

## Saudi Undergraduate Students' Needs of Pedagogical Education for Energy Literacy

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### ABSTRACT

This research focused on the interrelationships amongst students' willingness, attitudes, behaviors and factual knowledge of energy-related issues in Saudi Arabia. A valid survey was administered to undergraduate students in a public university in the Eastern Province of Saudi Arabia. The students (N=313) had positive attitudes and willingness on most energy concepts and issues. Mean score of behaviors indicated that they sometimes engaged in energy saving behavior. Most of their responses to the knowledge questions fell into low knowledge levels. The results revealed a positive willingness to voluntarily take action correlated with a positive attitude. Moreover, there were no other statistically significant differences between the factors under investigation. In summary, the students had a fairly positive attitude towards clean energy and energy conservation. However, they needed to be informed about a 'green' lifestyle that meets Saudi Arabian Vision 2030 strategies and national sustainable development goals. The present study recommends that energy-related content be included into undergraduate and university preparatory curricula to bolster future energy literacy in Saudi Arabia.

**Keywords:** Attitude, energy literacy, behavior, knowledge, Saudi Arabia, sustainability, university, willingness

### INTRODUCTION

Modern world requires to develop scientifically literate citizens, who are able to use scientific knowledge in their decision-making processes and tackle such socio-scientific issues (Upahi et al., 2017) as sustainability-related issues. Sustainability education crucially helps students understand and find solutions to contemporary and future global issues, such as climate change. University students (e.g., energy systems engineering and business management) play an important role in shaping future societies/generations (Eymur, 2017). Amidst environmental degradation and depletion of natural resources, a common goal for educators is 'to teach for a better world' (Cates, 2009). The evidence of global

warming/climate change cannot ignore the anthropogenic emission increase of carbon dioxide (CO<sub>2</sub>) (Intergovernmental Panel on Climate Change [IPCC], 2018). Younger generations need to be aware of their direct impacts on climate change (Saddington, 2014) and their responsibilities for counteracting global warming, protecting their own environmental resources and acting as global citizens of the world community. This calls for public school and university education. Any relevant curriculum needs to respect the connections among knowledge, attitudes, and behaviors that shape sustainability and energy-related decisions (DeWaters & Powers, 2008, 2011; Franzen & Vogl, 2013).

#### *LITERATURE REVIEW: energy and sustainability in the Saudi Arabian context*

This study investigated the idea ‘energy conservation is dependent on people’s knowledge, willingness, attitudes and behaviors (KWAB) about energy consumption and sustainability.’ Saudi Arabia (SA) has recently decided a transitional change from an oil-based to a knowledge-based economy. This political strategy is reflected in *Vision 2030*, which intends to carefully restructure SA vis-à-vis a three-pronged vision: a vibrant society, thriving economy, and ambitious nation (Kingdom of Saudi Arabia, 2017). Thus, Saudi citizens need to collaboratively work to achieve a new lifestyle, namely ‘green life’ and sustainable life. Sustainable life, which is an ethos and a lifestyle, attempts to reduce the individual or societal use of the natural resources (Laycock, 2016).

Two research questions are of particular interest in this study: (a) What is the relationship between Saudi undergraduate students’ attitudes, willingness, and behaviors concerning energy consumption and conservation? (b) What are their factual knowledge levels of energy? Results will shed light on how to incorporate environmental science or energy literacy (or ‘energy smarts’) into the Saudi educational curricula. Hence, younger generation may have an opportunity to pursue a better world through responsible energy conservation. Because Saudi people have been living in an oil-rich environment (Alyousef & Varnham, 2010), they need to change their oil-dependent habits with a knowledge-based economy (Kingdom of Saudi Arabia, 2017).

To illustrate this dependency, Germanwatch (2018) ranked Saudi Arabia 60th in the world in the Climate Change Performance Index (CCPI). That is, the Saudi Arabian CCPI was 11.20 whilst the Swedish one, which was the number one, was 74.32. As a caveat, no country has perfectly performed about climate protection despite of a decrease in greenhouse gas emissions (Burck, Marten, Höhne, & Hmaidan, 2018). Janssens-Maenhout et al. (2017) reported that the power industry in Saudi Arabia, which burned fossil fuels, constituted the majority of carbon dioxide (CO<sub>2</sub>) emission. In 2016, the total CO<sub>2</sub> emission per capita in Saudi Arabia was 16.009, which was close to the United States’ one (15.564). Given its low performance, Saudi Arabia has been moving forward to the development of a clean energy policy that minimizes an oil-dependent economy (Kingdom of Saudi Arabia, 2018; Kinnimont, 2017).

#### *Saudi Progress on United Nations’ Sustainable Development Goals*

To respect the global and regional need(s) for ecological sustainability, Saudi Arabia has actively addressed the United Nations’ (UN) (2015) sustainable development goals (SDGs). This strives to “free the human race from the tyranny of poverty and want and to heal and secure our planet” (p.2). In Saudi Arabia, “SDG-related activities will proceed hand-in-hand with the implementation of Vision 2030, which has already gathered significant momentum” (Kingdom of Saudi Arabia, 2018, p.165). In its first voluntary progress report to the United Nations Development Program (UNDP), the Saudi government reported the

quality of education at Goal 4; “a Royal Order was issued to include the SDGs into educational curricula. Work is in progress towards this end, led by the Ministry of Education” (MOE) (Kingdom of Saudi Arabia, 2018, p.24).

The country has still been striving to address Goals 7 and 11 (sustainable and modern energy; sustainable and resilient cities respectively) (Kingdom of Saudi Arabia, 2018). One of the notable energy-related efforts made by the Saudi Arabian Ministry of Energy, Industry and Mineral Resources has been the execution of its *National Renewable Energy Program* achieved by the Renewable Energy Project Development Office (REPDO) since 2017. Thereby, its intent is to deliver renewable energy across the country in line with *Vision 2030* (REPDO, 2017). Also, the *National Transformation Program 2020*, which involved the Saudi Ministry of Education, was launched in 2016. Its main goal is to improve education to support the national economy (Saudi Ministry of Education, 2017).

### *Sustainability Knowledge in Saudi Arabia*

Sustainability knowledge in the Arab region is generally poor due to the political, social and economic instability caused by conflicts and wars (Mezhar, Noamani, Abdul-Malak, & Maddah, 2011). ElHassan (2013), who gauged university students’ awareness of sustainable development in their country, found that one third (39%) of the respondents had a low level of awareness of governmental sustainability efforts. Other Saudi researchers and scholars, who have researched on environmental issues and education (e.g., Alyousef & Varnham, 2010; Islam & Amin, 2012; Jassim & Coskuner, 2007; Mezher et al., 2011; Taleghani, Ansari, & Jennings, 2010), have stressed that this topic should be integrated into the Saudi higher education system.

In more detail, an endemic culture of wasteful energy usage has evolved in Saudi Arabia. Saudi policy makers and citizens, who have recently become aware of the finite nature of the Kingdom’s fossil fuel resources (Alyousef & Varnham, 2010), claim that Saudi citizens have limited interest or awareness of energy efficiency and its benefits. However, subsidized energy and profligate energy usage in Saudi Arabia are no longer viable options, especially since Saudi Arabia neglected the use of its own renewable resources (e.g. wind and solar energy), which has been changing nowadays (Alyousef & Varnham, 2010). Energy literacy among Saudi citizens matters because well-informed citizens can support the design and implementation of smart and forward-looking policies (i.e., educational policies) (Yeh, Huang & Yu, 2017).

Because issues around environmental sustainability and energy are relatively new concepts in Middle Eastern countries, very few universities have designed their educational curricula around these issues (Taleghani et al., 2010). Further, although universities seem to understand sustainability principles, they are “slow to incorporate them into their core curriculum” (p.114). If they do so, these concepts are offered in elective classes that create “a ‘fringe’ reputation for sustainability” (p.113). For example, the growing interest in energy, sustainability-related issues and concepts has prompted several Saudi universities to relate them to architecture: climate and architecture, ecological analyzes, and ecosystems in Islamic traditions (Taleghani et al., 2010).

Islam and Amin (2013), who developed a similar argument for mechanical engineers (ME) in Saudi Arabia, referred to need for sufficient knowledge to deal with renewable-energy technologies (RET). They recommended that educational institutions needed to develop RET-related education for undergraduate students so they could enter the emergent Saudi and global job market for the diverse fields of RET. Further, they developed a model for ME undergraduate course. Jassim and Coskuner (2007) characterized Saudi Arabia (part of the Gulf Cooperation Countries) as a “global hydrocarbon energy centre” (p.93) and

necessitated university education for environmental engineers (EE). Likewise, Jassim and Coskuner (2007) called for EE education to be taught as a standalone course in a separate department rather than the larger disciplines of civil or chemical engineering.

The aforementioned studies have stated that the welfare of future Saudi generations depends on the development and implementation of rigorous university curricula focusing on energy and sustainability. Such an education prepares people to become proactive towards sustainability challenges. Graduated students, who have low knowledge levels for such issues as climate change, are unable to manage pollution and water management (Jassim & Coskuner, 2007). The prosperity of nations and the advancement of future generations highly depend on building knowledge (especially, sustainability knowledge) at the university level (Mezher et al., 2011).

### *Saudi Universities' Sustainability Activities*

A few Saudi universities have offered energy-related academic programs, for example, King Abdullah University of Science and Technology (KAUST) (2018), King Fahd University of Petroleum and Minerals (KFUPM) (2018), King Saud University (KSU) (2018), and Effat University (2018). KAUST, KFUPM and KSU are three of 28 *public* universities while Effat University (2018) is one of 10 *private* universities in the country. Notably, these are postgraduate or research programs and are not designed for specializing students in renewable and sustainable energy engineering fields. Exceptionally, KFUPM offers a short course on renewable energy systems for investors and entrepreneurs (EGPHIL Solar Solutions, 2016).

### *Saudi Government's Sustainability Activity*

The government has been working on raising citizens' awareness of sustainable life and the use of renewable energy by increasing their knowledge levels, for example, King Abdullah City for Atomic and Renewable Energy (KACARE) (2017). However, in view of Ratikainen (2017), such initiatives or government programs require a great effort to reach the whole Saudi population and not just for youth. She also expressed her concern(s) about the success of the Saudi renewable energy policies given the statement "the country's weak innovation culture, and lack of a skilled workforce and knowledge base hinders a successful development, manufacturing and implementation process" (p.iv). Zafar (2017) maintained a well-trained and performed workforce, which is crucial for the development of solar market. However, Salam and Khan (2017) claimed the localization of a workforce that is unskilled, untrained and semi-skilled challenges for the success of solar energy development in Saudi Arabia. In the spirit of *Vision 2030's* economic developmental goals, the SA government should partner higher education institutions to match the Saudi graduated students' skills and knowledge to meet the local renewable energy job market as well as the sustainability of society and the Earth (see Islam and Amin, 2013).

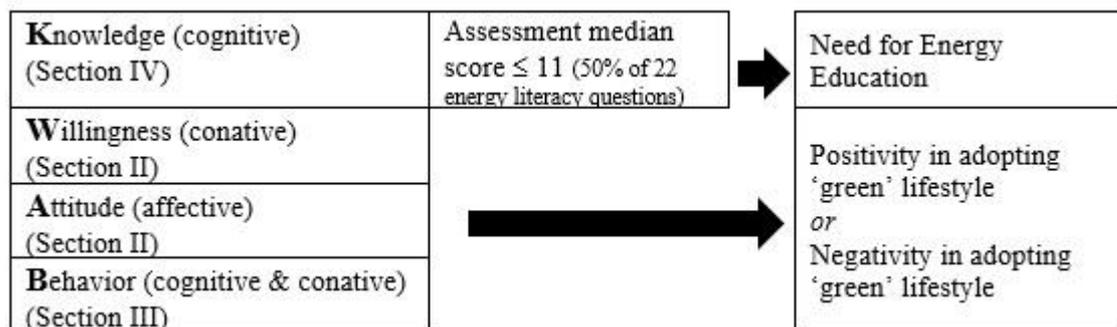
### *Conceptual Framework*

DeWaters and Powers (2011), who focused on American junior and senior high school students' energy literacy levels, addressed that they did not have sufficient knowledge or skills to effectively suggest solutions towards energy problems. In addition, even though relatively mature high school students were more energy literate than their middle school counterparts, their behaviors may not reflect it (see DeWaters & Powers, 2008). A focused education as a starting point requires nurturing sustainable consumption and development for

a global scale. Franzen and Vogl (2013) asserted the statement “the most direct way to keep environmental concern up seems to be through increased access to education” (p.7).

Indeed, UNESCO (2014) maintained that sustainability and sustainable life begins with education. Additionally, the benefits of ‘green life’ are more evident to work with their families, neighbors and communities at the same educated individuals (Winter, 2007). Education plays an important role in raising students’ awareness of knowledge about key issues arising from globalization, especially energy and sustainability. It is noteworthy that students’ knowledge of environmental issues varies with the specific issue(s) (Organization for Economic Cooperation and Development (OECD), 2007). Hence, any relevant curriculum needs to be diverse and comprehensive for environmental issues. The development of such a curriculum requires identifying students’ current knowledge levels of and attitudes towards sustainability and energy issues (called energy literacy).

DeWaters et al. (2013) equated attitudes with affective (valuing and judgments), behaviors with habits, and cognitive with concepts for energy literacy. They proposed that affective and behavioral characteristics were generally concerned with global energy issues and exhibited a willingness to voluntarily address them. In detail, an attitude, which is a positive or negative disposition towards something (e.g. smoking or violence), produces “a set of potential behaviors ... from which one will be chosen and deliberately performed” (De la Sierra, Smith, & Mitchell, 2017, p.7). Moreover, behavior is a “specific and concrete action” (De la Sierra et al., 2017, p.7). Bilir and Özbaş (2017), who investigated high school students’ roles of the conservation of biodiversity, applied the Value-Belief-Norm (VBN) theory developed by Stern et al. (1999) and stated that “the environment is directly or indirectly affected by the behavior of individuals” (p.27). An environmental concern entails both cognition (having rational insight) and conation (willingness to do something with that insight) (Franzen & Vogl, 2013). Regarding willingness, conation is a mental process referring to the will. If someone is *willing*, it means they are ready to do something voluntarily (Anderson, 2014). Any tendency to alter people’s behaviors depends on their willingness to both act and change (Franzen & Vogl, 2013). For this study, the researchers drew on these four concepts to develop a Knowledge, Willingness, Attitude and Behavior (KWAB) model under investigation (see Figure 1).



**Figure 1.** A Knowledge, willingness, attitude and behavior (KWAB) model developed for this study

Decision making, which precedes behavior (Ortega, 2017), is part of this model. DeWaters et al. (2013) asserted that “improving students’ energy literacy will empower them to become engaged in objectively assessing energy-related decisions throughout their daily lives” (p.57). This emphasizes decision making for any change, which entails each of KWAB. Figure 2 outlines what happens in a person’s mind when facing with decision making. It involves external input and internal self-talk leading to mental images of the world that form their thoughts. Thereby, any decision making can, in turn, result in action and behavior. The word ‘act’ means doing something. These acts (actions) constitute the manner (i.e., range and

scope of acts) in which someone behaves (i.e., *behaviors*). Sustainable behavior also requires people to engage in rational decision making, which is a complex and challenging process (Ortega, 2017) (see Figure 2).

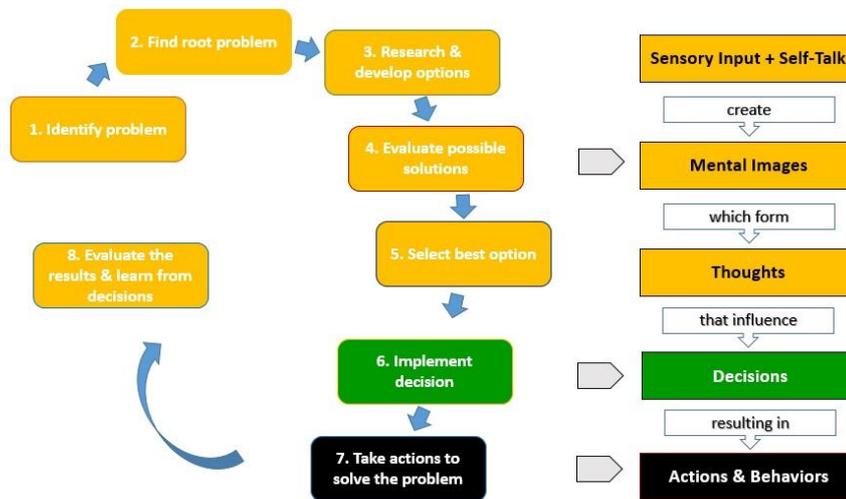


Figure 2. Decision making models (adapted from Ortega, 2017)

## METHODOLOGY

Through survey research design, an instrument was administered to Saudi undergraduate students in a public university in the Eastern Province of Saudi Arabia to respond to two research questions reflecting the KWAB model developed for this study (see Figure 1).

### a) The Sample of the Study

Since the objectives of this study were to understand Saudi Arabian undergraduate students' behaviors, assess their knowledge levels of energy, and tap into their attitudes and willingness towards energy conservation, the sample of the study was drawn from a public Saudi university in the Eastern Province, whose student population comprised of 45,000 undergraduate students and 6,000 university preparation students over 20 colleges. The university preparation in the university provides additional courses for the English language, mathematics, and learning skills to meet the needs of such programs determined by placement tests.

In selection process, this university has made some sustainable development efforts. For example, a Deanship of Community Service and Sustainable Development has been established as well as creating a Sustainable Development Club to promote sustainability on campus and in the community. However, no educational programs for energy literacy and sustainability education have been planned, apart from postgraduate research, which was not the focus of this study.

The university's Research Ethics Committee approved a request to undertake data collection at their institutions/colleges. With the university's permission, the colleges and programs (e.g., education, law, literature, science, and computing and IT) on both male and female campuses agreed to participate in the study. Rather than contacting the students personally, the researchers contacted the university administration and lecturers and asked them to briefly explain the study's rationale and goals. Later, they instructed the students about how to complete the survey or decline with no penalty. The researchers virtually

approached all students via this recruitment protocol. In brief, 313 undergraduate students completed the survey (94% response rate).

### **b) Data Collection**

The current research employed the Energy Literacy Questionnaire (ELQ) previously validated by DeWaters and Powers (2008, 2011) and DeWaters, Qaqish, Graham, and Powers (2013) the “instrument (ELQ) was pilot tested ... and was shown to be a valid and reliable quantitative measure” (DeWaters and Powers, 2011, p. 1700). “The internal consistency reliability of each subscale, as measured by Cronbach’s alpha, is 0.79 (cognitive), 0.83 (affective), and 0.78 (behavioral), all satisfying generally accepted criteria for internal reliability” (p.1701).

Because the ELQ was designed for developed countries (DeWaters et al., 2013), the researchers conducted a pilot study to adapt it into Saudi Arabian context, as a developing country. That is, two universities in the Eastern Province took part in the pilot study. The pilot study resulted in some revisions, i.e., 25% of the questions were Saudi-specific. The instrument for the current study was concurrently in English and Arabic languages and available upon request. It comprised of 60 questions into four sections of the KWAB model developed for the study (see Figure 1).

Section 1 contained nine fill-in-the-blank and menu option questions pertaining to demographics and self-evaluation of energy literacy and issues. Section 2, which was concerned with *attitudes* and *willingness* to act towards energy issues, was divided into two parts. First, 12 questions used a 5-point Likert scale ranging from strongly agree to strongly disagree. Most of these were positive statements. These *cognition* questions required respondents to reveal their attitudes towards energy issues (Franzen & Vogl, 2013). In the second part (six questions), a different 5-point Likert scale was used to measure *willingness* to act from very willing to very unwilling. These *conative* questions (Franzen & Vogl, 2013) were modeled on the International Social Survey Program’s (ISSP) (2010) survey focusing on the environment. These questions dealt mainly with environmental degradation, pollution and protection as well as behaviors, attitudes and opinions. They were mostly negative in nature in the current study, and necessitated reverse coding.

Section 3 contained 13 questions focused on *behaviors* towards energy issues and used another 5-point Likert scale from almost always to hardly ever. Section 4 (22 questions), which concentrated on their *knowledge* about energy issues (i.e., energy literacy), asked the students to select the best answer from menu items. To facilitate this selection, the researchers also created a best-answer key before administering the survey. The median score for satisfactory knowledge assessment was 11 representing half of 22 questions. High scores demonstrated a high level of knowledge around energy issues and vice versa.

### **c) Data Collection**

Data were collected in January 2017. Lecturers, who had agreed to take part in the research protocol, introduced the study’s rationale and goals to the students and asked them to complete the survey. Upon receiving hardcopies of the instrument from the lecturers, they completed and returned them on the same day. No attempt was made to improve their initial response rate (N=313; 94%), which was likely so high for returning the instrument at the same day (Wählberg & Poom, 2015). Its average response rate vis-à-vis the undergraduate population was 43% (Porter & Umbach, 2006).

#### d) Data Analysis

All data were entered into Microsoft Excel spreadsheets for descriptive statistics, statistical significance tests (t-tests) and correlations. Microsoft Excel was also employed to cross-check various statistical calculations and analyze the scores collected in Section 4 (knowledge). To reiterate, this section required the students to select their answers from menu options. Thus, their answers were scored by comparing the number of correct answers with a previously-prepared answer key.

### RESULTS AND DISCUSSION

This section presents the results for each of the four-survey sections (i.e., self-evaluation of energy literacy, attitudes and willingness, behaviors, and knowledge) and discussed their meanings and importance in light of the related literature. Further, their positions were handled within the KWAB model developed for the study (see Figure 1).

#### Section 1: Demographics and Students' Self-Evaluation

The sample of the study comprised of 313 undergraduate students (n=199 females, 64%; and n=114 males, 36%; aged 18-22 years, 88%). Most of them (87%) used the Arabic language to study at university. Slightly more than half (55%) were enrolled in the university programs while the rest of them (45%) took the university preparatory program. There was a fairly even spread across the four university levels (averaging 10% for each level), e.g., 12% for sophomore or 11% for senior of the program. Fields of study mainly included education, 'other,' literature, sciences, and law (see Figure 3).

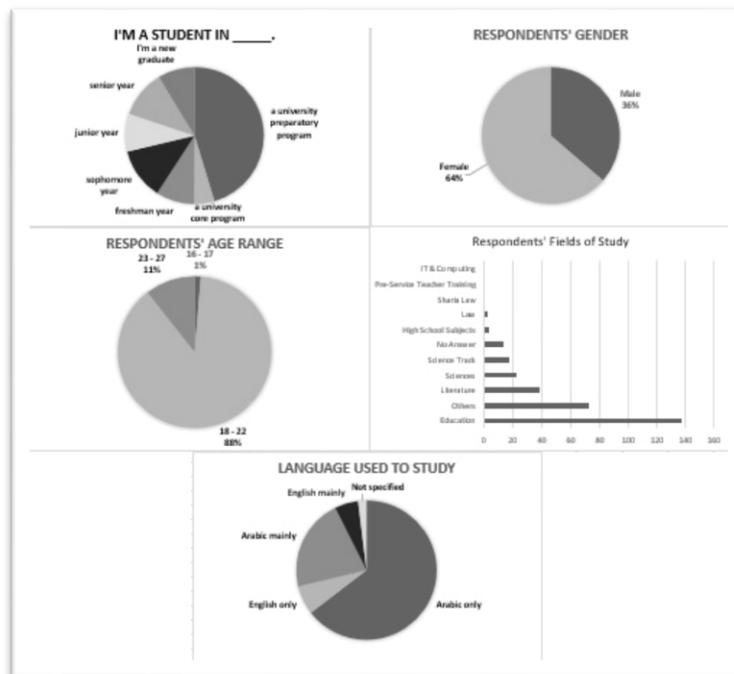


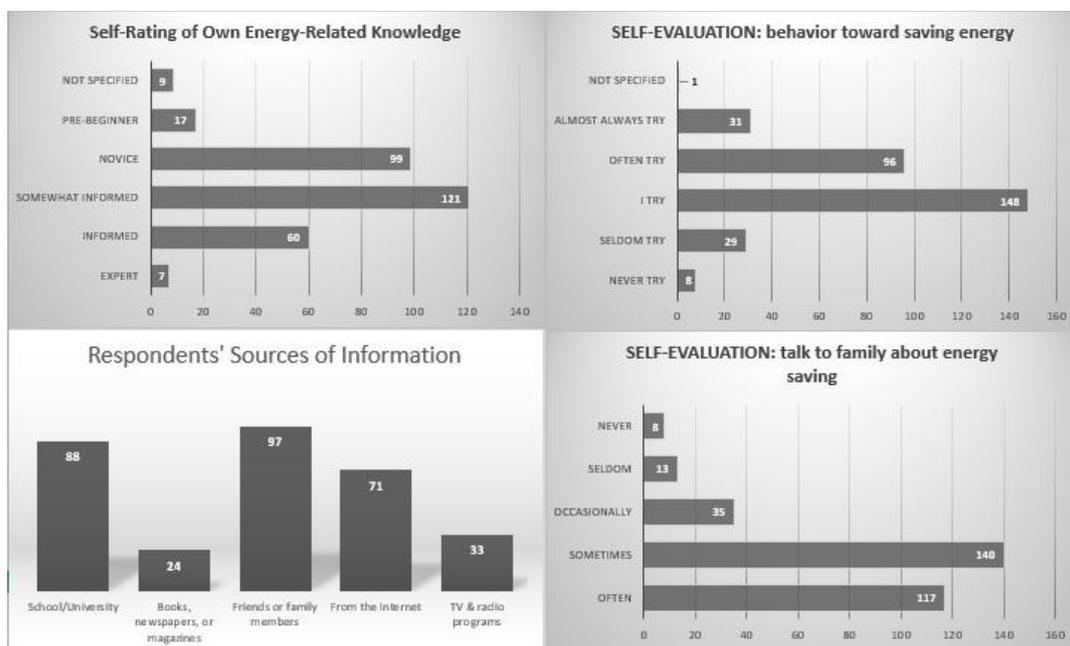
Figure 3. Demographics of the sample (N=313)

*Students' self-evaluations of energy literacy.* More than one-third (39%) of the students said that they were *somewhat* informed (i.e., to some extent) about energy issues while a third of them (32%) implied that they were *novice* (i.e., new and inexperienced).

Almost 20% of the respondents said they were *informed*. Very few of them (5.5%) identified themselves as *pre-beginner* (i.e., no knowledge at all).

*Students' behavior toward saving energy.* Almost half of them (47%) stated the statement 'I try' (i.e., make an attempt or put some effort into it) about their behaviors towards saving energy, whilst 41% of them referred to the statement 'often and always try.' Minority of them (12%) addressed 'seldom or never try.' Framed another way, over three quarters of them (78%) said the statements 'try' or 'often try' to save energy. These results pointed to their mental readiness and positivity for reduction of energy consumption. This result reflects recent observations that the Saudi citizens have been beginning to realize that they can no longer sustain their culture of wasteful energy usage (Alyousef & Carnham, 2010).

Over a quarter (31%) of them said that they obtained their energy-related information from their friends and family members, whereas majority of them (58%) depicted to only 'occasionally' or 'sometimes' talk with their families about energy issues. Percentages of other sources of energy-related information, e.g., internet and TV/radio, school and university, printed material (books, magazines, newspapers) were 43, 28 and 7.6 respectively (see Figure 4).



**Figure 4.** The Saudi undergraduate students' self-evaluations of energy literacy

In short, the results of the current study pointed to the important role of family members and social networks on obtaining and sharing energy knowledge and discussing related issues. The benefits of 'green life' increase when people engage with their families, neighbors and communities around these issues (Winter, 2007). As well, sharing an understanding of energy-related problems and solutions among family members will nourish a family tradition of environmental protection, hopefully contributing to the shift away from a culture of wasteful energy usage (Alyousef & Carnham, 2010).

The results also strongly suggest that universities – a place where the undergraduate students sought energy-related knowledge – need to provide energy education. However, this idea may be challenging to Mezher et al.'s (2011) view of limited sustainability knowledge in the Arab region's internet relative to social networking sites. Previous researchers have referred to the inadequacies of energy knowledge in university and sustainability-related topics (e.g. Islam & Amin, 2013; Jassim & Coskuner, 2007; Taleghani et al., 2010). The

results call for much more efforts to equip undergraduate students with confidently using the information sources.

### *Sections 2: Students' Attitudes and Willingness*

Ninety-one percent of the undergraduate students, who completed Section 2 on attitudes and willingness, deemed an acceptable nonresponse rate (Ritz, 2018). Statistical analysis affirmed a positive correlation between their attitudes and willingness to take an action towards energy issues. There was a statistically significant correlation between attitude and willingness reflected in a Pearson Correlation coefficient value of  $r=0.343$  based on a significance level of  $p=0.01$  (2-tailed). As noted by Franzen and Vogl (2013), people have a tendency to alter their behaviors by depending on their willingness. The results bode well for the Saudi undergraduate students' propensity to effective environmental change in Saudi Arabia.

The students under investigation profiled more positive willingness than negative one. High mean scores ( $\bar{x} > 4$ ) on the 5-point Likert scales reflected their positive attitudes towards and willingness to take an action on *particular* energy issues. They made several suggestions, for instance, 'energy education should be placed in the school or university curriculum', 'information on energy efficiency should be displayed on appliances.' Further, they seem to have moderately been willing to do what is right for energy conservation, even when it takes more time. Also, they agreed that burning fossil fuels caused global warming, and offered that electricity should have been produced by using renewable resources rather than oil. Further, they suggested that Saudi Arabia was supposed to develop more ways of using renewable energy to protect the environment despite of its possible high energy cost. Moreover, they also felt that Saudis needed to work on saving energy despite of having oil reserves. They disagreed that there was no need to worry about turning off classroom lights or computers because the university paid the electricity. Overall, these results indicated their positive attitudes toward energy education, government intervention and individual actions to address energy issues.

At the other end of the spectrum, the students showed negative attitudes and unwillingness towards some energy issues (mean =  $1 < \bar{x} < 2$ ). They did not think that modern science would solve energy problems and limitedly change their ways of living. They were unwilling to pay much higher prices in order to cut down on consuming energy and traveling by car or plane to slow down climate change. In other words, they were not ready to change *these* aspects of their lifestyles.

Mixed results of the 'attitude and willingness' variables may be understandable because Saudi citizens are relatively new to the idea of shifting their culture of wasteful energy usage to one of efficient usage (Alyousef & Carnham, 2010). Positive predispositions to voluntarily act as energy conservation and willingness are differently emergent in Saudi Arabia. As well, the energy-related concepts are new ideas in the Middle East region and are not yet firmly entrenched in higher education (Taleghani et al., 2010). The lack of sustainability knowledge on Saudi websites (Mezher et al., 2010) may also contribute to the mixed attitudes and degree of willingness towards energy-issues. That is, this study did not find any statistical difference between attitudes, willingness and knowledge (Pearson Correlation coefficient values of  $r=0.096$  and  $r=0.027$  respectively based on 0.01 significance level - 2-tailed).

### Section 3: Students' Behaviors

Majority (92%, n=288) of them, who completed Section 3 pertaining to their actual energy-related behavior, deemed an acceptable nonresponse rate (Ritz, 2018). Mean score of this variable was 3.40 ( $\mu=3.40$ ) indicating *sometimes* (i.e., infrequently and irregularly). This represents a less-than-desirable degree of well-established energy conservation habits. Any behavior is tied to a decision making to change one's action(s) (Ortega, 2017). Decision making involves external input and internal self-talk (Ortega, 2017, see Figure 2). Indeed, Saudi citizens have lived in an oil-rich nation for decades, and have not thought about conservation as part of their mental self-talks (Alyousef & Varnham, 2010; Taleghani et al., 2010). This means that a score of *sometimes* engaging in energy-related behaviors might be expected.

High mean scores ( $\bar{x} < 4$ ) of *particular* behaviors reflected their positive behaviors towards saving water, and turning off both lights and computers when not in use. Low mean scores ( $1 < \bar{x} < 2$ ) indicated their negative behaviors towards decision making based on energy use, encouraging the purchase of energy efficient light bulbs, and carpooling. Again, these behaviors are well entrenched in the Saudi psyche with its long history of oil reserves and an economy based on such (Alyousef & Varnham, 2010).

### Section 4: Students' Energy Knowledge

Some of earlier researches have believed that factual knowledge does not offer insights regarding consumer decision-making on energy conservation (Demeo, Feldman, & Peterson, 2013). Nonetheless, the researchers felt that making an initial assessment of the Saudi undergraduate students' factual knowledge about energy issues (i.e., their energy literacy) was worthwhile since they have lived in a historically and economically oil-based nation (Alyousef & Varnham, 2010; Kingdom of Saudi Arabia, 2017, 2018). Generally, they failed to score satisfactorily in the knowledge section of this survey. Median score of satisfactory knowledge assessment fell into 11 correct answers representing half of 22 questions. Mean score was 9.03 ( $\mu=9.03$ ), which was equivalent to 43% of their responses. This means that most of them inadequately answered knowledge questions (see Table 1). Mezhar et al. (2011) also determined that sustainability knowledge in the Arab region was generally poor.

**Table 1.** The students' performances of knowledge questions in Section 4

70% - 75%	60% - 69%	50% - 59%	40% - 49%	0% - 39%
Good	Not too Bad	Worker Harder	Not Good	Oh No!
Q.39 (73.89%)	Q.46 (67.83%)	Q.40 (54.14%)	Q.41 (40.76%)	Q.43 (27.39%)
Q.54 (70.06%)	Q.50 (68.47%)	Q.52 (55.10%)	Q.42 (47.45%)	Q.44 (17.20%)
Q.59 (72.61%)	Q.56 (60.19%)	Q.53 (50.96%)	Q.47 (Pilot: 40%)	Q.45 (13.06%)
	Q.58 (66.56%)		Q.48 (31.53%)	Q.49 (10.83%)
	Q.60 (65.92%)		Q.51 (36.31%)	Q.55 (29.30%)
				Q.57 (19.75%)

As seen from Table 1, the students' performances of 11 questions illustrated a poor understanding of the *particular* concepts 'defining and measuring energy, and energy efficiency.' Conversely, their higher scored concepts ( $69% >$ ) were related to renewable energy, and transportation concerns. Their middle range scores (50-59%) pertained to energy usage in the home. PISA results also indicated that students' knowledge of environmental issues varied with the specific issue(s) or concept(s) (OECD, 2007). The students' overall

level of energy knowledge may affect their behaviors of energy saving and improvement on energy consumption (DeWaters & Powers, 2011). Unfortunately, similar to DeWaters and Powers' (2011) findings, the students under investigation did not have enough knowledge resulting in effectively finding solutions to energy problems.

As observed in Figure 3, the sample frame was fairly balanced between university preparatory students (45%) and university students (55%). The results revealed that the university preparatory students were statistically more knowledgeable (mean=9.6) about energy literacy than the undergraduate students (mean=8.5) ( $p=0.011$ , greater than  $p=0.01$ ). The undergraduate science students (who were all female) performed better than non-science ones in both the preparatory program (mean=11.0 for the science students, and mean: 9.4 for the non-science student) and university level (mean=10.0 for the science students, and mean: 8.34 for the non-science students). These results affirmed the importance of science knowledge in improving people's energy literacy. As a matter of fact, Yeh et al. (2017) claims that energy literacy depends on people's abilities of understanding and applying scientific knowledge/methods to energy issues and problems.

The students' unsatisfactory performances of the questions in the knowledge section may not correspond to their higher self-ratings of perceived energy knowledge. The results clearly showed that their actual knowledge level was indicative of 'pre-beginner' (scoring below 50% on the questions) instead of 'somewhat informed' (i.e., to some extent) (38.5%). Also, 'I Do not Know' (IDK) answers reflected their knowledge gap in energy-related issues and lack of confidence in providing correct answers.

#### *KWAB Model Statistically-Significant Results*

The results of the KWAB model (previously illustrated in Figure 1) indicated a statistically-significant correlation between attitude and willingness with a Pearson Correlation coefficient value of 0.343 ( $r=0.343$ ) based on a significance level of 0.01 (2-tailed). Even though a moderately strong correlation between attitude and willingness asks for taking any voluntary action towards energy issues (*conative* power) for Saudi university students (see Franzen & Vogl, 2013), there were no other statistically-significant correlations between the other variables in the KWAB model (see Figure 5).

Variables	Knowledge	Willingness	Attitude	Behavior
Knowledge	1			
Willingness	0.027 Sig. (2-tailed)	1		
Attitude	0.096 Sig. (2-tailed)	0.343** Sig. (2-tailed)	1	
Behavior	0.034 Sig. (2-tailed)	0.050 Sig. (2-tailed)	0.22 Sig. (2-tailed)	1

\*\*Correlations is significant at the 0.01 level (2-tailed).

N=313

**Figure 5.** The results of Pearson Correlation for the KWAB model

The fact that there was no correlation between knowledge and behavior (i.e., 'what you know' was compared to 'how you behave') may be explained with Demeo et al.'s (2013) statement asserting that factual knowledge does not offer insights into decision-making on energy conservation, and behaviors directly affecting their decision-making processes

(Ortega, 2017). Since knowledge scores were low in this study, the students may not have made energy-related decisions with their ill-informed knowledge. These results support both the Royal Decree to include the SDGs in Saudi Arabian education (Kingdom of Saudi Arabia, 2018) and the intent to modernize education (Kinninmont, 2017). The Saudi Ministry of Education (2017) has aspired to achieve *Vision 2030* by enabling students to face modern life requirements, e.g., energy literacy. That is, moving away from an oil-based economy requires teaching about energy conservation and sustainability.

In summary, the results generally affirmed the need for more education about energy issues (cognitive knowledge) and particularly curriculum foci on attitudes, willingness and behaviors. That is, making rational energy-related decisions requires a predisposition towards sustainability (attitude), the willingness to voluntarily take action (conation), and the energy-literacy habits of behavior patterns (DeWaters & Powers, 2011; DeWaters et al., 2013; Franzen & Vogl, 2013).

### *Limitations of the Study*

Because this study focused on only one university in one province, this may be seen as a limitation of the study. Thus, future studies should include other universities in Saudi Arabia to conduct cross comparative analyses and curriculum planning. Despite a very high response rate, further studies should be carried out with a large sample size to generalize their results to the Saudi university population. Diversity in response rates may be viewed as another limitation because type of institution and the makeup of the student body responded differently to the questionnaire (Porter & Umbach, 2006).

## **CONCLUSIONS AND RECOMMENDATIONS**

Given the results of previous researches (e.g., Islam & Amin, 2012; Jassim & Coskuner, 2007; Taleghani et al. 2010), the current study recommends that Energy Sustainability Education be included in the university curricula. For example, a university course should be suggested for science or non-science students. Also, a compulsory course may be offered for the university preparatory program. Apart from English and Math courses, renewable energy and sustainability knowledge should be incorporated in the university placement tests prior to the university admission.

Low knowledge levels found in this study call for an urgent need to make the Saudi university students energy literate (Mezhar et al. (2011). Equipping young generations with sustainability knowledge may be an indicator to succeed in technological innovation of clean energy. That is, this is in a harmony with the Kingdom's *Vision 2030*, which purposes to develop, supply and store clean energy via modernized policies (Kingdom of Saudi Arabia, 2017, 2018; Yeh et al., 2017).

Because the results revealed that the primary sources of energy-related knowledge were parents, other family members and friends to share and discuss energy issues with them, public school educators, university educators and adult educators should encourage parents and family members to seek information on renewable energy and energy sustainability. Educators should work collaboratively with relevant stakeholders to make energy-related and sustainability information accessible and relevant (Winter, 2007).

Despite many years of oil-dependent life (Alyousef & Varnham, 2010), the Saudi university students appeared to be willing to somewhat change *certain* aspects of their lifestyles. Since their knowledge levels of energy issues were low, they need to learn energy-related knowledge that helps them understand natural resource challenges (Alyousef & Varnham, 2010) and environmental degradation worldwide. Further, undergraduate curricula

ought to be reviewed and revised to establish current benchmarks for future directions. Curriculum development studies should focus on privilege standalone courses pertaining to Saudi related energy issues. These curricula and courses should be ever greened, kept fresh, current and relevant as RET technologies to shift and change global and ecological realities.

To sum up, the results suggested that the students' poor performances of energy literacy might undermine their abilities of energy-related issues. This would adversely affect their abilities at developing positive attitudes, forming a willingness to voluntarily take action, and making informed choices on how to tackle energy-related issues (see Figure 2). Thereby, Saudi university curricula should be revised to achieve *Vision 2030* throughout efficient production and use of clean energy and its effective consumption. New curricula should not only equip Saudi science and non-science students with relevant knowledge but also help them choose to take an action upon energy-related issues. That is, education leading to new knowledge is supposed to inform their attitudes and willingness, which can, in turn, influence their behaviors. Energy literacy will be able to accelerate sustainability and efficiency-oriented culture achieve the UN's SDGs and Saudi Arabian *Vision 2030*.

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