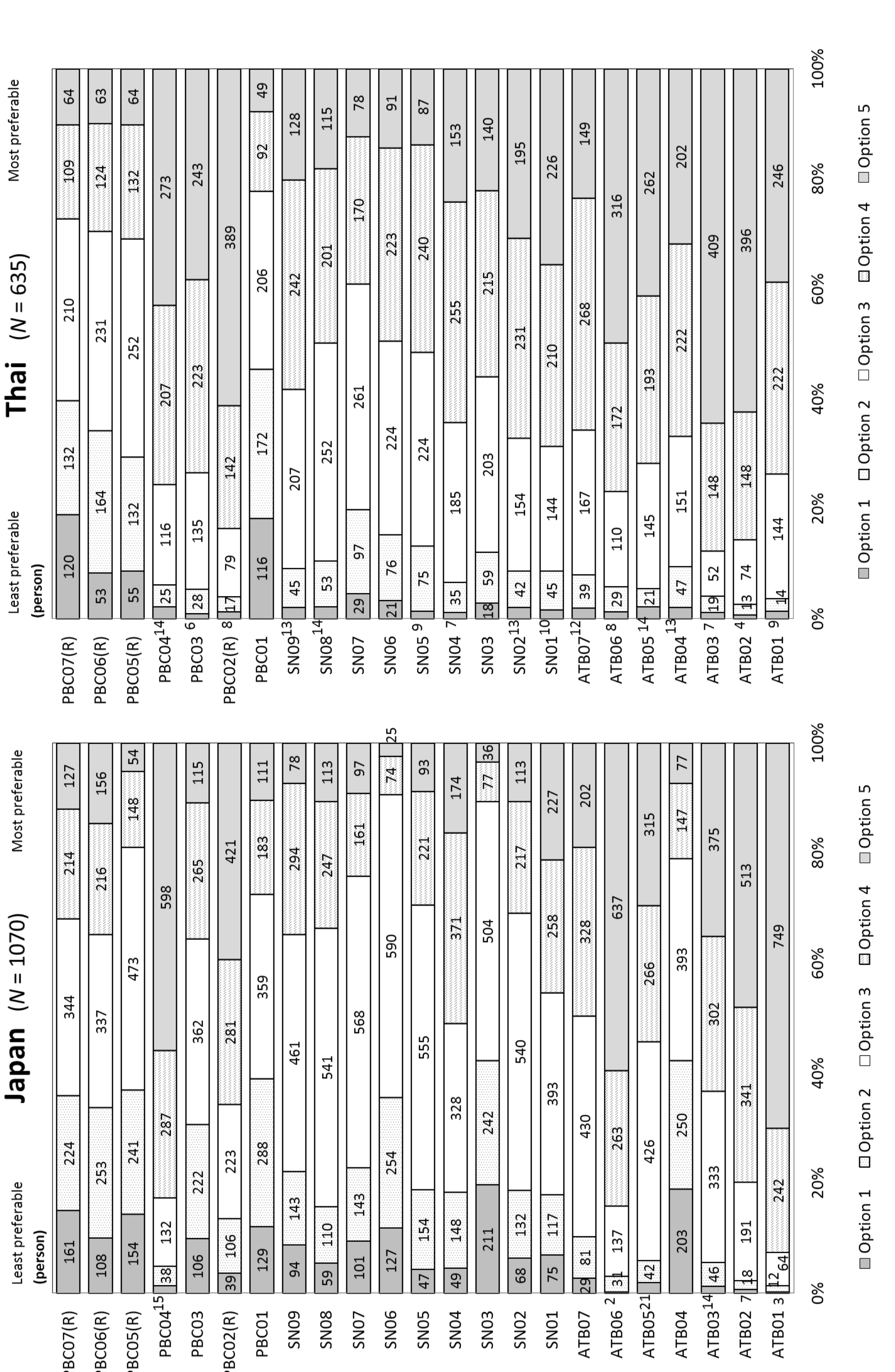

Fig. D.4. Students' Selection on Attitude toward the Behavior, Subjective Norm, and Perceived Behavioral Control.

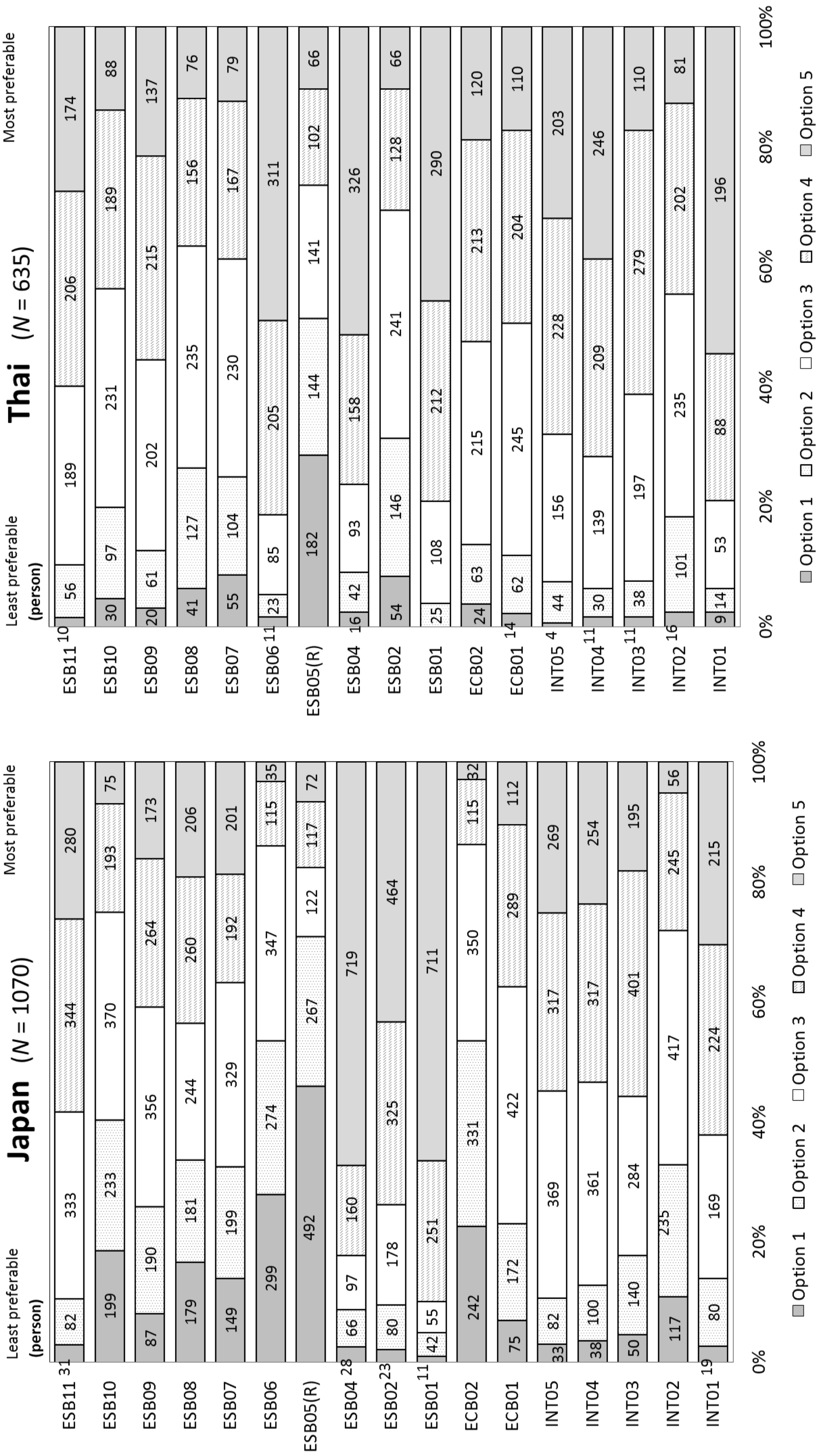

Fig. D.5. Students' Selection on Intention and Energy-Saving Behavior.

Appendix E

Survey questionnaires used for energy literacy assessment

There are three questionnaires.

- Fig. E.1 was developed for the assessment of Japanese students and the comparison with the result of the U. S. middle students (Chapter 3).
- Fig. E.2 was developed for the improvement of energy literacy model (Chapter 5).
- Lastly, Fig. E.3 was developed based on the Fig. E.2. It was modified to meet Thai situation and translated into Thai language (Chapter 6). The item numbers of Thai questionnaire are indicated by two numbers with underscore. The former is a serial number of Thai and the latter corresponds to the number of the questionnaire for Japanese students (Fig. E.2). The questionnaire provided to Thai students has no latter number. Demographic items in English was presented at the end of Thai questionnaire.

Table E.1 presents the correspondence between question numbers and survey variables in questionnaire for Japan 2016 and for Thai 2017. Items with an asterisk (*) have been deleted from Thai questionnaire beforehand. Variables of ABC01, ABC02, and ABC03 of the actual behavioral control in the TPB were eliminated from analysis due to lack of internal consistensy (Table E.2).

E.1 Questionnaire for Japanese Students 2014

京都大学
KYOTO UNIVERSITY

エネルギー・リテラシー調査（中学生用）

2014 年 3 月

A Broad Assessment of Energy-related Knowledge, Attitudes and Behaviors

【お問合せ先】
京都大学大学院エネルギー科学研究科
エネルギー社会・環境科学専攻
エネルギー社会工学分野（石原研究室）
修士課程　秋津　裕
akitsu@social-system.energy.kyoto-u.ac.jp
〒606-8507 京都府京都市左京区吉田本町
tel & fax: 075-753-5488

Fig. E.1. Questionnaire for Japanese Students 2014.

エネルギー･リテラシー調査（中学生用）

A Broad Assessment of Energy –related Knowledge, Attitudes and Behaviors

はじめに

この調査は**テストではありません**ので相談したり調べたりする必要は全くありません.

まだ学校で習ってないことや，知らないことも出てくるかもしれませんが，皆様がエネルギーについてどの様なことを知っていて，考えたり行動したりしているかを知るための重要な調査です．どなたの回答かはわからないようになっていますので，回答者ご自身が思った通りに正直にお答え下さい.

アンケートには５つのセクションがあります.

① セクション１，２，３，４では，いずれも１～５の選択肢がありますので，ご自分がそうだと思ったところに１つだけ○をつけて下さい.
② また，あなたが「どのくらい」そう思うか，その通りなのかを１～５の物差しでたずねているものがあります．自分の気持ちの大きさにあっている番号に○をつけて下さい．遠慮はいりません.
③ セクション４では，**「まちがっているもの」**や**「～～ではないもの」**をたずねている質問もありますので，よく読んで回答頂けますようお願いします.
④ セクション５はこの研究の大切な基礎資料ですので必ずご記入ください.

わからないことがありましたら先生におたずねください.

ご協力をありがとうございます.

Section 1　どのくらい「そうなのか」をたずねている質問は，気持ちが最も近い番号に**1つだけ**○をつけてください．

1/78	あなたはエネルギーについてどのくらい知っていると思いますか． あなた自身を評価してみてください．	1．　かなり知っている 2．↑ 3． 4．↓ 5．　全く知らない
2	エネルギー使用ということからみると，あなた自身はどの様なタイプと考えますか．感じるままに回答してください．	1.　高使用者である 2.↑ 3. 4.↓ 5.　いつも省エネ生活をしている
3	エネルギー問題を知る上であなたにとって<u>**最も有効**</u>なものはどれですか．<u>**1つ**</u>選んでください．	1.　理科の授業 2.　社会の授業 3.　技術・家庭の授業 4.　総合的な学習の授業 5.　博物館・科学館・展示館 6.　テレビ・ラジオ 7.　本 8.　新聞・雑誌 9.　インターネット 10．家族との会話 11．友人や知人との会話 12．その他（　　　　　　　　　　　）
4	あなたは家族とエネルギーの節約方法や将来のエネルギー問題についてよく話をしますか． （例えば電気を消す，エアコンの温度をひかえめにする，扉や窓を閉めるなども含む）	1.　とてもよく話す 2.↑ 3. 4.↓ 5.　全く話さない

Section 2　あなたの考えに最も合っていると思う番号に**1つだけ**○をつけてください．

5/78	再生可能な資源から電気の多くをつくる必要がある．	1.　とてもそう思う 2.↑ 3. 4.↓ 5.　全くそう思わない
6	私は他の人とも協力して，エネルギー問題の解決に貢献できると考えている．	1.　とてもそう思う 2.↑ 3. 4.↓ 5.　全くそう思わない
7	国が直面しているエネルギー問題に対して，私個人のエネルギー使用方法はそれほど問題にはならない．	1.　とてもそう思う 2.↑ 3. 4.↓ 5.　全くそう思わない
8	もしも景色の良いところや，農地，自然保護地域に風力発電に適した場所があったら，発電のためにはどんどん利用するべきだ．	1.　とてもそう思う 2.↑ 3. 4.↓ 5.　全くそう思わない

9	全ての電化製品は，それらが製品となるまでに，どれだけのエネルギーを必要とし，資源を使い，営業コストがかかったかといったラベルを付けるべきだ.	1. とてもそう思う 2. ↑ 3. 4. ↓ 5. 全くそう思わない
10	エネルギーの節約は重要だ.	1. とてもそう思う 2. ↑ 3. 4. ↓ 5. 全くそう思わない
11	再生可能エネルギー技術を開発することは，新しい資源を見つけ開発することよりも重要である.	1. とてもそう思う 2. ↑ 3. 4. ↓ 5. 全くそう思わない
12	政府は車の二酸化炭素排出量についての強い規制をする必要がある.	1. とてもそう思う 2. ↑ 3. 4. ↓ 5. 全くそう思わない
13	学校が電気代を支払っているのだから教室の電気やパソコンを消すことは心配いらない.	1. とてもそう思う 2. ↑ 3. 4. ↓ 5. 全くそう思わない
14	エネルギー問題の重要性はわかるが，日常生活に大きな負担をかけるような省エネ，節電は現実的ではない.	1. とてもそう思う 2. ↑ 3. 4. ↓ 5. 全くそう思わない
15	新たな発電方法が開発されればエネルギー問題を解決してくれるから，エネルギーの節約についてはそれほど心配はいらない.	1. とてもそう思う 2. ↑ 3. 4. ↓ 5. 全くそう思わない
16	日本人はもっとエネルギーを節約するべきだ.	1. とてもそう思う 2. ↑ 3. 4. ↓ 5. 全くそう思わない
17	エネルギー生産を許すために環境に関する法律はもっとゆるやかにするべきだ.	1. とてもそう思う 2. ↑ 3. 4. ↓ 5. 全くそう思わない

18	エネルギーの節約方法を知っていれば，もっとやりたい.	1. とてもそう思う 2. 3. 4. 5. 全くそう思わない
19	国内のエネルギー自給率を上げるためなら，国立公園内の温泉地の地熱発電開発をすすめるべきだ.	1. とてもそう思う 2. 3. 4. 5. 全くそう思わない
20	たとえ国民が負担する費用が多くなるとしても，日本はもっと再生可能エネルギーを開発する必要がある.	1. とてもそう思う 2. 3. 4. 5. 全くそう思わない
21	私自身が適切なエネルギー関連の選択をし行動をおこすことによって、エネルギー問題の解決に貢献できると考えている. （たとえば，エネルギー効率のよい製品を買う，ひとつのものを長く使用するなど）	1. とてもそう思う 2. 3. 4. 5. 全くそう思わない
22	エネルギー教育は学校教育の中で重要だ.	1. とてもそう思う 2. 3. 4. 5. 全くそう思わない
23	資源の少ない日本は，さまざまな発電方法をもちいて安全を確認した原子力発電も，再生可能エネルギーも共に発展させ，エネルギーベストミックスを構築する必要がある.	1. とてもそう思う 2. 3. 4. 5. 全くそう思わない

Section 3 あなたの考えや行動に最も合っていると思う番号に**1つだけ**○をつけてください.

24/78	私が暮らしのなかで何かを決める時は，このエネルギー使用はどのくらいなのだろうと考えて選択している.	1. いつもそうだ 2. 3. 4. 5. 全くそうではない
25	エネルギーを節約するために物は買わない，増やさない.	1. いつもそうだ 2. 3. 4. 5. 全くそうではない
26	ゴミの分別をし，資源ごみはリサイクルをしている.	1. いつもそうだ 2. 3. 4. 5. 全くそうではない

27	家族や友人にも，エネルギーを節約するために，不要な電気を消したり，ドアを開けっぱなしにしたりしないように言う．	1．いつもそうだ 2． 3． 4． 5．全くそうではない
28	歯磨きや洗面，シャワーのときの水は途中で止めない．	1．いつもそうだ 2． 3． 4． 5．全くそうではない
29	地球環境を保全し，持続可能な社会を築くためのエネルギー選択であることが理解できれば，自分の考えを変えることもある．	1．いつもそうだ 2． 3． 4． 5．全くそうではない
30	部屋を出るときは照明やコンピューターのスイッチを消す．	1．いつもそうだ 2． 3． 4． 5．全くそうではない
31	私の家族はエネルギー効率の良い蛍光灯・LEDなどの省エネ電球を買う．	1．いつもそうだ 2． 3． 4． 5．全くそうではない
32	再生可能エネルギーの開発は重要だが，経済や産業活動の負担になる政策は慎重に行うべきだ．	1．とてもそう思う 2． 3． 4． 5．全くそう思わない
33	地球温暖化やエネルギーに関する情報は，テレビや新聞で得てる．	1．いつもそうだ 2． 3． 4． 5．全くそうではない
34	暖房や冷房の設定温度を「おさえめ」にする．	1．いつもそうだ 2． 3． 4． 5．全くそうではない
35	エネルギー効率の良い電球や蛍光灯，電化製品を購入するように家族に言う．	1．いつもそうだ 2． 3． 4． 5．全くそうではない

Section 4　あなたがそうだと思う番号に**1つだけ**〇をつけてください.

36/78	地球上のあらゆるもの（例えば機械，生物）の動きには，次のうち何が必要となると思いますか.	1．食べ物 2．エネルギー 3．太陽 4．水 5．運動
37	私達が使う電気エネルギー（電気）の単位は次のどれだと思いますか.	1．kWh 2．kW 3．N.m 4．V 5．A
38	近年の日本の平均的な家庭で最もエネルギーを使用しているものは次のうちどれだと思いますか.	1．食べ物，飲み物を冷蔵すること 2．部屋を暖房，冷房すること 3．水を温めたり冷やしたりすること 4．家庭の照明 5．料理と食事の準備
39	石炭や石油の替わりに原子力を使う利点を考えるとき，それは次のうちどれだと思いますか.	1．原子力発電所は建造費用が安い 2．二酸化炭素を排出しない 3．総合的に安全である 4．廃棄物を貯蔵しやすい 5．建設に住民の理解がある
40	次のうちどれが再生可能**<u>ではない</u>**資源だと思いますか.	1．太陽光 2．石炭 3．バイオマス（木材，廃棄物，植物，アルコール燃料） 4．水力 5．地熱
41	日本，アメリカ，ヨーロッパなどの先進国で使用される約85%のエネルギーは次のうちどの資源によって生産されていると思いますか.	1．バイオマス（木材，廃棄物，植物，アルコール燃料） 2．水力 3．原子力 4．風力 5．化石燃料
42	省エネ性マークがついている家電製品を購入する最適な理由とは… 省エネ性マーク	1．値段のわりにサイズが大きい 2．値段が高い 3．値段が安い 4．エネルギー消費が少ない 5．見た目がモダン
43	現在日本全体のエネルギー消費量のうち，外国からの輸入に頼っている割合はどのくらいだと思いますか.	1．ほぼ100% 2．約80% 3．約60% 4．約40% 5．約20%
44	エネルギーについて**<u>不可能</u>**なことは次のどれだと思いますか.	1．化学エネルギーから熱エネルギーに変換する 2．食べ物の中のエネルギーを測定する 3．エネルギーを消費する以上にもっと多くのエネルギーを生む機械を造る 4．車の動力源としてエタノールを使用する 5．製品をリデュース（減らす），リユース(再使用)，リサイクル(再利用)，(3R)してエネルギーを節約する

45 白熱電球をつけると，エネルギーの10%は光に変換されます．残りのエネルギーは次のうちどれになると思いますか．

1. きらめき
2. フロン
3. 熱
4. 空間
5. 電子

46 わが国はメタンハイドレートの研究開発を進めています．メタンハイドレートについて正しい内容は次のどれだと思いますか．

1. 家畜のふんやにょうが固まったものである
2. 人工的につくる資源である
3. 日本の周りには存在しない
4. 鉱山にあり採取が容易で，資源として実用化できるとわかった
5. 海底にあり採取が容易でなく，資源として実用化できるかまだわからない

47 近年の地球温暖化の原因はCO2の増加によるものと言われています．このことについて述べている内容のうち，正しいものはどれだと思いますか．

1. 人間や動物が呼吸でCO2を出しているから
2. 土の中の微生物が増えだしているから
3. 太陽の活動が近年活発になっているから
4. 産業が発展して大量の水を使うから
5. 産業が発展して化石燃料を大量に燃やすから

48 毎日片道10kmの距離を自動車通勤している人がガソリンを節約したいと思いました．次のうちどの方法が最もガソリンを節約できると思いますか．

1. ガソリン1リットルあたり20km走る車よりも30km走る車を買う
2. 時速65kmではなく，時速55kmで運転する
3. 時速65kmではなく，時速45kmで運転する
4. 自動車通勤の人が集まって1台の車にいっしょに乗って通勤する
5. 上記の全てはほぼ同じ量のガソリンの節約になる

49 過去10年間，日本へ輸入される石油は・・・

1. 増加していて値段も上がっている
2. 増加していて値段は下がっている
3. 減少していて値段も下がっている
4. 減少していて値段は上がっている
5. 過去10年間の石油の輸入量も値段も変化していない

50 光合成の結果できたエネルギー資源はどれだと思いますか．

1. 石炭
2. 石油
3. 天然ガス
4. シェールガス
5. 上記の全て

51 放射線について説明している文のうち，1つだけ**<u>まちがっている</u>**ものがあります．どれだと思いますか．

1. 多すぎると危険だ
2. 医療，工業，農業などで利用されている
3. 食べ物や飲み物には全くない
4. 不要な放射線被ばくをふせぐ方法がある
5. 誰でも日常の中で身体に受けている

52 石油は様々なものに利用される重要な資源です．日本経済で最も石油を消費しているのは次のうちどの部門だと思いますか．

1. 家や建物などの住宅部門
2. デパートやコンビニなどの商業部門
3. セメントや製紙，鉄鋼などの産業部門
4. 自動車やトラックなどの運輸部門
5. インターネットや携帯電話などの情報部門

53 エネルギーを最も正しく説明（定義）しているのは次のどれだと思いますか．

1. 何かを動かす力
2. 位置と運動の関係
3. 仕事がなされた割合
4. 仕事をする能力
5. 化石燃料

54	“再生可能エネルギー資源”とは次の説明のうち最も適切なものはどれだと思いますか.	1. 自由で便利に使える資源 2. 熱と電気に直接変換することができる資源 3. 大気汚染を生まない資源 4. エネルギー生産にとても効率のよい資源 5. 人間が利用する以上の速度で自然に再生する資源
55	電気製品の電気消費量を決めるのは2つの要素が関係しています. 次のうちどの組み合わせだと思いますか.	1. 製品の大きさと電気代 2. 製品にスイッチを入れた時の温度と使用時間 3. 製品の設定ボタンの電力（ワットやキロワット）と電気代 4. 製品の設定ボタンの電力（ワットやキロワット）とスイッチを入れている時間の長さ 5. 製品の設定ボタンの電力（ワットやキロワット）とコンセントの大きさ
56	科学者たちは、私たちがエネルギー問題に対応するための方法として, **<u>最も費用もかからず早い方法</u>**は次の内容であるといいます. どれだと思いますか.	1. 可能な限り国内の化石資源を開発する 2. 原子力発電所を建設する 3. 省エネルギーを促進する 4. 再生可能エネルギーの発電所をさらに開発する 5. ガソリンにかわる燃料自動車を開発する
57	2010年度の日本の一次エネルギー(燃料, 電力）供給で最も多いのは次のうちどの資源によるものだと思いますか.	1. 石油 2. 石炭 3. 天然ガス 4. 水力 5. 原子力
58	気候変動政府間パネル（IPCC)は, 地球の平均気温が上昇している重要な原因の一つを次のように言っています. どれだと思いますか.	1. 酸性雨 2. 海面上昇 3. 太陽の地球の距離が縮まっている 4. 化石燃料燃焼による二酸化炭素濃度上昇 5. 原子力発電所による二酸化炭素濃度上昇
59	次のうちエネルギーの表現として合っているものはどれだと思いますか.	1. エネルギーはなくなる 2. エネルギーは水のように長時間ためておける 3. エネルギーはなにもしなくても増える 4. エネルギーは集めることができる 5. エネルギーは何をするにも必要である
60/78	次にあげるエネルギー関連活動のうち, 人の健康と環境に対して最も**<u>害が小さいもの</u>**はどれだと思いますか.	1. 石炭を採掘する 2. 石油開発と運搬する 3. 電気をつくるために化石燃料を燃焼する 4. 発電用の太陽電池を製造する 5. 太陽電池で発電する
61	世界の石油はあと40年で枯渇する（採取できなくなる）と言われますが, これはどういうことを意味していると思いますか.	1. 地球上の石油を全てとってしまいなくなるから 2. 石油の性質が変わり燃やすことができなくなるから 3. 産油国が生産を中止することが決まっているから 4. 石油の井戸が土砂でうまり始めているから 5. 地層の中にはあるが技術的にとるのが難しくなると経済的にも成り立たなくなるから
62	近年の日本の平均的な家庭で最もエネルギーを使用して**<u>いない</u>**ものは次のうちどれだと思いますか.	1. 食べ物, 飲み物を冷蔵すること 2. 部屋を暖房, 冷房すること 3. 水を温めたり冷やしたりすること 4. 家庭の照明 5. 料理と食事の準備
63	木材には化学エネルギーがたくわえられていることを説明しているものは次のどれだと思いますか.	1. 木材は紙や家具といった他のものに換えることができる 2. 木材は静止している物体である 3. 木材は燃える時に熱を放つ 4. 木材はかつて生き物だった 5. 木材には潜在的なエネルギーはない

64	日本の再生可能エネルギーのうち，最も発電量が多いのは次のうちどれだと思いますか.	1. 太陽光 2. 水力 3. 風力 4. バイオマス（木材，廃棄物，植物，アルコール燃料） 5. 地熱
65	安全に稼働している原子力発電所について述べている内容について，**<u>まちがっている</u>**ものは次のうちどれだと思いますか.	1. ウラン燃料の多くは政治情勢が安定している国から輸入している 2. 火力発電所と同様に蒸気でタービンを回している 3. 廃棄物は厳しく管理されており所定の場所に保管されている 4. 地震対策は，新しい科学的知見に基づいて建物や設備・機器がチェックされるしくみである 5. 原子力発電所のまわりの地域は，その他の地域よりも放射線量が高い
66	ここ2～3年の日本の電力の大部分をまかなっているエネルギー源は次のうちどれだと思いますか. （本調査実施は2014年）	1. 石油火力 2. 石炭火力 3. 原子力 4. 水力 5. 天然ガス
67	これらはエネルギーの形態を示したものですが，1つだけ**<u>まちがっている</u>**ものがあります．どれだと思いますか.	1. 化学エネルギー 2. 熱エネルギー 3. 機械的エネルギー 4. 電磁エネルギー 5. 石炭エネルギー
68	「35%の効率の発電所」とはどの様な意味だと思いますか.	1. エネルギー生産に1万円投資するごとに3500円の利益を生む 2. エネルギー生産に3500円投資するごとに10000円の利益を生む 3. 発電で使用される全エネルギーを100とすると，そのうち35はエネルギー変換中に失われる 4. 発電所に取り込まれる全エネルギーのうち35ごとに，100の電気が作られる 5. 発電所に取り込まれる全エネルギーを100とすると，そのうち35のエネルギーが電気エネルギーに変換される
69	化石燃料にかわる新たなエネルギー資源開発が必要と言われていますが，その内容について正しいものはどれだと思いますか.	1. バイオマスを利用した時に出る二酸化炭素はカーボンニュートラルという考えで，温室効果ガスとしてカウントされない 2. 日本でつくるバイオディーゼル燃料は国内のひまわり油を原料としている 3. 現在水素燃料の多くは海水からつくられている 4. メタンハイドレードは温室効果ガスを出さない 5. 今後日本は，太陽光発電や風力発電がたくさん開発されればエネルギー資源は輸入しなくてもすむ
70	現在の日本国内の資源生産について，次のうち正しいのはどれだと思いますか.	1. もともと化石資源がないので資源は生産されていない 2. 化石資源はあるがシェールガスのみ生産している 3. 化石資源はあるがその生産量は海外からの輸入に比べてわずかである 4. 化石資源は採りきってしまった 5. 化石資源はすべて海外へ輸出している
71	エネルギー消費を**<u>低減するために</u>**適切なことは次のうちどれだと思いますか.	1. 家では皆がそれぞれ自分の部屋で過ごす 2. お風呂のお湯は入浴する人が変わるたびに入れ替える 3. 洗たくは，ある程度洗たく物がたまってから洗たく機を動かす 4. 食事はテーブルについた人から順にとる 5. まだ使える物でも流行が変わったので取りかえる

72	もし化石燃料が枯渇したら，電気自動車にすればいいという人がいます．この考えが**<u>まちがえているとすれば</u>**次のどの点をあげますか．	1．　現在，電気のほとんどは化石燃料からつくられている（石炭，石油，天然ガス） 2．　電気自動車へのきりかえは失業率を上げることになる 3．　電気自動車を大量に導入することは不可能であることが証明されている 4．　電気だけで自動車を動かすことはできない 5．　この考えには何も問題はない
73	今日の日本のエネルギー選択について述べられている内容として適切なものは次のうちどれだと思いますか．	1．　環境に影響を与えなければどの様なものでも用いることができる 2．　エネルギーのためなら環境に影響を与えてもかまわない 3．　エネルギーのためなら経済的に成り立たなくても問題はない 4．　私たちのこれまでの消費生活スタイルに影響を与える 5．　一度決めたら変えることはできない．
74	エネルギー資源を開発し利用する上であらゆる環境影響を考える時，最もふさわしいものは次のうちどれですか．	1．　CO2を排出さえしなければ環境には影響を与えない 2．　再生可能エネルギーは全く環境には影響を与えない 3．　水力発電は環境には影響を与えない 4．　人間がエネルギー資源を開発，利用するうえではどの様なものでも環境に影響を与える 5．　日本のエネルギー資源のほとんどは輸入なので，環境への影響は心配する必要なない
75	日本が最も消費する石油について述べた内容のうち，正しいのはどれだと思いますか．	1．　世界中から輸入しているので安定している 2．　国内で生産しているので安定している． 3．　中東地域から輸入しているので安定している 4．　中東地域から輸入しているがリスクもある 5．　ヨーロッパから輸入しているがリスクもある
76	日本は原子力発電をやめようという意見があります．これに対して次のうちどれが適切だと思いますか．	1．　不足する分を，再生可能エネルギーで補えば足りる 2．　不足する分を，火力発電で補えば問題ない 3．　日本のエネルギーのほぼ100%を海外にゆだねることになる 4．　放射性廃棄物の問題は解決する 5．　原子力発電をやめても電気代は上がらない
77	再生可能エネルギー（再可エネ）と再生できないエネルギー（非再生エネ）について述べた文章のうち，次のどれが適切だと思いますか．	1．　再可エネは値段が安く，非再生エネは値段が高い 2．　再可エネは環境に影響は与えないが，非再生エネは環境に影響を与える 3．　再可エネは人に影響は与えないが，非再生エネは人に影響を与える 4．　再可エネは資源がなくなることはないが，非再生エネは資源には限りがある 5．　再可エネで日本のエネルギーはまかなえるので，非再生エネは使わなくてよい
78/78	地球上のほとんど全ての生物のエネルギー根源となっているのは次のどれだと思いますか．	1．　太陽 2．　水 3．　土 4．　植物 5．　風

Section 5

（1） お住まいの都道府県をご記入ください．	（　　　　　　　　　　　　　　　　）
（2） お住まいの区市町村をご記入ください．	（　　　　　　　　　　　　　　　　）
（3） 性別に○をつけて下さい．	1．男　　2．女
（4） 学年に○をつけて下さい．	1． 中学1年生 2． 中学2年生 3． 中学3年生
（5） 年齢を記入して下さい．	（　　　　）歳
（6） 好きな科目<u>全て</u>に○をつけてください．	1．算数 2．国語（・現代国語　・古文　・漢文） 3．理科（・物理　・化学　・生物　・地学） 4．社会（・地理　・歴史　・公民） 5．英語 6．技術・家庭 7．道徳 8．美術 9．音楽 10．体育 11．その他（　　　　　　　　　　）
（7） 今までエネルギーに関する学習をしたことがありますか？	1．ある　　2．ない
（8） 上記で「ある」とお答えになった方はどこで学習をしましたか？　<u>全て</u>に○をつけてください．	1．小学校の授業 2．中学校の授業 3．部活やサークル 4．学校以外の活動（それは何ですか？　　　　　　） 5．家庭（親やきょうだいなど） 6．地域の会合 7．その他（　　　　　　　　　　）
（9） エネルギー関連施設を見学したことがありますか？	1．ある　　2．ない
（10） 上記で「ある」とお答えになった方はどこへ行きましたか？　<u>全て</u>に○をつけてください．	1．火力発電所 2．水力発電所 3．太陽光発電所 4．風力発電所 5．バイオマス発電所 6．バイオマス燃料製造工場 7．原子力発電所 8．六ヶ所再処理工場 9．発電所のPR館（どこですか？　　　　　　） 10．その他（　　　　　　　　　　）
（11） 家庭で節電や省エネを心がけるよう言われますか？	1．言われる　　2．言われない
（12） それは何歳くらいの時から言われていましたか？　覚えている範囲でけっこうです．	（　　　　）歳くらいの時から言われている

アンケートは以上です．　ご協力有難うございました．

E.2 Questionnaire for Japanese Students 2016

京都大学
KYOTO UNIVERSITY

エネルギーリテラシー調査 2016

はじめに

（１）この調査は**テストではありません**。

まだ学校で習ってないことや、知らないことも出てくるかもしれませんが、あなたがエネルギーや環境についてどの様なことを知っていて、考えたり行動したりしているかを知るための調査です。無記名ですので、あなた自身が思ったとおりに正直に記入してください。

（２）最後の **Section 4** は、この調査の大切な基礎資料ですので必ず記入してください。

（３）アンケートへの回答は、以下に注意し、記入例にしたがって答えてください。

> ➢ あなたが「そうだ」と思うものに 1 つだけ 丸をつけてください
> ➢ すべての項目に回答してください

（４）記入例

◆ 5 段階のものさしの選択肢は、あなたの考えや状況をもっとも表している番号に 1 つだけ丸をつけてください。

1　天気予報サービスはとてもよい

全くよくない　1 － 2 － 3 － 4 － 5　とてもよい

2　天気予報は完璧だ

ほとんど完璧ではない　1 － 2 － 3 － 4 － 5　とても完璧だ

3　天気予報を信じていれば問題ない

全くそうではない　1 － 2 － 3 － 4 － 5　そのとおりだ

◆ 正しいか、まちがっているかを、たずねている問題は、どれか 1 つに丸をつけてください。

4　天気予報は雲のかたちで決まる

□ 正しい　□ まちがっている　□ わからない

◆ 5 つの選択肢の中から正しいと思うものに、1 つだけ丸をつけてください。

天気予報について、もっとも適切に説明しているものは、次のうちどれだと思いますか

1. 前日の夜空を観測して予測する
2. 海の波の高さで予測する
3. カラスが飛ぶ方向で予測する
4. 過去の天気や各地の気象観測データをもとに予測する
5. 太陽のフレアで予測する

わからないことがありましたら質問してください

どうぞよろしくお願いします

Fig. E.2. Questionnaire for Japanese Students 2016.

Section 1

1	あなたはエネルギーについて、どのくらい知っていると思いますか	ほとんど知らない	1 － 2 － 3 － 4 － 5	かなり知っている
2	エネルギー使用ということからみると、あなた自身はどの様なタイプと考えますか	大量使用者だ	1 － 2 － 3 － 4 － 5	いつも省エネ生活をしている
3	あなたはエネルギーのことについて家族とよく話をしますか（例えば電気を消す、エアコンの温度をひかえめにする、扉や窓を閉める、再生可能エネルギー、原子力など）	ほとんど話さない	1 － 2 － 3 － 4 － 5	とてもよく話す

4　エネルギー問題を知る上であなたにとって**最も有効**なものはどれですか？
１つだけ選んでください。

１．理科の授業
２．社会科の授業
３．技術・家庭科の授業
４．総合的な学習の授業
５．博物館・科学館・展示館
６．テレビ・ラジオ
７．本・専門誌
８．新聞・雑誌
９．インターネット
10．facebook、twitter などのソーシャルメディア
11．家族との会話
12．友人や知人との会話
13．その他（　　　　　　　　　　　　）

Section 2

5　部屋を最後に出るときは照明を消す

ほとんど消さない　1 － 2 － 3 － 4 － 5　いつも消す

6　あなたの周りに10人いた場合、およそ何人が省エネをしているとおもいますか？人数の番号を○で囲んでください

0−1−2 － 3 － 4 － 5 － 6 － 7 － 8−9−10

7　役に立つか分からないことでも、できる限り多くのことを学びたい

全くそうではない　1 － 2 － 3 － 4 － 5　そのとおりだ

8　地球がささえられる人口の限界に近づいてきている

全くそうではない　1 － 2 － 3 － 4 － 5　そのとおりだ

9　省エネは重要だ

ほとんど重要ではない　1 － 2 － 3 － 4 － 5　とても重要だ

10　自分とは異なった考えの人と議論するのはおもしろい

ほとんどおもしろくない　1 － 2 － 3 － 4 － 5　とてもおもしろい

11　急いでいるときは、電気を消すのは難しいかもしれない

ほとんど難しくない　1 － 2 － 3 － 4 － 5　とても難しい

12　家族は、私自身が省エネするべきだと思っている

ほとんどそうは思っていない　1 － 2 － 3 － 4 － 5　とてもそう思っている

13　全ての電化製品は、それらが製品となるまでにどれだけのエネルギーを必要とし、資源を使い、費用がかかったか、というラベルをつけるべきだ

ほとんどその必要はない　1 － 2 － 3 － 4 － 5　そうするべきだ

14　分からないことがあると質問したくなる

ほとんどそうではない　1 － 2 － 3 － 4 － 5　いつもそうだ

15　ゴミはルールにしたがって分別をしている

全く分別していない　1 － 2 － 3 － 4 － 5　いつも分別している

16　省エネ方法を考えながら生活している

ほとんど考えずに生活している　1 － 2 － 3 － 4 － 5　いつも考えて生活している

17 複雑な問題について順序立てて考えることが得意だ

ほとんど得意ではない　１－２－３－４－５　とても得意だ

18 エネルギーの節約は重要だ

ほとんど重要ではない　１－２－３－４－５　とても重要だ

19 物事を見るときは、自分が信じる立場からみる

ほとんどそうしていない　１－２－３－４－５　いつもそうしている

20 省エネは価値がある

ほとんど価値はない　１－２－３－４－５　とても価値がある

21 冷房や暖房の設定温度を「ひかえめ」にする

ほとんど「ひかえめ」にしていない　１－２－３－４－５　いつも「ひかえめ」にしている

22 私にとって大切な人たちは、私自身が省エネするべきだと思っている

ほとんどそうは思っていない　１－２－３－４－５　とてもそう思っている

23 どちらか一方にかたよるような判断をしないようにする

ほとんどそうしていない　１－２－３－４－５　いつもそうしている

24 省エネをするのは自分次第だ

全くそうは思わない　１－２－３－４－５　そのとおりだ

25 たとえエネルギー問題を解決するために新しい技術が開発されたとしても、私たちは省エネを続けるべきだ

ほとんどその必要はない　１－２－３－４－５　そうするべきだ

26 気候変動を解決し地球環境を保護するために、省エネするべきだ

ほとんどその必要はない　１－２－３－４－５　そうするべきだ

27 人間が自然に手を出すと、しばしば悲惨な結果をまねく

全くそのようなことはない　１－２－３－４－５　そのとおりだ

28 誰もが納得できるような説明をすることができる

ほとんどできない　１－２－３－４－５　とてもできる

29 省エネしようと努力している

ほとんど努力していない　１－２－３－４－５　いつも努力している

30 エネルギー使用に対する考えが、日常生活に影響している

ほとんど影響していない　１－２－３－４－５　とても影響している

31 省エネは有益だ

ほとんど有益ではない　１－２－３－４－５　とても有益だ

32 ごみを分別できないのは、時間がなかったり保管しておく場所がなかったりするからだ

全くそうではない　１－２－３－４－５　そのとおりだ

33 物事を決めるときには客観的な態度を心がける

ほとんど心がけていない　１－２－３－４－５　いつも心がけている

34 クラスメイトは、私が省エネするべきだと思っている

ほとんどそうは思っていない　１－２－３－４－５　とてもそう思っている

35 政府は車の二酸化炭素排出量を減らすために、厳しい規制をするべきだ

ほとんどその必要はない　１－２－３－４－５　そうするべきだ

36 ひとつ、ふたつの立場だけではなく、できるだけ多くの立場から考えようとする

ほとんどそうしていない　１－２－３－４－５　いつもそうしている

37 省エネをする自信がある

ほとんど自信はない　１－２－３－４－５　とても自信がある

38 たとえ将来のためのエネルギー生産であっても、自然環境保護に関する法律をゆるめるべきではない

ほとんどその必要はない　１－２－３－４－５　そのとおりだ

39 企業や産業界は、温室効果ガス排出を減らし、気候変動を防ぐために省エネするべきだ

ほとんどその必要はない　１－２－３－４－５　そのとおりだ

40 人間は環境に対して、ひどい仕打ちをしている

全くそうではない　１－２－３－４－５　そのとおりだ

41	省エネするために、なるべく物を買わないようにしている	ほとんどそうではない 1－2－3－4－5 いつもそうだ
42	何か複雑な問題を考えるときは、順序立てて整理する	ほとんどそうしていない 1－2－3－4－5 いつもそうしている
43	コンピューターを使い終わったら電源を切る	ほとんど切っていない 1－2－3－4－5 いつも切っている
44	省エネ方法を知っていれば、もっとやりたい	全くやりたくない 1－2－3－4－5 とてもやりやい
45	自分が無意識のうちに、かたよった見方をしていないか、ふり返るようにしている	ほとんどそうしていない 1－2－3－4－5 いつもそうしている
46	省エネを考えるのはおもしろい	全くおもしろくない 1－2－3－4－5 とてもおもしろい
47	たとえ意見が合わない人の話にも耳をかたむける	ほとんどそうしていない 1－2－3－4－5 いつもそうしている
48	私個人の行動では、エネルギー問題に対処するのは難しい	ほとんど難しくない 1－2－3－4－5 とても難しい
49	私たちがもっと資源の開発方法を知れば、地球は天然資源の宝庫だ	全くそうではない 1－2－3－4－5 そのとおりだ
50	省エネはやろうと思えばできる	全くそうではない 1－2－3－4－5 そのとおりだ
51	判断をくだすときは、できるだけ多くの事実や証拠を調べる	ほとんどそうしていない 1－2－3－4－5 いつもそうしている
52	政府は、温室効果ガス排出を減らし、気候変動を防ぐエネルギー政策のリーダーシップをとるべきだ	ほとんどその必要はない 1－2－3－4－5 そのとおりだ
53	自分自身がエネルギーを適切に選び、省エネ行動することによって、エネルギー問題の解決に貢献できると思う（たとえば、エネルギー効率のよい製品を買ったり、1つのものを長く使用したりする）	ほとんど貢献できないと思う 1－2－3－4－5 とても貢献できると思う
54	ひと筋縄ではいかない、複雑で手間がかかる問題に対しても取り組み続けることができる	全くそうではない 1－2－3－4－5 そのとおりだ
55	私の家族は、省エネしている	ほとんど省エネしていない 1－2－3－4－5 とても省エネしている
56	日本人はもっとエネルギーを節約するべきだ	ほとんどその必要はない 1－2－3－4－5 そのとおりだ
57	私自身のエネルギーの使い方は、国が直面しているエネルギー問題につながっている	ほとんど関係ない 1－2－3－4－5 そのとおりだ
58	歯みがきや洗面、シャワーで水は出しっぱなしにしている	全くそうしていない 1－2－3－4－5 ほとんどそうしている
59	省エネは温室効果ガスを減らすことになる	ほとんどそうではない 1－2－3－4－5 そのとおりだ
60	なにごとも少しも疑わずに信じ込むようなことはしない	そのまま信じ込むことはない 1－2－3－4－5 そのまま信じ込むことがある
61	気候変動を防ぐために、省エネを含めてできることは、なんでもするという個人的義務を感じる	ほとんど感じない 1－2－3－4－5 とても感じる
62	私にとって大切な人たちは、省エネしている	ほとんど省エネしていない 1－2－3－4－5 とても省エネしている

63　植物や動物も、人間と同様に生存する権利がある

ほとんど そのようなことはない　1 − 2 − 3 − 4 − 5　そのとおりだ

64　「省エネができない」という思いがけない場面に、どのくらい出くわしますか?

ほとんど出くわさない　1 − 2 − 3 − 4 − 5　よく出くわす

65　エネルギー大量消費によって、もしも地球温暖化が進めば、今後多くの植物や動物の種が絶滅していく

ほとんど そのようなことはない　1 − 2 − 3 − 4 − 5　そのとおりだ

66　省エネはお金の節約になる

ほとんど節約にならない　1 − 2 − 3 − 4 − 5　とても節約になる

67　筋道を立てて物事を考えるほうだ

ほとんどそうではない　1 − 2 − 3 − 4 − 5　いつもそうだ

68　全ての人は地球環境を保護するために、省エネする責任がある

ほとんど責任はない　1 − 2 − 3 − 4 − 5　とても責任がある

69　エネルギー大量消費によって、もしも地球温暖化が進めば、環境や公衆衛生への影響は深刻になる

ほとんど そのようなことはない　1 − 2 − 3 − 4 − 5　そのとおりだ

70　省エネ性マークなどの、環境ラベルがついたものを選ぶ

ほとんどそうしていない　1 − 2 − 3 − 4 − 5　いつもそうしている

71　私のクラスメイトのほとんどは、省エネしている

ほとんど省エネしてない　1 − 2 − 3 − 4 − 5　とても省エネしている

72　遠くへ出かけるときは、なるべくバスや電車などの公共交通機関を使うようにしている

ほとんどそうしていない　1 − 2 − 3 − 4 − 5　いつもそうしている

73　省エネと環境に関する責任は、関係機関にあり、一般の人ではない

全くそうではない　1 − 2 − 3 − 4 − 5　そのとおりだ

74　自然界のバランスは強いので、現代の先進国の活動による影響にも十分もちこたえる

全くそうではない　1 − 2 − 3 − 4 − 5　そのとおりだ

75　省エネをよく忘れますか？

ほとんど忘れない　1 − 2 − 3 − 4 − 5　よく忘れる

76　いろいろな考え方の人と接して、多くのことを学びたい

ほとんど学びたくはない　1 − 2 − 3 − 4 − 5　とても学びたい

77　省エネは、これまでとは違う価値観で、生活スタイルを考えるチャンスになる

ほとんど チャンスにならない　1 − 2 − 3 − 4 − 5　とてもチャンスになる

78　生涯にわたり、新しいことを学び続けたいと思う

ほとんどそう思わない　1 − 2 − 3 − 4 − 5　とてもそう思う

79　私が尊敬する人は、私が省エネするべきと思っている

ほとんどそう思っていない　1 − 2 − 3 − 4 − 5　とてもそう思っている

80　たとえ学校が電気代を支払っているといっても、教室の照明やパソコンは、使用後自分たちで消すべきだ

ほとんどその必要はない　1 − 2 − 3 − 4 − 5　そのとおりだ

81　省エネがめんどくさいと感じますか？

ほとんどめんどうと感じない　1 − 2 − 3 − 4 − 5　とてもめんどうと感じる

82　レジ袋は断る

ほとんど断らない　1 − 2 − 3 − 4 − 5　いつも断る

83　地球は、とても限られた広さと資源をもつ、宇宙船のようなものだ

全くそうではない　1 − 2 − 3 − 4 − 5　そのとおりだ

84　省エネは、環境保護にとっても私たちの健康にとっても利益をもたらす

全くそうではない　1 − 2 − 3 − 4 − 5　そのとおりだ

85　ゴミの量を減らすようにしている

ほとんどそうしていない　1 − 2 − 3 − 4 − 5　いつもそうしている

86　私は省エネや地球環境について心配していない

ほとんど心配してない　1 − 2 − 3 − 4 − 5　いつも心配している

87 人間は他のいきものにはない特別な能力をもっているが、それでも私たちは自然の法則の影響を受ける

ほとんど影響は受けない　1 − 2 − 3 − 4 − 5　とても影響を受ける

88 省エネに関しては、自分にとって大切な人たちに期待されるようにやりたい

ほとんど そうやりたいとは思わない　1 − 2 − 3 − 4 − 5　とてもそうやりたい

89 化石燃料の大量消費は、地球温暖化、環境破壊を引き起こし、世界中の人々に影響を与える

ほとんど そのようなことはない　1 − 2 − 3 − 4 − 5　そのとおりだ

90 他国の考え方を勉強することは意義のあることだと思う

ほとんどそうは思わない　1 − 2 − 3 − 4 − 5　とてもそう思う

91 あなたの周りの人が「省エネするべきだ」と考えていることについて、あなたはどのくらい気にしていますか？

ほとんど気にしない　1 − 2 − 3 − 4 − 5　とても気にする

92 エネルギーの大量消費によって使える資源がなくなることは、今後非常に深刻な問題になる

ほとんど問題はない　1 − 2 − 3 − 4 − 5　とても問題になる

93 自分とは違う考え方の人に興味を持つ

ほとんど興味はもたない　1 − 2 − 3 − 4 − 5　とても興味をもつ

94 過去6か月間、私は省エネの努力をしていた

ほとんど努力しなかった　1 − 2 − 3 − 4 − 5　とても努力していた

95 事態がこれまでどおりのペースで続けば、主要な生態系への被害はまぬがれない

ほとんど そのようなことはない　1 − 2 − 3 − 4 − 5　そのとおりだ

96 結論をくだす場合には確たる証拠の有無にこだわる

ほとんどこだわらない　1 − 2 − 3 − 4 − 5　とてもこだわる

97 私にとって省エネは難しい

ほとんど難しくない　1 − 2 − 3 − 4 − 5　とても難しい

98 気候変動は、私たちにとって非常に深刻な問題になる

ほとんど問題にならない　1 − 2 − 3 − 4 − 5　とても問題になる

99 エネルギーの無駄遣いはうしろめたい

ほとんど うしろめたいことはない　1 − 2 − 3 − 4 − 5　とても うしろめたい

100 どんな話題に対しても、もっと知りたいと思う

ほとんどそうは思わない　1 − 2 − 3 − 4 − 5　とてもそう思う

101 私にとって省エネについて理解することは重要だ

ほとんど重要ではない　1 − 2 − 3 − 4 − 5　とても重要だ

102 人間による熱帯林の破壊は、私たちにとって非常に深刻な問題になる

ほとんど問題にならない　1 − 2 − 3 − 4 − 5　とても問題になる

103 私はデータを集めたり情報を探したりするとき、違いや似ているところを見つけられる

ほとんど見つけられない　1 − 2 − 3 − 4 − 5　いつも見つけられる

104 地球の中心部は非常に高温である

☐ 正しい　☐ まちがっている　☐ わからない

105 すべての放射能は人工的に作られたものである

☐ 正しい　☐ まちがっている　☐ わからない

106 人や環境へ悪影響を及ぼす原因は、ひとつではない場合がある

☐ 正しい　☐ まちがっている　☐ わからない

107 私たちが呼吸に使っている酸素は植物によって作られたものである

☐ 正しい　☐ まちがっている　☐ わからない

108 赤ちゃんが男の子になるか女の子になるかを決めるのは、父親の遺伝子である

☐ 正しい　☐ まちがっている　☐ わからない

109 データ数（調べた人数や動物の数）が十分多いことが重要である

☐ 正しい　☐ まちがっている　☐ わからない

110 レーザーは音波を集中することで得られる

☐ 正しい　☐ まちがっている　☐ わからない

111 電子の大きさは原子の大きさよりも小さい

☐ 正しい　☐ まちがっている　☐ わからない

112 科学者のデータは、何度も繰り返し同じ結果が現れることで信頼性が高まる

☐ 正しい　☐ まちがっている　☐ わからない

113 抗生物質は、バクテリアと同様にウイルスも殺す

☐ 正しい　☐ まちがっている　☐ わからない

114 宇宙は巨大な爆発によって始まった

☐ 正しい　☐ まちがっている　☐ わからない

115 同じことに関するデータでも科学者の立場や測定方法などで食い違うことがある

☐ 正しい　☐ まちがっている　☐ わからない

116 大陸は何万年もかけて移動しており、これからも移動するだろう

☐ 正しい　☐ まちがっている　☐ わからない

117 現在の人類は原始的な動物種から進化したものである

☐ 正しい　☐ まちがっている　☐ わからない

118 ある原因が、存在しているグループと存在していないグループとを比較することで、その原因が影響しているかが明らかになる

☐ 正しい　☐ まちがっている　☐ わからない

119 ごく初期の人類は恐竜と同時代に生きていた

☐ 正しい　☐ まちがっている　☐ わからない

120 放射能に汚染された牛乳は沸騰させれば安全である

☐ 正しい　☐ まちがっている　☐ わからない

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Section 3

121	エネルギー資源を開発し利用する上であらゆる環境影響を考えるとき、最もふさわしいものは次のうちどれですか	1． CO_2を排出さえしなければ、環境には影響を与えない 2． 再生可能エネルギーは、全く環境には影響を与えない 3． 水力発電は、環境には影響を与えない 4． 人間がエネルギー資源を開発、利用するうえでは、どの様なものでも環境に影響を与える 5． 日本のエネルギー資源のほとんどは輸入なので、環境への影響は心配する必要ない
122	地球上のあらゆるもの（例えば機械、生物）の動きには、次のうち何が必要となると思いますか	1． 食べ物 2． エネルギー 3． 太陽 4． 水 5． 運動
123	石炭や石油のかわりに、原子力を使う利点を考えるとき、それは次のうちどれだと思いますか	1． 建造費用が安い 2． 二酸化炭素を排出しない 3． 総合的に安全である 4． 廃棄物を貯蔵しやすい 5． 建設に住民の理解がある
124	現在日本全体のエネルギー消費量のうち、外国からの輸入に頼っている割合はどのくらいだと思いますか	1． ほぼ100% 2． 約80% 3． 約60% 4． 約40% 5． 約20%
125	省エネ性マークがついている家電製品を購入する最適な理由は、どれだと思いますか	1． 値段のわりにサイズが大きい 2． 値段が高い 3． 値段が安い 4． エネルギー消費が少ない 5． 見た目がモダン
126	エネルギーについて**不可能**なことは、次のどれだと思いますか	1． 化学エネルギーから、熱エネルギーに変換する 2． 食べ物の中のエネルギーを、測定する 3． エネルギーを消費する以上に、もっと多くのエネルギーを生む機械を造る 4． 車の動力源として、エタノールを使用する 5． 製品を、リデュース(減らす)、リユース(再使用)、リサイクル(再利用)、(3R)してエネルギーを節約する
127	光合成でできたエネルギー資源はどれだと思いますか	1． 石炭 2． 石油 3． 天然ガス 4． シェールガス 5． 上記の全て
128	エネルギーを最も正しく説明（定義）しているのは、次のどれだと思いますか	1． 何かを動かす力 2． 位置と運動の関係 3． 仕事がなされた割合 4． 仕事をする能力 5． 化石燃料
129	近年の地球温暖化の原因は、CO_2の増加によるものと言われていますが、このことについて正しい内容はどれだと思いますか	1． 人間や動物が、呼吸でCO_2を出しているから 2． 土の中の微生物が、増えだしているから 3． 太陽の活動が、近年活発になっているから 4． 産業が発展して、水を大量に使うから 5． 産業が発展して、化石燃料を大量に燃やすから
130	次のうちエネルギーの表現として合っているものは、どれだと思いますか	1． エネルギーは、なくなる 2． エネルギーは、水のように長時間ためておける 3． エネルギーは、何もしなくても増える 4． エネルギーは、集めることができる 5． エネルギーは、何をするにも必要である

131	電気製品の消費電力量を決めるには、2つの要素が関係しています 次のうち、どの組み合わせだと思いますか	1． 製品の大きさと、電気代 2． 製品にスイッチを入れた時の温度と、使用時間 3． 製品の設定ボタンの電力（ワットやキロワット）と、電気代 4． 製品の設定ボタンの電力（ワットやキロワット）と、スイッチを入れている時間の長さ 5． 製品の設定ボタンの電力（ワットやキロワット）と、コンセントの大きさ
132	木材には、化学エネルギーがたくわえられていることを説明しているものは、次のどれだと思いますか	1． 木材は、紙や家具といった他のものに換えることができる 2． 木材は、静止している物体である 3． 木材は、燃えるときに熱を放つ 4． 木材は、かつて生き物だった 5． 木材には、潜在的なエネルギーはない
133	気候変動政府間パネル（IPCC)は、地球の平均気温が上昇している重要な原因の1つを、次のように言っています どれだと思いますか	1． 酸性雨 2． 海面上昇 3． 太陽と地球の距離が縮まっている 4． 化石燃料燃焼による二酸化炭素濃度上昇 5． 原子力発電所による二酸化炭素濃度上昇
134	これらはエネルギーの形態を示したものですが、1つだけまちがっています どれだと思いますか	1． 化学エネルギー 2． 熱エネルギー 3． 力学的（機械的）エネルギー 4． 電磁エネルギー 5． 石炭エネルギー
135	「35%の効率の発電所」とは、どの様な意味だと思いますか	1． エネルギー生産に1万円投資するごとに、3500円の利益を生む 2． エネルギー生産に3500円投資するごとに、10000円の利益を生む 3． 発電で使用される全エネルギーを100とすると、そのうち35はエネルギー変換中に失われる 4． 発電所に取り込まれる全エネルギーのうち35ごとに、100の電気が作られる 5． 発電所に取り込まれる全エネルギーを100とすると、そのうち35のエネルギーが電気エネルギーに変換される
136	エネルギー消費を**減らすために**適切なことは、次のうちどれだと思いますか	1． 家では皆が、それぞれ自分の部屋で過ごす 2． お風呂のお湯は、入浴する人が変わるたびに入れ替える 3． 洗たくは、ある程度洗たく物がたまってから洗たく機を動かす 4． 食事は、テーブルについた人から順にとる 5． まだ使える物でも、流行が変わったので取りかえる
137	次にあげるエネルギー関連活動のうち、人の健康と環境に対して最も害が**小さいもの**はどれだと思いますか	1． 石炭を採掘する 2． 石油開発と運搬する 3． 電気をつくるために化石燃料を燃焼する 4． 発電用の太陽電池を製造する 5． 太陽電池で発電する
138	もし化石燃料が枯渇したら、電気自動車にすればいいという人がいます この考えがまちがっているとすれば、次のどの点をあげますか	1． 現在、電気のほとんどは、化石燃料からつくられている（石炭、石油、天然ガス) 2． 電気自動車へのきりかえは、失業率を上げることになる 3． 電気自動車を大量に導入することは、不可能であることが証明されている 4． 電気だけで自動車を動かすことはできない 5． この考えには何も問題はない
139	日本が最も消費する石油について述べた内容のうち、正しいのはどれだと思いますか	1． 世界中から輸入しているので、安定している 2． 国内で生産しているので、安定している 3． 中東地域から輸入しているので、安定している 4． 中東地域から輸入しているが、リスクもある 5． ヨーロッパから輸入しているが、リスクもある
140	地球上のほとんど全ての生物のエネルギー源は、次のうちどれだと思いますか	1． 太陽 2． 水 3． 土 4． 植物 5． 風

Section 4

(1)	お住まいの都道府県をご記入ください	（　　　　　　　　　　　　　　　　）
(2)	お住まいの区市町村をご記入ください	（　　　　　　　　　　　　　　　　）
(3)	性別に○をつけてください	1．男　　0．女
(4)	学年に○をつけてください	1．中学１年生 2．中学２年生 3．中学３年生
(5)	年齢を記入してください	（　　　　　）歳
(6)	得意な科目に**全てに**○をつけてください （複数回答可）	1．国語 2．社会 3．数学 4．理科 5．英語 6．音楽 7．美術 8．保健体育 9．技術・家庭 10．その他（　　　　　　　　　　　　）
(7)	今までエネルギーに関する学習をしたことがありますか？	1．ある　→ (8) へ　　0．ない　→ (9) へ
(8)	(7)で「ある」とお答えになった方は、どこで学習をしましたか？　**全てに**○をつけてください （複数回答可）	1．小学校の授業 2．中学校の授業 3．部活やサークル 4．学校以外の活動（それは何ですか？　　　　　　　　　） 5．家庭（親やきょうだいなど） 6．地域の会合 7．その他（　　　　　　　　　　　　）
(9)	エネルギー関連施設を見学したことがありますか？	1．ある　→ (10) へ　　0．ない　→ (11) へ
(10)	(9)で「ある」とお答えになった方は、右にあげる施設のうち、行ったことがある施設に**全て**○をつけてください （複数回答可）	1．火力発電所 2．水力発電所 3．太陽光発電所 4．風力発電所 5．バイオマス発電所 6．バイオマス燃料製造工場 7．原子力発電所 8．六ヶ所再処理工場 9．発電所のPR館（どこですか？　　　　　　　　　） 10．その他（　　　　　　　　　　　　）
(11)	家庭で節電や省エネを心がけるよう言われますか？	1．言われる　→ (12) へ　　0．言われない　→ アンケート終了
(12)	(11)で「言われる」と答えた方へ それは何歳くらいのときから言われていましたか？ 覚えている範囲でけっこうです	（　　　　　）歳くらいのときから言われている

アンケートは以上です。　ご協力有難うございました。 

E.3 Questionnaire for Thai Students 2017

การสำรวจความรู้เรื่องพลังงาน 2017

— ระดับโรงเรียนมัธยม —

Kyoto Univ., Japan

คำถามในการสำรวจนี้จะถามคุณเกี่ยวกับสิ่งที่คุณรู้และคิดเกี่ยวกับพลังงานและสิ่งแวดล้อม
และเกี่ยวกับทางเลือกส่วนบุคคลที่คุณเลือกบางอย่าง
กรุณาตอบคำถามตรงไปตรงมาและที่ดีที่สุดตามความสามารถของคุณ

หมายเหตุ:

นี่คือการสำรวจไม่ใช่การทดสอบ
คำตอบของคุณมีความสำคัญมากเพราะเราต้องการเข้าใจสิ่งที่คุณรู้และคิดเกี่ยวกับพลังงานและสิ่งแวดล้อม ดังนั้น
โปรดตอบคำถามแต่ละคำถามให้ดีที่สุดเท่าที่คุณสามารถ
หากคุณไม่ทราบคำตอบพยายามเลือกคำตอบที่ดีที่สุดของคุณ

ขอขอบพระคุณเป็นอย่างสูงสำหรับการมีส่วนร่วมในการตอบคำถามของแบบสำรวจนี้

ขอบคุณมากสำหรับความร่วมมือของคุณ!

Social Engineering of Energy Research Group
Department of Socio-Environmental Energy Science
Graduate School of Energy Science, Kyoto University

Fig. E.3. Questionnaire for Thai Students 2017.

Section 1 โปรดเลือกคำตอบที่คุณคิดว่าดีที่สุดของคำถามต่อไปนี้

1_1	คุณคิดว่าคุณรู้เกี่ยวกับพลังงานมากน้อยเท่าไหร่? (ประเมินตัวเองเป็น "ผู้เชี่ยวชาญ (มาก) " ถึง "**มือใหม่** (น้อย) ตามที่อธิบายไว้ด้านล่าง)	น้อย 1 — 2 — 3 — 4 — 5 มาก	
2_2	ถ้าพูดถึงเรื่องการใช้พลังงาน คุณคิดว่าคุณใช้พลังงานอย่างไร?	ผู้ใช้พลังงานมาก 1 — 2 — 3 — 4 — 5 ประหยัดพลังงาน	
3_3	บ่อยแค่ไหนที่คุณพูดคุยกับสมาชิกในครอบครัวของคุณเกี่ยวกับวิธีที่คุณสามารถประหยัดพลังงานในและรอบๆบ้านของคุณ (ตัวอย่างเช่น การปิดไฟเมื่อไม่ได้ใช้งาน, เปิดแอร์ที่อุณหภูมิไม่ต่ำกว่า 25 องศา เพื่อประหยัดพลังงานและปิดประตู-หน้าต่างเพื่อป้องกันการสูญเสียความเย็น)	ไม่เคยเลย 1 — 2 — 3 — 4 — 5 บ่อยมาก	
4_4	ทางเลือกต่อไปนี้ สามารถช่วยให้คุณเข้าใจเรื่องพลังงานและปัญหาด้านพลังงานมากที่สุด? เลือกเพียงหนึ่งข้อ	1 การเรียนวิชาวิทยาศาสตร์ทั่วไป 2 การเรียนวิชาสังคมศาสตร์หรือสังคมวิทยา 3 การเรียนวิชาคณิตศาสตร์ 4. การเรียนวิชาของโรงเรียนอื่น 5 พิพิธภัณฑ์, พิพิธภัณฑ์วิทยาศาสตร์, นิทรรศการพลังงาน 6 โทรทัศน์หรือวิทยุ 7 หนังสืออ่านนอกเวลา 8 หนังสือพิมพ์หรือนิตยสาร 9 ข้อมูลจากอินเทอร์เน็ต 10 ข้อมูลจาก Social media (Facebook, Twitter และอื่น ๆ) 11 พ่อแม่ผู้ปกครอง, พี่น้อง หรือ สมาชิกในครอบครัว 12 เพื่อนหรือคนรู้จัก 13 อื่น ๆ ( )	

Section 2 กรุณาระบุว่าคุณรู้สึกหรือคิดอย่างไรเกี่ยวกับข้อความด้านล่างดังต่อไปนี้

อ่านแต่ละข้อความอย่างรอบคอบ แล้วเลือกหนึ่งตัวเลขที่บอกระดับความคิดเห็นของคุณต่อข้อความนั้น

5_5	เมื่อฉันออกจากห้อง ฉันจะปิดไฟ แทบจะไม่เคย 1 — 2 — 3 — 4 — 5 ทุกครั้ง	9_13	เครื่องใช้ไฟฟ้าทุกประเภทควรมีฉลากที่แสดงให้เห็นว่าในการผลิตอุปกรณ์นั้นใช้ทรัพยากรอะไรบ้าง และใช้พลังงานเท่าไหร่ ไม่เห็นด้วยอย่างยิ่ง 1 — 2 — 3 — 4 — 5 เห็นด้วยอย่างยิ่ง
6_6	ในจำนวนคนสิบคนรอบตัวคุณ คุณคิดว่ามีกี่คนที่ประหยัดพลังงาน? (เลือกจำนวนของบุคคล) 0—1—2 — 3 — 4 — 5 — 6 — 7 — 8—9—10	10_15	ฉันคัดแยกขยะเป็นประจำ แทบจะไม่เคย 1 — 2 — 3 — 4 — 5 เกือบตลอดเวลา
7_9	การประหยัดพลังงานเป็นเรื่องที่สำคัญสำหรับฉัน ไม่สำคัญเลย 1 — 2 — 3 — 4 — 5 สำคัญมาก ๆ	11_16	ฉันจะคิดเรื่องการประหยัดพลังงานเสมอในการใช้ชีวิตประจำวัน ไม่น่าเป็นไปได้อย่างมาก 1 — 2 — 3 — 4 — 5 เป็นไปได้สูงมาก
8_12	คนในครอบครัวของฉันคิดว่าฉันควรจะประหยัดพลังงาน ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน	12_18	การประหยัดพลังงานเป็นสิ่งสำคัญ ไม่สำคัญอย่างมาก 1 — 2 — 3 — 4 — 5 สำคัญมาก

13_20 การประหยัดพลังงานเป็นสิ่งที่มีคุณค่า

ไร้ค่ามาก 1 — 2 — 3 — 4 — 5 มีคุณค่ามาก

14_22 คนที่มีความสำคัญกับฉันคิดว่าฉันควรประหยัดพลังงาน

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

15_24 การประหยัดพลังงานขึ้นอยู่กับตัวเราเอง

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

16_25 แม้ว่าเทคโนโลยีใหม่จะถูกพัฒนาเพื่อแก้ปัญหาด้านพลังงานสำหรับการผลิตพลังงานในอนาคต เราควรจะประหยัดพลังงานอย่างต่อเนื่อง

ไม่เห็นด้วยแน่นอน 1 — 2 — 3 — 4 — 5 เห็นด้วยแน่นอน

17_26 ฉันรู้สึกว่าฉันควรจะประหยัดพลังงานเพื่อแก้ปัญหาการเปลี่ยนแปลงสภาพภูมิอากาศและปกป้องสภาพแวดล้อมของโลก

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

18_29 ฉันได้ใส่ความพยายามเพื่อประหยัดพลังงาน

แน่นอนฉันจะไม่ทำ 1 — 2 — 3 — 4 — 5 ฉันจะทำแน่นอน

19_30 การตัดสินใจหลายๆเรื่องในชีวิตประจำวันของฉันได้รับอิทธิพลจากความคิดของฉันเกี่ยวกับการใช้พลังงาน

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

20_31 การประหยัดพลังงานเป็นเรื่องที่มีประโยชน์

ไม่ได้ผลมาก 1 — 2 — 3 — 4 — 5 มีประสิทธิภาพ

21_34 นักเรียนส่วนใหญ่ในชั้นเรียนนี้คิดว่าฉันควรจะประหยัดพลังงาน

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

22_35 รัฐบาลควรมีข้อกำหนดที่เข้มงวดเกี่ยวกับมาตรฐานด้านประสิทธิภาพการใช้น้ำมันของรถยนต์ใหม่

ไม่เห็นด้วยแน่นอน 1 — 2 — 3 — 4 — 5 เห็นด้วยแน่นอน

23_37 ฉันมั่นใจว่าฉันสามารถประหยัดพลังงานได้

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

24_38 ถึงแม้ว่าในอนาคตจะสามารถผลิตพลังงานได้มากขึ้น กฎหมายเพื่อปกป้องสภาพแวดล้อมทางธรรมชาติก็ควรจะทำอย่างเคร่งครัด

ไม่เห็นด้วยแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

25_39 ภาคธุรกิจและอุตสาหกรรมควรจะประหยัดการใช้พลังงานเพื่อลดการปล่อยก๊าซเรือนกระจกซึ่งจะช่วยป้องกันปัญหาการเปลี่ยนแปลงสภาพภูมิอากาศ

ไม่เห็นด้วยแน่นอน 1 — 2 — 3 — 4 — 5 เห็นด้วยแน่นอน

26_41 ฉันยินดีที่ซื้อสิ่งของให้น้อยลงเพื่อช่วยในการประหยัดพลังงาน

เท็จแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

27_43 ฉันปิดเครื่องคอมพิวเตอร์เมื่อไม่ได้ใช้งาน

แทบจะไม่เคย 1 — 2 — 3 — 4 — 5 เกือบตลอดเวลา

28_44 ฉันจะประหยัดพลังงานได้มากขึ้นถ้าฉันได้รู้วิธีการ

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

29_46 สำหรับฉันการประหยัดพลังงานเป็นเรื่องที่น่าสนใจ

น่าเบื่อมาก 1 — 2 — 3 — 4 — 5 น่าสนใจอย่างมาก

30_50 สำหรับฉันการประหยัดพลังงานเป็นสิ่งที่เป็นไปได้

เป็นไปไม่ได้ 1 — 2 — 3 — 4 — 5 เป็นไปได้

31_52 รัฐบาลควรจะเป็นผู้นำที่เข้มแข็งในเรื่องนโยบายด้านพลังงานเพื่อลดการปล่อยก๊าซเรือนกระจกและป้องกันไม่ให้เกิดการเปลี่ยนแปลงสภาพภูมิอากาศโลก

ไม่เห็นด้วยแน่นอน 1 — 2 — 3 — 4 — 5 เห็นด้วยแน่นอน

32_53 ฉันเชื่อว่าฉันสามารถมีส่วนร่วมในการแก้ปัญหาพลังงานได้โดยการเลือกทางเลือกที่เหมาะสมด้านพลังงานและลงมือปฏิบัติ

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

33_55 ครอบครัวของฉันประหยัดพลังงาน

แทบจะไม่เคย 1 — 2 — 3 — 4 — 5 เกือบตลอดเวลา

34_56 คนในประเทศของเราควรประหยัดพลังงานมากขึ้น

ไม่เห็นด้วยแน่นอน 1 — 2 — 3 — 4 — 5 เห็นด้วยแน่นอน

35_57 การใช้พลังงานของฉันสามารถสร้างการเปลี่ยนแปลงในการแก้ไขปัญหาพลังงานในอนาคต

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

36_58 ฉันมักจะเปิดน้ำให้ไหลทิ้งตลอดเวลาในขณะ แปรงฟัน ล้างหน้า หรือสระผม

แทบจะไม่เคย 1 — 2 — 3 — 4 — 5 เกือบตลอดเวลา

37_59 การประหยัดพลังงานจะช่วยให้เราลดการปล่อยก๊าซเรือนกระจก

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

38_61 ฉันรู้สึกเป็นหน้าที่ที่ฉันจะทำการประหยัดพลังงานควบคู่ไปกับการกระทำอื่นๆ เพื่อป้องกันการเปลี่ยนแปลงสภาพภูมิอากาศ

แทบจะไม่เคย 1 — 2 — 3 — 4 — 5 เกือบตลอดเวลา

39_62 คนที่มีความสำคัญกับฉันส่วนใหญ่จะประหยัดพลังงาน

แทบจะไม่เคย 1 — 2 — 3 — 4 — 5 เกือบตลอดเวลา

40_64 คุณเจอเหตุการณ์ที่ไม่คาดคิดที่ทำให้คุณไม่สามารประหยัดพลังงานได้บ่อยแค่ไหน?

ไม่ค่อยมาก 1 — 2 — 3 — 4 — 5 บ่อยมาก

41_65 ถ้าภาวะโลกร้อนมีความรุนแรงมากขึ้นจากการการบริโภคพลังงานจำนวนมาก พืชและสัตว์หลายชนิดจะสูญพันธุ์

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

42_66 การประหยัดพลังงานจะช่วยให้เราประหยัดเงิน

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

43_68 ประชาชนทุกคนควรมีความรับผิดชอบในการประหยัดพลังงานเพื่อปกป้องสภาพแวดล้อมของโลก

ไม่เห็นด้วยแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

44_69 ถ้าภาวะโลกร้อนมีความรุนแรงมากขึ้นจากการการบริโภคพลังงานจำนวนมาก จะส่งผลต่อสิ่งแวดล้อม และต่อสุขภาพของประชาชนอย่างความรุนแรง

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

45_70 ฉันพยายามเลือกซื้ออุปกรณ์ไฟฟ้า/สินค้าที่ติดฉลากเบอร์ 5

แทบจะไม่เคย 1 — 2 — 3 — 4 — 5 เกือบตลอดเวลา

46_71 นักเรียนส่วนใหญ่ในชั้นเรียนนี้ใช้พลังงานอย่างประหยัด

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

47_72 เมื่อฉัน (ครอบครัวของฉัน) เดินทางไปยังพื้นที่ห่างไกล ฉันพยามใช้ระบบขนส่งสาธารณะ เช่น รถบัส หรือ รถไฟ แทนการขับรถของตัวเองมากเท่าที่จะทำได้

แทบจะไม่เคย 1 — 2 — 3 — 4 — 5 เกือบตลอดเวลา

48_73 เจ้าหน้าที่ภาครัฐมีความรับผิดชอบในการประหยัดพลังงานและสิ่งแวดล้อม

เท็จแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

49_75 บ่อยแค่ไหนที่คุณมักจะลืมประหยัดพลังงาน?

ไม่ค่อยมาก 1 — 2 — 3 — 4 — 5 บ่อยมาก

50_77 การประหยัดพลังงานจะทำให้เรามีโอกาสเพิ่มมูลค่าในการดำเนินชีวิต

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

51_79 คนส่วนใหญ่ที่ฉันเคารพชื่นชมพฤติกรรมการประหยัดพลังงานของฉัน

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

52_80 ถึงแม้ว่าโรงเรียนจะจ่ายค่าไฟฟ้า แต่ฉันก็ควรปิดไฟหรือปิดคอมพิวเตอร์ในห้องเรียน

ไม่เห็นด้วยแน่นอน 1 — 2 — 3 — 4 — 5 เห็นด้วยแน่นอน

53_81 บ่อยแค่ไหนที่คุณรู้สึกลำบากที่จะประหยัดพลังงาน?

ไม่ค่อยมาก 1 — 2 — 3 — 4 — 5 บ่อยมาก

54_82 ฉันลดการใช้สิ่งฟุ่มเฟือยทุกครั้งที่มีโอกาส เช่น ไม่ใช้ถุงพลาสติกจากซูเปอร์มาร์เก็ต

แทบจะไม่เคย 1 — 2 — 3 — 4 — 5 เกือบตลอดเวลา

55_84 การประหยัดพลังงานเป็นประโยชน์ต่อการปกป้องสิ่งแวดล้อมและสุขภาพของฉัน

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

56_85 ฉันพยายามที่จะลดขยะ

แทบจะไม่เคย 1 — 2 — 3 — 4 — 5 เกือบตลอดเวลา

57_86 ฉันไม่กังวลเกี่ยวกับการประหยัดพลังงานและสิ่งแวดล้อมของโลก

แทบจะไม่ต้องกังวล 1 — 2 — 3 — 4 — 5 มักจะกังวล

58_88 เมื่อคิดถึงเรื่องการประหยัดพลังงาน ฉันอยากจะทำตามที่คนสำคัญในชีวิตฉันคาดหวัง

ฉันไม่ได้อยากทำ 1 — 2 — 3 — 4 — 5 ฉันอยากทำมาก

59_89 การใช้เชื้อเพลิงฟอสซิลปริมาณมากทำให้เกิดภาวะโลกร้อน ความเสียหายด้านสิ่งแวดล้อม และผลกระทบต่อคนทั่วโลก

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

60_91 โดยทั่วๆไป คุณสนใจแค่ไหนหากคนที่อยู่รอบตัวคุณคิดว่าคุณควรประหยัดพลังงาน

ไม่สนใจ 1 — 2 — 3 — 4 — 5 สนใจอย่างมาก

61_92 การสูญเสียทรัพยากรจากการใช้พลังงานจำนวนมากจะเป็นปัญหาที่รุนแรงมากสำหรับประเทศในภาพรวม

ไม่ใช่เลย 1 — 2 — 3 — 4 — 5 เป็นอย่างมาก

62_94 ฉันได้พยายามประหยัดพลังงานในช่วงหกเดือนที่ผ่านมา

ไม่ใช่เลย 1 — 2 — 3 — 4 — 5 เป็นอย่างมาก

63_97 สำหรับฉันการประหยัดพลังงานเป็นเรื่องยาก

ง่ายมาก 1 — 2 — 3 — 4 — 5 ยากมาก

64_98 การเปลี่ยนแปลงสภาพภูมิอากาศเป็นปัญหาที่ร้ายแรงมากสำหรับฉันและครอบครัวของฉัน

เล็กน้อยมาก 1 — 2 — 3 — 4 — 5 ร้ายแรงมาก

65_99 ฉันรู้สึกผิดเมื่อฉันใช้พลังงานอย่างสิ้นเปลือง

ไม่จริงแน่นอน 1 — 2 — 3 — 4 — 5 จริงแน่นอน

66_101 การเข้าใจเรื่องการประหยัดพลังงานอย่างถูกต้องเป็นสิ่งสำคัญสำหรับฉัน

ไม่สำคัญเลย 1 — 2 — 3 — 4 — 5 สำคัญมาก ๆ

67_102 การบุกรุกทำลายป่าเขตร้อนเพื่อตอบสนองความต้องการของมนุษย์จะเป็นปัญหาที่ร้ายแรงมากสำหรับฉันและครอบครัวของฉัน

ไม่มีปัญหา 1 — 2 — 3 — 4 — 5 ปัญหาที่รุนแรง

ยังมีต่อ

Section 3

68_121	ข้อใดต่อไปนี้เป็นคำอธิบายที่เหมาะสมมากที่สุดเกี่ยวกับผลกระทบต่อสิ่งแวดล้อมจากการพัฒนาทรัพยากรและการใช้พลังงาน	1. ไม่ส่งผลกระทบต่อสภาพแวดล้อมถ้ามันสามารถหลีกเลี่ยงการปล่อยก๊าซคาร์บอนไดออกไซด์ 2. ไม่มีผลกระทบต่อสิ่งแวดล้อมถ้าใช้พลังงานทดแทนเท่านั้น 3. ไม่มีผลกระทบต่อสิ่งแวดล้อมถ้าใช้ไฟฟ้าจากพลังงานน้ำ 4. ผลกระทบต่อสิ่งแวดล้อมไม่สามารถหลีกเลี่ยงได้เมื่อมนุษย์พัฒนาและใช้ทรัพยากรเพื่อผลิตพลังงาน 5. เราไม่ต้องกังวลเกี่ยวกับผลกระทบต่อสิ่งแวดล้อมในประเทศของเราเพราะแหล่งพลังงานเกือบทั้งหมดถูกนำเข้ามาจากต่างประเทศ
69_122	ทุก ๆการกระทำบนโลกเกี่ยวข้องกับ ...	1. อาหาร 2. พลังงาน 3. ดวงอาทิตย์ 4. น้ำ 5. การเคลื่อนไหว
70_123	ข้อดีอย่างหนึ่งของการใช้พลังงานนิวเคลียร์แทนถ่านหินหรือน้ำมันปิโตรเลียมคือว่า ...	1. การก่อสร้างโรงไฟฟ้านิวเคลียร์ไม่แพง 2. มีมลพิษทางอากาศน้อย 3. มีความปลอดภัยมาก 4. ของเสียจากโรงไฟฟ้าสามารถจัดเก็บได้ง่าย 5. ไม่มีใครคัดค้านที่จะสร้างโรงไฟฟ้านิวเคลียร์ใหม่
71_124	การใช้พลังงานในประเทศพึ่งพาการนำเข้าของเชื้อเพลิงจากต่างประเทศคิดเป็นเท่าไหร่เมื่อเทียบกับปริมาณทั้งหมดของเชื้อเพลิงที่ใช้ในประเทศ?	1. ประมาณ 100% 2. 80% 3. 70% 4. 55% 5. น้อยกว่า 20%
72_125	เหตุผลที่ดีที่สุดที่เลือกซื้อเครื่องใช้ไฟฟ้าที่ติดฉลากเบอร์ 5 คือ ... 	1. เครื่องใช้ไฟฟ้าที่ติด ฉลากเบอร์ 5 มักจะมีขนาดใหญ่กว่าสินค้าที่ไม่ติดฉลาก 2. เครื่องใช้ไฟฟ้าที่ติด ฉลากเบอร์ 5 ราคาแพงกว่า 3. เครื่องใช้ไฟฟ้าที่ติด ฉลากเบอร์ 5 ใช้พลังงานน้อยลง 4. เครื่องใช้ไฟฟ้าที่ติด ฉลากเบอร์ 5 มีความทันสมัยมากกว่า 5. เครื่องใช้ไฟฟ้าที่ติด ฉลากเบอร์ 5 ราคาถูกกว่า
73_126	มันเป็นไปไม่ได้ที่จะ ...	1. เปลี่ยนรูปพลังงานเคมีเป็นพลังงานความร้อน 2. วัดปริมาณพลังงานในอาหาร 3. สร้างเครื่องจักรที่ผลิตพลังงานมากกว่าที่มันใช้ในการผลิต 4. ใช้เอทานอลเป็นแหล่งพลังงานให้รถยนต์ 5. ประหยัดพลังงานด้วยการ ลดการใช้ การนำกลับมาใช้ซ้ำ และการนำกลับมาใช้ใหม่โดยผ่านกระบวนการผลิตใหม่
74_127	ข้อใดต่อไปนี้ถูกผลิตจากการสังเคราะห์แสง?	1. ถ่านหิน 2. ปิโตรเลียม 3. ก๊าซธรรมชาติ 4. ก๊าซธรรมชาติจากชั้นหิน 5. ทั้งหมดที่กล่าวมา

75_128	ข้อใดต่อไปนี้ให้คำนิยาม พลังงาน ชัดเจนที่สุด?	1. แรงที่เคลื่อนย้ายบางสิ่ง 2. ศักยภาพและการเคลื่อนไหว 3. อัตราที่สามารถทำให้เกิดงาน 4. ความสามารถที่สามารถทำงานได้ 5. เชื้อเพลิงจากการทับถมของซากดึกดำบรรพ์
76_129	คำอธิบายใดดังต่อไปนี้ถูกต้องเกี่ยวกับการปล่อยก๊าซ CO2 เพิ่มขึ้นซึ่งเป็นสาเหตุของภาวะโลกร้อน?	1. การปล่อยจากการหายใจของมนุษย์และสัตว์ 2. การเพิ่มจำนวนจุลินทรีย์ในดิน 3. การใช้พลังงานแสงอาทิตย์เพิ่มขึ้นของ 4. การใช้น้ำจำนวนมากสำหรับการพัฒนาอุตสาหกรรม 5. การเผาไหม้เชื้อเพลิงฟอสซิลในปริมาณมาก
77_130	คำอธิบายใดต่อไปนี้ถูกต้องเกี่ยวกับพลังงาน? พลังงาน ...	1. จะหายไป 2. สามารถเก็บไว้ได้นานในรูปของน้ำ 3. เพิ่มขึ้นได้โดยไม่ต้องทำอะไร 4. สามารถเก็บรวยรวมได้ 5. จำเป็น ขาดไม่ได้เมื่อใดก็ตามที่เราต้องใช้
78_131	สองสิ่งใดที่เป็นตัวกำหนดปริมาณการใช้พลังงานไฟฟ้า (ไฟฟ้า) ของเครื่องใช้ไฟฟ้า?	1. ขนาดของเครื่อง (ลิตรหรือแกลลอน) และราคาค่าไฟฟ้า 2. อุณหภูมิของเครื่องใช้ไฟฟ้าเมื่อมีการเปิดใช้งาน และระยะเวลาที่เปิดใช้งาน 3. อัตรากำลังของเครื่องใช้ไฟฟ้า (วัตต์หรือกิโลวัตต์) และราคาค่าไฟฟ้า 4. อัตรากำลังของเครื่องใช้ไฟฟ้า (วัตต์หรือกิโลวัตต์) และระยะเวลาที่เปิดใช้งาน 5. อัตรากำลังของเครื่องใช้ไฟฟ้า (วัตต์หรือกิโลวัตต์) และขนาดของปลั๊กไฟ
79_132	คุณจะรู้ได้อย่างไรว่าชิ้นส่วนของไม้ได้เก็บพลังงานเคมีไว้?	1. สามารถเปลี่ยนรูปเป็นสิ่งอื่นๆ เช่น กระดาษ และเฟอร์นิเจอร์ 2. เป็นวัตถุที่หยุดนิ่ง 3. ปลดปล่อยความร้อนออกมาเมื่อถูกเผา 4. ครั้งหนึ่งเคยเป็นสิ่งมีชีวิต 5. ไม้ไม่มีการเก็บพลังงานไว้
80_133	นักวิทยาศาสตร์หลายคนบอกว่าอุณหภูมิเฉลี่ยของโลกเพิ่มขึ้น พวกเขาบอกว่าสาเหตุที่สำคัญอย่างหนึ่งของการเปลี่ยนแปลงนี้คือ ...	1. ฝนกรด 2. การเพิ่มขึ้นของระดับน้ำทะเล 3. ดวงอาทิตย์กำลังเคลื่อนที่เข้าใกล้โลกมากขึ้น 4. การเพิ่มความเข้มข้นของก๊าซคาร์บอนไดออกไซด์จากการเผาไหม้เชื้อเพลิงฟอสซิล 5. การเพิ่มความเข้มข้นของก๊าซคาร์บอนไดออกไซด์จากโรงไฟฟ้านิวเคลียร์
81_134	ทั้งหมดต่อไปนี้เป็นรูปแบบของพลังงานยกเว้น ...	1. สารเคมี 2. ความร้อน 3. เชิงกล 4. แม่เหล็กไฟฟ้า 5. ถ่านหิน

82_135	โรงไฟฟ้ามีประสิทธิภาพ 35% หมายความว่าอย่างไร?	1. สำหรับการลงทุนในการผลิตพลังงานทุก 100 บาท 35 บาท เป็นกำไร 2. สำหรับการลงทุนในการผลิตพลังงานทุก 35 บาท 100 บาท เป็นกำไร 3. ทุกๆ 100 หน่วยของพลังงานที่เข้าไปในโรงงาน 35 หน่วยของพลังงานสูญหายในระหว่างการเปลี่ยนรูปพลังงาน 4. ทุกๆ 35 หน่วยของพลังงานที่เข้าไปในโรงงาน จะผลิตพลังงานไฟฟ้าออกมา 100 หน่วย 5. ทุกๆ 100 หน่วยของพลังงานที่เข้าไปในโรงงาน 35 หน่วยของพลังงานจะถูกเปลี่ยนรูปเป็นพลังงานไฟฟ้า
83_136	ทางเลือกใดต่อไปนี้ทำให้เกิดการประหยัดพลังงาน?	1. การใช้เตาไฟฟ้าแบบพกพาสำหรับประกอบอาหารเพิ่มแทนการใช้น้ำมันหรือก๊าซ 2. เลือกซื้อรถที่ประหยัดน้ำมันมากและขับรถดังกล่าวแทนการขึ้นรถบัส 3. เปิดไฟไว้แทนการปิดเป็นระยะเวลาสั้น ๆ เมื่อไม่ใช้งาน 4. การเปิดโปรแกรมรักษาหน้าจอคอมพิวเตอร์ของคุณไว้ในระหว่างการใช้ 5. ปิดเครื่องยนต์รถเมื่อรถหยุดอยู่กับที่เป็นเวลา 15 วินาทีหรือมากกว่า
84_137	กิจกรรมที่เกี่ยวข้องกับพลังงานใดต่อไปนี้เป็นอันตรายต่อสุขภาพของมนุษย์และสิ่งแวดล้อมน้อยที่สุด?	1. การทำเหมืองถ่านหิน 2. การสำรวจและการขนส่งปิโตรเลียม 3. การเผาไหม้เชื้อเพลิงฟอสซิลในการผลิตไฟฟ้า 4. การผลิตแผงเซลล์แสงอาทิตย์ (โซลาร์) สำหรับผลิตกระแสไฟฟ้า 5. การผลิตกระแสไฟฟ้าด้วยเซลล์แสงอาทิตย์ (พลังงานแสงอาทิตย์)
85_138	บางคนคิดว่าถ้าเราใช้เชื้อเพลิงฟอสซิลจนหมดแล้วเราก็แค่เปลี่ยนไปใช้รถยนต์ไฟฟ้า อะไรผิดเกี่ยวกับความคิดนี้?	1. ไฟฟ้าส่วนใหญ่ในปัจจุบันผลิตมาจากเชื้อเพลิงฟอสซิล (ถ่านหิน น้ำมัน ก๊าซธรรมชาติ) 2. การเปลี่ยนไปใช้รถยนต์ไฟฟ้าจะทำให้อัตราการว่างงานเพิ่มขึ้นไป 3. มันได้รับการพิสูจน์แล้วว่ามันเป็นไปไม่ได้ที่จะสร้างรถยนต์ไฟฟ้าในปริมาณมาก 4. คุณไม่สามารถใช้กระแสไฟฟ้าในการขับเคลื่อนรถ 5. ไม่มีอะไรผิดปกติกับความคิดนี้
86_139	ข้อความใดต่อไปนี้ถูกต้องมากที่สุดเกี่ยวกับปิโตรเลียมที่ใช้ในประเทศของเรา?	1. มีความมั่นคงเพราะปิโตรเลียมนำเข้าจากทั่วทุกมุมโลก 2. มีความมั่นคงเพราะปิโตรเลียมผลิตในประเทศของเราเอง 3. มีความมั่นคงเพราะปิโตรเลียมนำเข้าจากประเทศแถบตะวันออกกลาง 4. มีความเสี่ยงเพราะปิโตรเลียมนำเข้าจากประเทศแถบตะวันออกกลาง 5. มีความเสี่ยงเพราะปิโตรเลียมนำเข้าจากประเทศแถบยุโรป
87_140	แหล่งต้นกำเนิดของพลังงานสำหรับสิ่งมีชีวิตบนโลกคือ ...	1. ดวงอาทิตย์ 2. น้ำ 3. ดิน 4. ชีวิตของพืช 5. ลม

----- เกือบจะเสร็จแล้ว !!!-----

Section 4

(1)	ชื่อประเทศ	( )
(2)	ชื่อเมืองที่คุณอาศัยอยู่	( )
(3)	ชื่อโรงเรียนของคุณ เช่นมหาวิทยาลัยเกียวโต Doshisha, Sapix	( )
(4)	การป้อนข้อมูลประเภทโรงเรียนของคุณ เช่น เอกชน, รัฐบาล หรือ อื่นๆ	( )
(5)	เพศ	1. ชาย 0. หญิง
(6)	ชั้นปี	The ( )th grade
(7)	อายุของคุณ	( ) ปี
(8)	โปรดเลือกวิชาที่คุณชื่นชอบ (สามารถตอบได้มากกว่า 1 ข้อ)	1. วิทยาศาสตร์ 2. สังคมศาสตร์ 3. วรรณคดี 4. ภาษาศาสตร์ 5. คณิตศาสตร์ 6. อื่นๆ ระบุ
(9)	คุณเคยได้เรียนรู้ประเด็นที่เกี่ยวข้องกับพลังงาน? ถ้าคุณตอบว่า "ใช่" ไปที่ข้อ (10) หรือถ้าคุณตอบว่า "ไม่" ให้ไปที่ข้อ (11)	1. ใช่ 0. ไม่ → ไปที่ (10) → ไปที่ (11)
(10)	หากคุณตอบว่า "ใช่" ในข้อ (9) คุณเรียนรู้มาจากที่ใด? (สามารถตอบได้มากกว่า 1 ข้อ)	1. ชั้นเรียนในโรงเรียนประถมศึกษา 2. การศึกษาในระดับมัธยมศึกษาตอนต้น 3. กิจกรรมภายในของการศึกษาของโรงเรียน 4. กิจกรรมภายนอกของการศึกษาของโรงเรียน 5. ที่บ้าน (พ่อแม่ พี่น้อง ผู้ปกครอง) 6. เหตุการณ์ชุมชน 7. อื่น ๆ
(11)	คุณเคยไปดูสถานที่ฝสถานประกอบการที่เกี่ยวข้องกับพลังงาน? (โรงไฟฟ้า โรงกลั่น แหล่งผลิตและขุดเจาะปิโตเลียมและก๊าซ เป็นต้น)	1. ใช่ 0. ไม่ → ไปที่ (12) → ไปที่ (13)

(12)	หากคุณตอบว่า "ใช่" ในข้อ (11) ที่ที่คุณเคยไปคือ? (สามารถตอบได้มากกว่า 1 ข้อ)	1. โรงไฟฟ้าความร้อน 2. โรงไฟฟ้าพลังน้ำ 3. โรงไฟฟ้าพลังงานแสงอาทิตย์ 4. โรงไฟฟ้าพลังงานลม 5. สถานีพลังงานชีวมวล 6. โรงงานผลิตเชื้อเพลิงชีวมวล 7. โรงไฟฟ้านิวเคลียร์ 8. อื่น ๆ
(13)	ครอบครัวของคุณเคยบอกเล่าเรื่องการประหยัดพลังงานกับคุณหรือไม่?	1. ใช่ → ไปที่ (14) 0. ไม่ → คุณเสร็จ
(14)	หากคุณตอบว่า "ใช่" ในข้อ (13) โปรดเขียนอายุที่คุณได้รับการบอกเล่าเรื่องการประหยัดพลังงานครั้งแรก	( ) ปี

ปลาย - ขอขอบคุณ 

Section 4

DEM01	(1)	Country name	( )
DEM02	(2)	City name you live in	( )
	(3)	Please enter your school name e.g., Doshisha, Sapix	( )
	(4)	Please enter your school type e.g., Private, Cram	( )
DEM03	(5)	Gender	1. Male 0. Female
DEM04	(6)	Your school year grade	The ( )th grade
DEM05	(7)	Your age Fro example: 14 years old -> Enter just "14"	( ) years old
DEM06	(8)	Please choose your favorite classes (multiple response)	1. Science class 2. Social study 3. Literature 4. Language 5. Mathematics 6. Others
DEM07	(9)	Have you ever learned energy related issues?	1. Yes 0. No → go to (10) → go to (11)
DEM08	(10)	If you answered "Yes" to item (9), where have you learned it? (multiple response)	1. Classes in elementary school 2. Classes in lower secondary school 3. Internal activity of school education 4. External activity of school education 5. At home (parents, siblings, guardians) 6. Community event 7. Others
DEM09	(11)	Have you ever been to energy-related facilities?	1. Yes 0. No → go to (12) → go to (13)
DEM10	(12)	If you answered "Yes" to item (11), where have you been to? (multiple response)	1. Thermal power plant 2. Hydroelectric power plant 3. Solar farm 4. Wind farm 5. Biomass power station 6. Biomass fuel production plant 7. Nuclear power plant 8. Others
DEM11	(13)	Have your parents ever told you about save electricity or energy? If you answer "Yes", then go to (14)	1. Yes 0. No → go to (14) → you finished
DEM12	(14)	If you answered "Yes" to item (13), how old were you when your parents first told you about energy saving?	( ) years old

Table E.1. Correspondence between Question Numbers and Survey Variables.

No.	Variable		No.	Variable		No.	Variable		No.	Variable	
1	Self-rating 01		36	CTA17	*	71	SN06		106	CSL13	*
2	Self-rating 02		37	PBC03		72	ESB07		107	CSL03	*
3	Self-rating 03		38	AR03		73	AR06		108	CSL04	*
4	Self-rating 04		39	PN03		74	NEP06	*	109	CSL14	*
5	ESB01		40	NEP03	*	75	PBC06		110	CSL05	*
6	INT01		41	ECB02		76	CTA06	*	111	CSL06	*
7	CTA11	*	42	CTA03	*	77	ATB07		112	CSL15	*
8	NEP01	*	43	ESB04		78	CTA07	*	113	CSL07	*
9	ATB01		44	INT04		79	SN07		114	CSL08	*
10	CTA12	*	45	CTA18	*	80	AR01		115	CSL16	*
11	ABC01	Deleted	46	ATB04		81	PBC07		116	CSL09	*
12	SN01		47	CTA19	*	82	ESB08		117	CSL10	*
13	AC01		48	ABC03	Deleted	83	NEP08	*	118	CSL17	*
14	CTA13	*	49	NEP04	*	84	AC07		119	CSL11	*
15	ESB02		50	PBC04		85	ESB09		120	CSL12	*
16	INT02		51	CTA21	*	86	AR07		121	CEI05	
17	CTA01	*	52	PN04		87	NEP07	*	122	BEK01	
18	AC02		53	INT05		88	SN08		123	BEK02	
19	CTA15	*	54	CTA04	*	89	AC08		124	BEK03	
20	ATB02		55	SN04		90	CTA08	*	125	CEI01	
21	ESB03	*	56	AC04		91	SN09		126	BEK04	
22	SN02		57	AR04		92	AC09		127	BEK05	
23	CTA14	*	58	ESB05		93	CTA09	*	128	BEK06	
24	PBC02		59	ATB05		94	ESB10		129	CEI02	
25	AR02		60	CTA22	*	95	NEP09	*	130	BEK08	
26	PN02		61	PN05		96	CTA20	*	131	BEK07	
27	NEP02	*	62	SN05		97	PBC01		132	BEK09	
28	CTA02	*	63	NEP05	*	98	AC10		133	CEI03	
29	INT03		64	PBC05		99	PN01		134	BEK10	
30	ECB01		65	AC05		100	CTA10	*	135	BEK11	
31	ATB03		66	ATB06		101	ESB11		136	BEK12	
32	ABC02	Deleted	67	CTA05	*	102	AC11		137	CEI04	
33	CTA16	*	68	AR05		103	CSL18	*	138	BEK13	
34	SN03		69	AC06		104	CSL01	*	139	BEK14	
35	AC03		70	ESB06		105	CSL02	*	140	BEK15	

Table E.2. Items of Actual Behavioral Control.

No.	Variable	Question
11	ABC01	If I encountered unanticipated events that placed demands on my time, it would make it more difficult for me turning off the lights (R)
32	ABC02	The difficulty of garbage separation would depend on less time or space to organize it (R)
48	ABC03	I feel that it would be difficult to solve energy issues by my own action (R)

List of publications

Papers related to this thesis

① Chapter 3
秋津 裕, 石原慶一, 奥村英之, 山末英嗣
“日本の中学生のエネルギーリテラシー調査ー知識、関心、行動の評価と日米比較ー”
エネルギー環境教育研究, vol. 10(2), pp. 15-28, (2016-06).
（An Investigation of Energy Literacy among Lower Secondary School Students in Japan: A Comparison with the US (NY State) Measuring of Knowledge, Affect, and Behavior）http://ci.nii.ac.jp/naid/40020901298

② Chapter 4
Y. Akitsu, K. N. Ishihara, H. Okumura, E.Yamasue
“Investigating Energy Literacy and its Structural Model for Lower Secondary Students in Japan”
International Journal of Environmental & Science Education, vol. 12(5), pp. 1067-1095, Article Number: ijese.2017.072, (2017).
DOI: http://www.ijese.net/makale/1867

③ Chapter 5
Y. Akitsu, K. N. Ishihara
“An Investigation of Energy Literacy Structural Model Extended from the Theory of Planned Behavior and Value-Belief-Norm Theory”
Energy Research & Social Science
Manuscript under review, submitted on Dec. 13, 2017.

④ Chapter 6
Y. Akitsu, K. N. Ishihara
“Energy literacy assessment: A Comparison of Energy Literacy of Lower Secondary Students between Thailand and Japan”
Manuscript in preparation.

雑誌掲載，著書（査読なし）

エネルギー関係

⑤ 秋津 裕, 金氏 顯, 寄稿 “原発事故について正確な知識を得て正しく怖がる－一般市民向け福島原子力発電所事故講演会のアンケート分析から,” *エネルギーフォーラム*, pp. 108-109, 2011. 10.

⑥ 秋津 裕, “消費者の視点でエネルギーを考える－草の根活動で得たこと－,” *エネルギーレビュー*「徹底分析」, pp. 28-31, 2012. 8.

⑦ 秋津 裕, “エネルギー・リテラシー醸成のためのエネルギー教育のすすめ,” *エネルギーレビュー*「女の視点」, p. 27, 2014. 2.

⑧ 秋津 裕, “今こそ，エネルギー教育を,” *日本原子力学会誌*「時論」, vol. 56, no. 44, pp. 222-223, 2014.

⑨ 秋津 裕, “エネルギーリテラシー向上を目指したエネルギー教育を,” *エネルギーレビュー*「百花繚乱 エネルギーに一言」, p. 26, 2017. 5.

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放射線教育関係

⑪ 秋津 裕, “小学生への「出前授業」を終えて－子ども達に放射線を正しく知ってもらいたい－,” *エネルギーフォーラム*, pp. 10-11, 2012. 6.

⑫ 秋津 裕, 内海博司, “「特別企画」知っていますか, 放射線,” *環境と健康*, vol. 27, no. 4, pp. 443-458, 2014.

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⑮ 秋津 裕, エネルギー環境学習絵本 *はじめまして ほうしゃせん*, 株式会社原子力安全システム研究所 社会システム研究所, エネルギー問題研究プロジェクト（福井）, 2013. http://www.inss.co.jp/book/1083.html

Oral presentations

(1) 秋津 裕, 石原慶一, 奥村英之, 山末英嗣
“日本の中学生のエネルギー・リテラシー調査”
日本エネルギー環境教育学会 第10回全国大会, 京都, 2015.8.8-10.

(2) 秋津 裕, 石原慶一, 奥村英之
“タイと日本の中学生のエネルギーリテラシー調査”
日本エネルギー環境教育学会 第12回全国大会, 福井, 2017.8.19-20.

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