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Exploring the impact of the COVID-19 pandemic on energy literacy and conservation behavior in academic buildings of Kuwait

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ABSTRACT

This study investigates the impact of the COVID-19 pandemic on energy literacy and conservation behavior among occupant groups in academic buildings in Kuwait. It explores influential factors, focusing on the pandemic's effect on attitudes, intentions, and behaviors related to energy conservation. The research adopts a mixed-methods approach, incorporating quantitative and qualitative data collection methods. Participants, including students, faculty, and staff, completed surveys, participated in questionnaires, focus groups, and took part in interviews. Statistical tests are used to validate the survey data, while thematic analysis is applied to the qualitative data. The findings of the research showed that COVID-19 had a significant impact on participants' attitudes, intentions, and behavior regarding energy literacy and conservation. Specifically, the student group experienced a significant increase in the relationship between their intentions and behavior, while the faculty group exhibited a strong correlation between intention and behavior. The study also found that education, awareness, personal motivation, values, religiosity, and culture were all crucial factors in promoting energy literacy and conservation behavior. The study recommends specific educational interventions, fostering a culture of conservation, providing access to information and resources, promoting community engagement, incorporating religiosity, and improving policies and infrastructure to enhance energy literacy in academic buildings. Additionally, the study highlights the importance of tailored educational interventions that consider the specific needs and challenges of different occupant groups and suggests incorporating religious perspectives to align with the cultural and religious context of the Kuwaiti population. The study's findings offer comprehensive insights into the impact of unforeseen events, such as pandemics, on energy literacy and conservation behavior. These insights have practical implications for policymaking and implementation. Future research could explore the effectiveness of various educational interventions and examine the role of social and cultural factors in shaping energy literacy and behavior.

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1. Introduction

Energy and environmental degradation have always been complex issues in the world to be dealt with from various perspectives. It has been commonly studied in econometrics to develop macro-economic strategies. Işık et al. [1] presented the advantages of using renewable energy in the US. Liu et al. [2] examined the significance of alternative energy resources in developing countries. Işık et al. [3] examined the convergence of per capita ecological footprints for the nations that signed The North American Free Trade Agreement and indicated that they have adopted similar environmental strategies to reduce or stop environmental damage.

With the appearance of the COVID-19 pandemic, the complexity has increased as it has extensively affected all aspects of life, including energy, environment, and education. It has significantly impacted the educational sector worldwide, disrupting traditional classroom learning and schools' operations. The massive shifts in people's lives due to COVID viruses have drawn their attention to environmental problems. COVID-19 has not only had far-reaching impacts on our lives but also changed how we think about environmental conservation and highlights its crucial role in protecting humanity [4,5]. Several studies have found that COVID-19 has altered attitudes and views toward environmental behavior because of its protective and beneficial qualities. COVID-19 brought attention to the relationship between environment and health [6]. Sajid et al. [7] demonstrated that environmental attitudes are strengthened, and their pro-environmental behaviors are reinforced due to fear produced by the COVID-19 virus among people. Zebardast and Radaei [8] presented that COVID-19 has increased people's environmental understanding and favorably impacted their subjective norms or the sense of societal pressure to engage in ecologically beneficial behavior. As a result of this incidence, people's attitudes toward engaging in pro-environmental acts have also improved. Valenzuela et al. [9] revealed that consumers' behaviors had changed for the better in terms of social responsibility and the environment due to COVID-19. Consumers have changed their behavior as a result of worries about the social consequences of their activities rather than just the immediate repercussions of consuming.

In recent years, there has been an increasing awareness of the need for energy literacy, particularly among students and educators [10–12]. Energy literacy is a person's knowledge and understanding of energy, its impact on society and the environment, and its ability to make optimal decisions and to take execute appropriate energy-use behaviors [13]. COVID-19 has prompted society to become more knowledgeable regarding the energy industry and its effect on our environment. Consequently, individuals have adopted less detrimental habits toward our planet's resources. El Zowalaty et al. [14] stated that even though the positive effects of COVID-19 on the environment, like lower air pollution, are likely to be short-term, they still show that our actions can have an instant and direct impact on the environment. While the pandemic is primarily a worldwide calamity, it may drive future behavioral changes that positively impact the environment. Moreover, previous research has also shown that energy literacy can positively impact energy behavior in buildings [15]. Yoshino et al. [16] have emphasized the significance of understanding human behavior in determining building energy use. This highlights the importance of improving energy literacy levels in the university community to promote sustainable energy behavior in buildings.

As a wake-up call to society, COVID-19 has served as a catalyst for more environmentally conscious behaviors [17–19]. It has highlighted the need to prioritize human well-being and existence and the importance of sustainable practices to achieve that goal. This makes it a unique opportunity for exploration, particularly in energy literacy. There is a need for more research to understand the effect of COVID-19 on energy literacy, including cognitive, affective, and behavioral changes. This research could inform policy makers and educational interveners to promote sustainable energy consumption and conservation behaviors in the future, leading to a more sustainable and resilient society.

Universities significantly impact information transmission, research, and education, all of which are essential to energy literacy [20]. First, they play a key role in teaching and increasing knowledge of energy-related ideas, sustainable practices, and the value of conserving energy among university occupants [21]. Energy-related educational efforts, programs, and classes may considerably improve students' understanding of energy. Second, universities can potentially have a revolutionary role in promoting behavioral shifts about energy conservation. University occupants may act as examples and catalysts for transformation in embracing sustainable energy practices in their lifestyles and affecting wider populations by fostering energy conservation attitudes, behaviors, and practices within universities. Universities frequently engage with businesses, national organizations, and non-profit organizations [22]. To deal with energy-associated concerns, alliances promote information sharing, formulation of policies, and energy conservation activities. Partnering with external stakeholders helps the academic community have an influence outside the university, helping to promote larger energy literacy initiatives.

COVID-19 has emphasized the importance of promoting sustainable energy practices and the role of energy literacy in achieving this goal. Universities are vital in developing Kuwait's future leaders and decision-makers' energy decisions since they encourage energy literacy and sustainable development. People must have energy literacy, including understanding, consciousness, and comprehension of energy-related topics, to make educated decisions about energy consumption, preservation, and sustainable practices. As centers of education, research, and information dissemination, universities are well-positioned to promote energy literacy and sustainable development. Universities in Kuwait may successfully help promote sustainable development, especially the energy sector, by utilizing their positions in teaching, research, knowledge distribution, policy advocacy, and partnerships. Kuwaiti universities, as centers for shaping future leaders and decision-makers in a country heavily reliant on oil exports, provide an ideal population to study. In addition, Kuwait's "New Kuwait" strategy highlights the importance of achieving a sustainable energy transition [23]. Therefore, understanding COVID-19's EFFECT on the energy literacy and conservation behavior of university occupants can inform policy and programs to promote sustainable energy practices and contributing to a more sustainable future for Kuwait. This research focuses on Kuwaiti university occupants, who represent a diverse group with varying levels of energy literacy and aims to inform policymakers and educational interveners on how to promote sustainable energy practices among educational institution occupants in the post-pandemic period. Overall, the study aims to contribute to Kuwait's national effort to achieve a sustainable energy transition by

examining the effect of COVID-19 on the energy literacy levels of Kuwaiti university occupants.

This research provides valuable insights into the effect of COVID-19 on energy literacy and conservation behavior among university occupants in Kuwait. The findings can be used to develop effective strategies to promote sustainable behavior towards energy consumption, which will contribute to achieving national transition goals towards sustainable energy and environmental conservation in line with the New Kuwait 2035 vision. The study builds on previous research by Alomari et al. [24] and Alomari et al. [25] that emphasized the need for interventions to improve energy literacy levels in Kuwait, particularly among students, and by El-Kanj et al. [26] that highlighted the importance of tailoring interventions to specific groups and considering cultural and societal norms that may influence energy conservation behavior.

Previous studies [27–31] have primarily focused on the impact of education and awareness campaigns on energy literacy and conservation behavior, with limited attention given to unexpected events such as pandemics. Therefore, this study aims to address this gap by examining the impact of COVID-19 on energy literacy and energy conservation behavior among university occupants in Kuwait, and by answering the following research questions:

1. How did COVID-19 affect energy literacy among different occupant groups in academic buildings in Kuwait?
2. What are the cognitive dimensions of energy literacy among Kuwait University occupants, and have there been any changes in perceptions before and after the pandemic?
3. How have the affective dimensions of energy literacy, such as attitudes and intentions towards energy conservation, been influenced by COVID-19 among occupants at Kuwait University?
4. Are there any differences in perceptions of energy literacy and conservation behavior between students, faculty, and staff?
5. What factors influence energy literacy and conservation behavior among university occupant groups?

Questions 1 to 4 will be addressed through the quantitative method. Questions 2 through 4 reflect the Energy Literacy Scale Attributes and Characteristics model (Adapted from El-Kanj et al. [26]) and are shown in Fig. 1. Question 5 will be addressed through the qualitative method.

This study adds to the current knowledge of energy literacy and conservation behavior in various ways. The study initially explores changes in energy literacy across various occupant groups in universities in Kuwait after the pandemic. Secondly, the study investigates the variables that influence energy literacy and conservation behavior, particularly emphasizing the pandemic's effect on attitudes, intentions, and behaviors linked to energy conservation. Thirdly, the study employs a mixed-methods approach that integrates qualitative and quantitative information to give an in-depth knowledge of energy literacy and conservation behavior among various occupant groups.

The results of this study have a number of consequences for theory, practice, and policy. It emphasizes the significance of energy literacy in encouraging sustainable energy use and conservation behavior among various occupant groups in university buildings. Second, the study highlights a number of characteristics that impact energy literacy and conservation behavior among various occupant groups, such as education, awareness, personal motivation, values, religiosity, culture, social norms, and social identity. Third, the study sheds light on how COVID-19 has influenced people's attitudes, intentions, and behaviors towards energy consumption and conservation.

In summary, this research contributes to the realm of energy literacy and conservation behavior by giving a complete assessment of shifts in energy literacy among various occupant groups during the pandemic. The study's findings can inform the development of policies and programs that promote sustainable behavior towards energy consumption, ultimately contributing to a more sustainable future for Kuwait. Moreover, the findings can be used to develop energy literacy programs that target university occupants and enhance their energy-related knowledge and behaviors.

2. Literature review

COVID-19 considerably impacts environmentally responsible behavior and energy consumption, which is closely related to energy

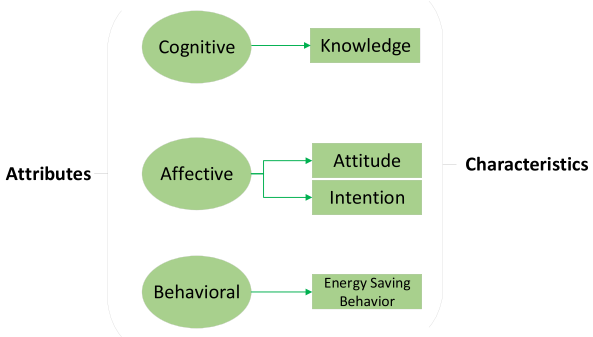

Fig. 1. Energy literacy scale attributes and characteristics.

literacy. It is crucial to investigate these factors. The literature review in this study plays a vital role in providing a comprehensive understanding of the current state of knowledge in the environmental cognition and behavior research field, including the pandemic's effects on environmental attitudes and behaviors. This study can build on previous research and provide new insights into the field by synthesizing existing literature. The literature review is critical since it offers an in-depth understanding of environmental cognition and behavior research, including the effects of COVID-19 on environmental attitudes and behaviors.

During the pandemic, a profusion of scientific publications emerged, most understandably centering on the pandemic's direct impacts on human health [32]. While certain studies probed the environmental consequences of the pandemic and posited a reduction in pollutants [33], others point out the need to address pressing environmental challenges like waste management and recycling [34]. This paper adds to the growing body of literature by providing a review of recent research on the impact of the pandemic on environmentally responsible behavior among various populations, including university students, consumers, and tourism sector employees. The studies suggest that the pandemic has enhanced environmental awareness, improved attitudes towards sustainable consumption, and increased participation in pro-environmental behavior.

A review of recent studies presents that COVID-19 has significantly affected environmentally responsible behavior. Jribi et al. [35] found that Tunisian consumers became more aware of food waste and took steps to reduce it during the pandemic, leading to improved attitudes and behavior towards food waste. Similarly, Lucarelli et al. [36] investigated the influence of the pandemic on university students' environmentally responsible behavior towards climate change. While they did not find a moderating effect of the pandemic on attitude and intention, they concluded that the pandemic helped to increase understanding of the relationship between global warming and human behavior, leading to improved intention and behavior. These findings highlight the potential positive effects of the pandemic on environmentally responsible behavior and call for further research in this area. Researchers have explored the effect of COVID-19 on environmental knowledge and behavior. Rousseau and Deschacht [37] analyzed online searches across 20 European nations and found that the pandemic led to a positive shift in public knowledge of environmental issues. Similarly, Milfont et al. [38] reported that the pandemic has increased socio-political effectiveness in New Zealand and contributed to a more positive attitude towards environmentally responsible behavior. Shulman et al. [39] examined the relationship between COVID-19 and environmental intentions in the UK and the US, revealing a positive correlation. Pop et al. [40] examined the influence of behavioral traits, such as attitudes towards energy conservation and environmental knowledge, on the environmental behavior of young people in Romania.

Table 1
Summary of studies about the effect of COVID-19 on the field of environmental cognitive and behavior research.

Author	Population	Findings	Investigated Field
Kim et al. [18]	People in general	People commit to sanitary practices, prefer local eateries, and participate in sustainable consumption with COVID-19.	Experience; Concern; Intention; Behavior
Zebardast and Radaei [19]	People in Iran	The pandemic increased people's environmental awareness and benefited subjective norms.	Cognition; Emotion; Attitude; Behavior
Jribi et al. [35]	Tunisian consumers	The pandemic had a beneficial influence on food waste reduction behavior.	Knowledge; Attitude; Behavior
Lucarelli et al. [36]	University students	The pandemic did not moderate the relationship between attitude and intention but improved environmental awareness.	Attitude; Subjective norms; Perceived behavioral control; Intention; Behavior
Rousseau and Deschacht [37]	People in 20 European nations	The pandemic led to a favorable shift in public knowledge of environmental issues.	Knowledge; Attitude
Milfont et al. [38]	New Zealanders	The pandemic boosted socio-political effectiveness and increased attitude towards environmental behavior.	Awareness; Ecological consumption; Social responsibility
Shulman et al. [39]	People from UK and US	There is a relationship between the pandemic and environmental intentions.	Attitude; Behavior
Pop et al. [40]	Romanian young generation	Attitudes towards energy conservation, arbitrary standards, and environmental knowledge influence environmental behavior.	Responsible behavior; Knowledge; Ethics; Perception; Behavior
Ali et al. [41]	Malaysian community	Environmental concerns about climate change have increased, and consumption habits have improved.	Awareness; Behavior
Ben Hassen et al. [42]	People in Bosnia and Herzegovina	The pandemic changed shopping patterns, increased local food consumption, and reduced food waste.	Awareness; Sustainable consumerism; Social responsibility
Burlea-Schiopoiu et al. [43]	University students	The pandemic increased the number of students practicing food waste reduction.	Awareness; Willingness to pay; Behavior
Lieven and Hügler [44]	People in 25 countries	Concerns about the environment due to the pandemic and global warming increased public awareness, and the sale numbers of electric vehicles increased.	Attitude; Intention; Subjective norm; Motive; Perceived behavioral control; Behavior
Severo et al. [45]	Generation X and Generation Y in Portugal and Brazil	The pandemic tremendously affects sustainable consumption, followed by environmental awareness and social responsibility.	Awareness; Responsibility; Efficacy; Ability; Behavior
Timpanaro and Cascone [46]	Customers	Customers are more prepared to pay more for sustainable goods and act more sustainably.	Motivation; Affective response; Intention; Behavior
Darco et al. [47]	People in general	Tragic occurrences like a pandemic might work as a catalyst to promote behavior change.	Efficacy; Behavior
Elshaer et al. [48]	Tourism sector employees	The pandemic positively changed employees' perspectives on participating in environmental actions.	Knowledge; Attitude; Subjective norms; Behavior
Zhou [49]	Consumers in China	The pandemic had a substantial	Knowledge; Attitude; Intention; Behavior

In a study conducted by Ali et al. [41], the impact of the pandemic on ecological consumption and social responsibility was investigated among different Malaysian communities based on their age and religion. The study found that the pandemic has increased people's environmental concerns about climate change, resulting in positive changes in their consumption habits. This shift towards sustainable consumption may lead to a decrease in air pollution. However, the study also highlighted the influence of demographic variables on the relationship between the pandemic and sustainable behavior.

Ben Hassen et al. [42] studied the effect of the pandemic on people's food behavior in Bosnia and Herzegovina. It revealed changes in people's shopping patterns, with individuals reducing the frequency of trips to the store and increasing the amount of food purchased during each visit. The pandemic also increased the consumption of regional dishes due to concerns about food safety.

Burlea-Schiopoiu et al. [43] showed that the COVID-19 pandemic increased the number of university students practicing food waste reduction. The study indicates that the pandemic has raised awareness among students about the importance of reducing food waste. In Lieven and Hügler's [44] study, they aimed to examine the effect of the pandemic on electric vehicle sales in 25 countries. They found that the pandemic heightened people's environmental concerns and awareness, resulting in increased sales of electric vehicles despite the overall decrease in vehicle sales. Severo et al. [45] explored the effects of the pandemic on the environmental consciousness, consumerism, and social responsibility of Generation X and Generation Y in Brazil and Portugal. They concluded that the pandemic significantly affected sustainable consumption, followed by environmental awareness and social responsibility.

Timpanaro and Cascone [46] discovered that customers were more likely to purchase sustainable goods, were willing to pay more, were more sensitive to environmental concerns, and acted more sustainably. Also, Darco et al. [47] showed that witnessing tragic events like the pandemic could promote behavior change and concrete previously psychologically remote topics. Elshaer et al. [48] demonstrated that COVID-19 positively affected the perspectives of tourism sector employees regarding environmental actions. Kim et al. [18] also found that people preferred local eateries, committed to sanitary practices, and participated in sustainable consumption due to COVID-19. Zebardast and Radaei [19] conducted a study to investigate the effect of the pandemic on sustainable behavior among Iranians and to determine whether the pandemic had a moderating effect on this behavior. Findings revealed that the pandemic had led to an increase in environmental awareness and had positively influenced people's subjective norms. People were more inclined to adopt environmentally friendly behavior during the pandemic, and the relationship between environmental behavior and intention was strengthened.

Zhou [49] examined the impact of COVID-19 on consumers' environmental behavior in China and found that the pandemic significantly impacted pro-environmental behavior and specific emotions. Ekawati et al. [50] investigated the factors influencing consumers' green purchasing behavior after COVID-19 and found that social influence did not significantly affect this behavior. However, green attitude, green value, and green trust had a positive and significant influence on green buying behavior.

The research in Table 1 sheds light on the connection between the COVID-19 pandemic and eco-friendly behavior, emphasizing energy usage. According to Chen et al. [51], a sizeable portion of New York State residents utilize more energy than is typical. The impact of the pandemic on energy and water usage in Serbian homes was examined by Cvetkovi et al. [52]. During the isolation time, they observed a significant rise in natural gas and electricity usage. According to Todeschi et al. [53], energy use for heating and cooling climbed dramatically in residential buildings in Switzerland during the lockdown. However, the demand for energy in the commercial and industrial sectors declined due to shutdowns. Geraldi et al. [54] found a significant drop in energy use in government buildings and schools in Brazil during the lockdown. Cihan [55] reported a reduction in electricity and natural gas use in industrial zones of Turkey during the pandemic. Increasing energy literacy among individuals is an effective tool for improving energy behavior.

In Kuwait context, the findings of Alomari et al. [24] and Alomari et al. [25] suggest that there is a need for interventions to improve energy literacy levels in Kuwait, particularly among students. Improving energy literacy can lead to a shift in behavior towards energy conservation, which can have positive environmental and economic impacts. The study by El-Kanj et al. [26] highlights the need to consider the educational level of the target population when designing interventions to improve energy literacy. These studies suggest that interventions should be tailored to specific groups and consider societal and cultural norms that may influence energy conservation behavior. Overall, the findings suggest that improving energy literacy is an important step towards promoting sustainable behavior and reducing energy consumption in Kuwait.

The effect of COVID-19 on people's energy literacy in Kuwait is yet to be determined. This study builds on previous studies that looked at the energy literacy levels of occupants before the pandemic by Alomari et al. [25] found that many Kuwaiti university students needed more energy literacy, which hindered their ability to answer energy-related questions. Moreover, El-Kanj et al. [26] compared the energy literacy levels of students, teachers, and staff. They found that while students could improve their literacy levels, the faculty group had the highest overall educational level. The previous work likely provided a baseline understanding of the energy literacy levels of the population before the pandemic.

This study aims to address the gap in the literature by examining the impact of COVID-19 on the energy literacy of university occupants in Kuwait. To our knowledge, the pandemic's impact on energy literacy has not been examined yet. Previous studies have highlighted the need to improve energy literacy levels, and this study aims to identify any changes that may have occurred due to the pandemic. By comparing energy literacy levels before and after the pandemic, the study aims to inform policymakers and researchers about the pandemic's impact on energy literacy. The importance of understanding the pandemic's influence on environmentally responsible behavior and energy consumption, which are closely linked to energy literacy, has been emphasized in the preceding paragraph. Based on these insights, the study will investigate the cognitive, affective, and behavioral aspects of energy literacy among Kuwaiti university students, teachers, and staff. The results of this study can aid in developing strategies to promote sustainable behavior and energy consumption among occupants of university buildings in Kuwait and beyond, thereby contributing to the existing literature on energy literacy.

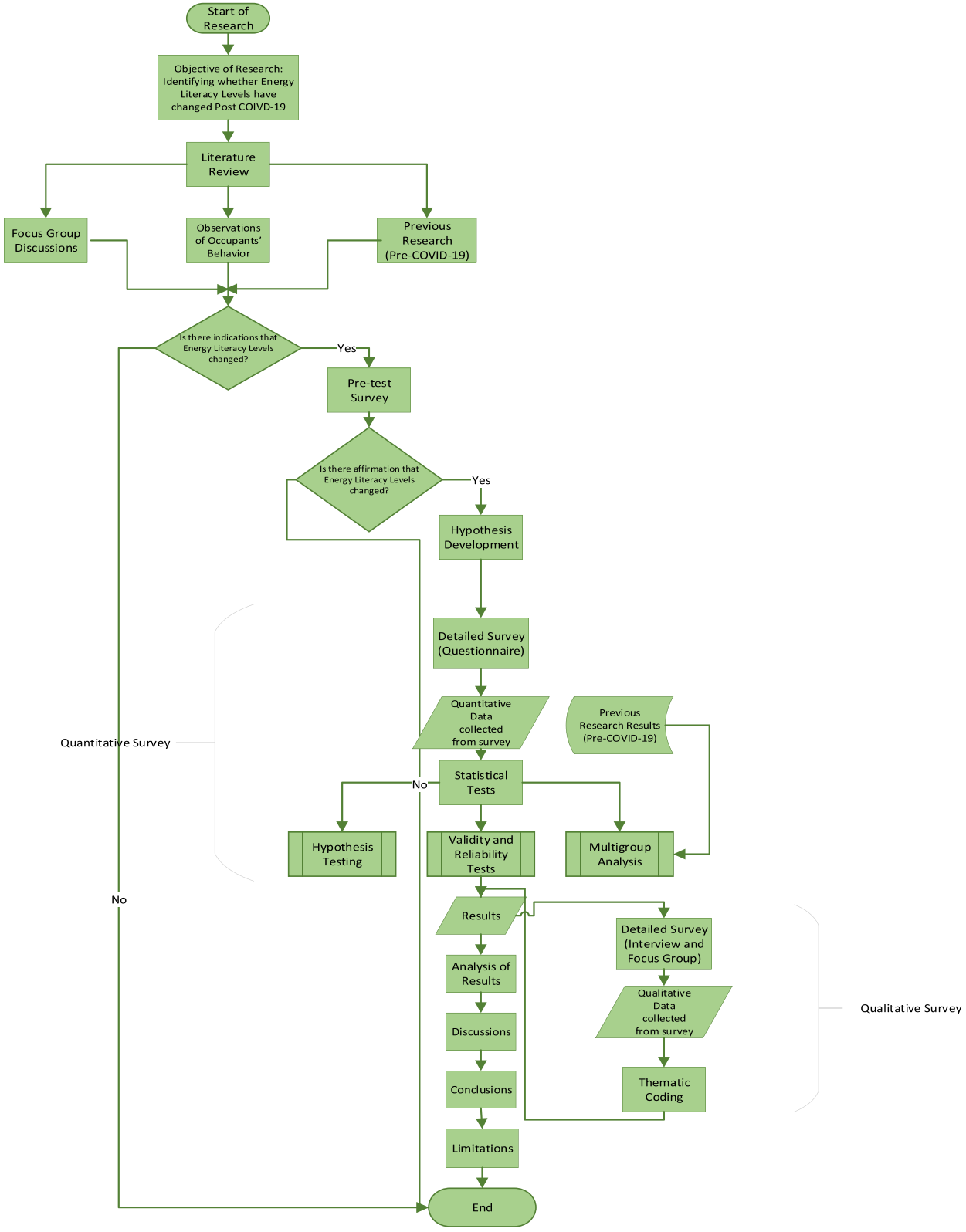

Fig. 2. Flowchart of research methodology.

3. Research methodology

The current study is based on prior research conducted by Alomari et al. [24,25] and El-Kanj et al. [26]. The previous studies aimed to assess the energy literacy levels and energy conservation behavior of the occupants at the Australian University in Kuwait before COVID-19. Moreover, it focused particularly on assessing the energy literacy levels and energy conservation behavior of students, faculty, and staff at the university. Expanding on the findings extracted from the previous studies, the current research aims to investigate whether COVID-19 has had an impact on the occupants' energy literacy levels. Specifically, this study seeks to explore the cognitive, affective, and energy conserving behavioral dimensions of energy literacy among Kuwait University occupants and determine whether there are any differences in perceptions before and after the pandemic.

A mixed-approaches strategy integrating quantitative and qualitative research methods was used to meet the study aims. A survey was administered to students, faculty, and administrative staff at the Australian University in Kuwait, with sample sizes determined based on enrollment figures which constitute the whole population. The data gathered from the survey was assessed for reliability and validity with partial least squares structural equations modeling (PLS-SEM) which is used to analyze the cognitive, affective, and behavioral dimensions of energy literacy. In-depth interviews were also conducted with students and faculty members to gain further insights into how COVID-19 has affected energy literacy knowledge and behavior. The interview data were analyzed using NVivo 12, developing two "conceptual code maps" to identify the factors and sources that influence energy literacy knowledge and behavior. Fig. 2 shows the flowchart of the methodological framework.

3.1. Quantitative methods

3.1.1. Questionnaire design and measures

To assess the impact of COVID-19 on energy literacy and energy conserving behaviors, a comprehensive questionnaire consisting of 28 questions across 7 sections was developed. The questionnaire encompassed various aspects such as pandemic sensitivity, energy knowledge, attitudes, intentions, and behaviors, utilizing a cross-sectional approach. Drawing from the framework proposed by De-Waters et al. [13], the Energy Literacy and Energy Conservation Behavior Questionnaire incorporated measures targeting energy literacy and behavior. It evaluated participants' understanding of energy concepts, engagement in energy conservation practices, and attitudes and intentions towards energy-conserving behaviors. The questionnaire was adapted to Kuwait's unique cultural, social, and economic context, ensuring its relevance and applicability to the study population. This involved obtaining feedback from energy education experts and conducting a pre-test with a sample of students, faculty, and administrative staff from the Australian University in Kuwait. The resulting questionnaire covered various topics related to energy literacy, such as energy sources, forms, conservation, and efficiency. These questions were multiple choice questions (MCQ) designed in a way where the respondent must select based on his/her best knowledge. The other sections of the questionnaire consisted of questions about attitudes, intention, and behaviors towards energy use. Questions related to the pandemic were added to the questionnaire to examine the effect of - COVID-19 - on energy knowledge and behavior among respondents. The responses were rated on a 5-point Likert scale and later translated into quantitative measures, with scores ranging from 1 to 5. To ensure the questionnaire's item validity and reliability, a focus group approach was used, and feedback was received from experts in the field of energy education. A pre-test was then conducted with a diverse group of participants, which helped identify any unclear vague questions and ensure the questionnaire was appropriate and understandable for each group. The questionnaire was designed with Google Forms, and a link was sent online through email and other online distribution tools.

The data collected for this study included responses from 158 engineering students, 67 faculty members, and 52 administrative staff members at Australian University in Kuwait. The overall sample size for the study was 277 participants, with 56.3 % male and 43.7 % female respondents. The sampling size was selected based on the population size of each group with a confidence level of 95 %. The population size of students was estimated to be 250, while 75 for faculty, and 59 for staff. With a margin of error of 5 %, confidence level of 95 %, sample proportion of 50 % ($p = 0.5$ and $q = 0.5$), and utilizing the known population size of each group, estimated suggested sample size for the student group was 152, for the faculty group was 63 and for the staff group was 52. The collected responses from each group were 158 for the students, 67 for the faculty, and 52 for the staff, which makes the collected sample size sufficient. The method of sampling followed was the random sampling method, and it was adopted for its simplicity and to ensure that the population is entirely reflected within the sample selected. The population size was initially determined, and then the suggested sample size was calculated. Accordingly, the survey instrument was distributed to the entire population, and random samples were taken from the collected responses to meet the suggested sample size. Every individual in the population has an equal chance of being selected, and each selection is independent of previous selections. The age range of the participants was between 18 and 65 years, with most respondents falling between 18 and 30 years old (70.4 %). Additionally, most of the participants were undergraduate students (57.04 %), followed by faculty members (24.19 %) and administrative staff (18.77 %).

The inclusion of participants from different academic levels and occupational roles ensured a diverse sample that could provide a comprehensive understanding of energy literacy among university occupants in Kuwait. It is worth noting that the participants were affiliated with a private university, which may only be representative of some of the Kuwaiti population. Nonetheless, the sample size was large enough to provide meaningful insights into energy literacy in the Kuwaiti context. Using a convenient sample may also limit the generalizability of the findings, as individuals who chose to participate in the study may have had different characteristics or motivations than those who did not. However, the researchers used various online channels to distribute the questionnaire and encourage participation, which may have increased the likelihood of reaching a representative sample. Overall, the participants in this study were university occupants in Kuwait, providing valuable insights into energy literacy among this population.

3.1.2. Conceptual model and hypotheses

Based on the literature review, this study developed two major hypotheses. Hypothesis 1 (H1) relates the effect of attitude on intention and hypothesis 2 (H2) relates the effect of intention on behavior. These two hypotheses have been linked to the three groups: student (std), faculty (fcl) and staff (stf). The model and hypotheses are presented in Fig. 3. The same model was previously tested before pandemic and is now tested to measure the effect of COVID-19 on the power of the model. Moreover, testing the model post pandemic will not only reveal if the pandemic has impact on it but will also verify if the hypotheses are still valid.

3.1.3. Statistical techniques

To analyze the data extracted from the multiple-choice questions related to the cognitive part, the researchers used SPSS 26 software to conduct multiple tests to evaluate the cognitive levels using the difficulty level (p) and discrimination power (D). These tests have been employed to evaluate the respondents' performance in three groups.

On the other hand, to analyze the data extracted from the 5-point Likert scale questions related to the affective and behavioral parts, the researchers employed PLS-SEM multigroup analysis techniques using SmartPLS4 software, which can handle smaller sample sizes. Validity and reliability tests were done to verify the accuracy of the collected data, including Cronbach's alpha, composite reliability, and overall discriminant validity. These tests were carried out separately for each group to ensure the highest internal validity and reliability level for multigroup analysis (MGA).

Following the completion of validity and reliability tests, the researchers employed the Partial Least Squares Structural Equation Modeling (PLS-SEM) method to assess the measurement invariance of composite models (MICOM) through three subprocesses: configural invariance, compositional invariance, and composite equality. Once the measurement invariance was established, the researchers proceeded with multigroup analysis (MGA) to test the proposed hypotheses using t-tests with bootstrapping. The researchers also used various tests to identify direct and indirect effects as well as moderation effects. These tests included permutation, parametric, and Welch-Satterthwait tests, which helped determine significant differences in energy literacy levels between groups and identify factors influencing energy literacy in the Kuwaiti context.

Finally, to evaluate the model's predictive capacity, a blindfold approach was employed. This approach included dividing a portion of the collected data into a separate set specifically for testing purposes, enabling the model to make predictions on unseen data. The assessment of the model's predictive capability was based on various factors, including path coefficients, the strength of least squares R^2, and cross-validated redundancy Q^2. t-values were used to identify differences between groups and variances. The use of robust statistical methods ensured the validity and reliability of the findings. Overall, Fig. 4 provides a flowchart of the statistical methods followed in the study. These rigorous statistical methods were employed to ensure the reliability and validity of the findings and to provide a comprehensive understanding of the COVID-19 effect on energy literacy behaviors.

3.2. Qualitative methods

Qualitative research methods, including focus groups and interviews, are common for comprehending complex phenomena such as energy literacy during the pandemic. Accordingly, Kefalaki et al. [56] conducted a study using focus group discussions to examine the effect of COVID-19 on teaching and learning practices in Greece higher education. Similarly, Schwander-Maire et al. [57] employed focus groups to investigate the psychological responses and strategies adopted by higher education students in Portugal and Switzerland towards COVID-19.

These and other studies demonstrate the effectiveness of qualitative research methods in providing valuable insights into the effect of COVID-19 on different aspects of society. Qualitative research methods, particularly focus groups, are commonly employed to gain a comprehensive and in-depth understanding of complex phenomena such as the impact of COVID-19 on higher education. The studies conducted by Dutta [58], Jung et al. [59], Choi et al. [60] used qualitative research methods, particularly focus groups, to understand the effect of COVID-19 on higher education and various societal aspects for exploring the experiences and attitudes of students, faculty, and administrators in different countries, such as Hong Kong, Pakistan, Korea, and Malaysia.

The focus group method examines participants' experiences with energy use and conservation behavior during the pandemic and the subsequent effects on their energy literacy. The primary objective of this qualitative research approach is to achieve a more profound comprehension of the influence of the pandemic on energy literacy and to identify possible measures for enhancing energy literacy in the future. The focus group technique enables the gathering of a small group of participants to facilitate discussions and provide insights into their experiences regarding energy use and behavior during the pandemic. Consequently, the qualitative data obtained through the focus group method provides a detailed and comprehensive understanding of participants' attitudes, beliefs, and experiences regarding energy literacy in the context of COVID-19.

In the context of energy literacy research during the pandemic, interviews were conducted with both students and faculty members.

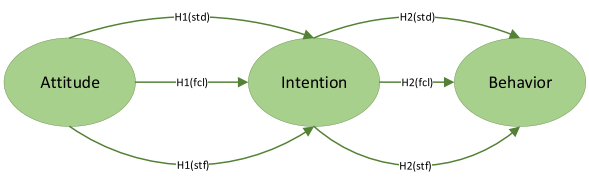

Fig. 3. The conceptual model and hypotheses.

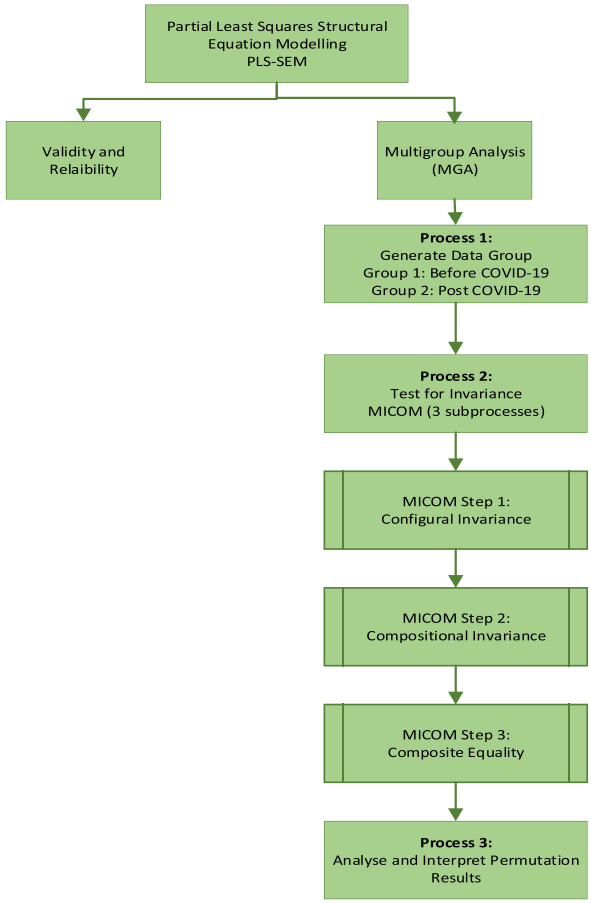

Fig. 4. Flowchart of the statistical methods.

These two groups were selected to be included in the qualitative survey based on the results observed from the quantitative survey, which revealed that these two groups were the most impacted groups. These interviews aimed to gain a deeper understanding of the reasons behind the changes in energy literacy knowledge observed during the pandemic and explore factors that can influence energy behavior among occupants. Interviews were conducted individually with participants, allowing for a more personalized exploration of their experiences related to energy use and behavior during the pandemic. Moreover, interviews enable a thorough discussion that can be steered towards particular points that need more exploration and reflection. Students were asked about their experiences studying from home, their energy use patterns during this time, and their attitudes toward energy conservation. Faculty members were asked about their experiences working from home, energy use patterns, and attitudes toward energy conservation.

The research employed a thematic analysis approach to examine the data obtained from focus groups and interviews conducted with students, faculty members, and administrators. Thematic analysis is a commonly used qualitative data analysis approach which entails understanding patterns, themes, and codes in the data to gain an in-depth comprehension of the phenomenon being studied [61]. This method includes a systematic and iterative process of coding and categorizing the data into themes and subthemes, which are then used to develop an overarching narrative of the findings [62].

Multiple rounds of coding and review were conducted during the analysis process to verify the reliability and validity of the findings. The themes and patterns that emerged from the analysis were then categorized into broader themes to provide a comprehensive understanding of the complex factors influencing energy literacy during the pandemic. The results from the qualitative analysis were also integrated with the findings from the quantitative portion of the study to provide a more complete picture of the research problem.

Using the thematic analysis method, the study explored the data in greater depth and provided a nuanced understanding of the factors influencing energy literacy during the pandemic. The integration of both qualitative and quantitative data enabled a more comprehensive and robust interpretation of the findings.

4. Results and analysis

The research aimed to assess the effect of COVID-19 on the energy literacy levels of occupants in an academic building, including

engineering students, faculty, and administrative staff. The research objectives focused on determining if there were any significant differences in energy literacy levels between these groups before and after the pandemic. A mixed method technique was employed, integrating both quantitative and qualitative data collection and analysis methods. To link the data collected from the quantitative and qualitative research, and explanatory design was followed. This design involves collecting and analyzing quantitative data first, followed by collecting and analyzing qualitative data. Qualitative data are used to explain or provide a deeper understanding of the quantitative findings. The quantitative data was gathered through a self-administered questionnaire based on DeWaters et al. [7], while the qualitative data was gathered through focus groups and interviews. PLS-SEM multigroup analysis was utilized to assess the quantitative data collected and to conduct the comparison analysis across the three groups. The qualitative data were analyzed using thematic analysis, providing a more comprehensive understanding of the factors affecting energy literacy during the pandemic.

4.1. Quantitative analysis and results

The study utilized PLS-SEM multigroup analysis techniques to analyze the data, which can handle complex models with latent variables and small sample sizes. SmartPLS4 software was used for the analysis as it is a user-friendly tool that enables researchers to perform PLS-SEM analysis easily. The software was used to estimate and evaluate the measurement and structural models and perform the multigroup analysis to test for differences in the relationships between the variables across the three groups of respondents.

Initially, to ensure that the data collected will present reliable and valid results that can be generalized, the validity and reliability of the measurement model is assessed. The study employed the Measurement Invariance of Composite Models (MICOM) process. This statistical process assesses the extent to which a set of latent variables measured by composite indicators are equivalent across groups or time points. The MICOM process involves three sub-processes: measuring configural invariance, compositional invariance, and composite equality, which are all essential for constructing valid and reliable measures.

The study also used multigroup analysis (MGA) with t-tests and bootstrapping to compare the means of three groups of occupants and assess whether there were significant differences in energy literacy levels between the groups pre- and post-pandemic. The researchers employed various statistical tests to examine the direct and indirect effects of variables on the outcome variable. These tests included the permutation test, bootstrapping method, and the Welch-Satterthwait test. Additionally, the blindfold approach was implemented using PLS-SEM, where the model's predictive capability was evaluated on randomly split training and testing sets of the data. For a more comprehensive understanding, Fig. 4 provides a detailed flowchart illustrating the quantitative research statistical tests conducted to derive the results.

4.1.1. Quantitative results

4.1.1.1. Demographics. In the pre-pandemic study, 338 respondents were students, 158 were faculty, and 147 were administrative [26]. In this post-pandemic study, 158 respondents were students, 67 were faculty, and 52 were administrative. Table 2 shows the demographic representations of 277 respondents randomly sampled for this study.

4.1.1.2. Item analysis of the cognitive part. The questions related to the cognitive part were multiple-choice questions, hence, assessing the difficulty level (p) and discrimination power (D) of the multiple-choice questions in the survey provides a way to evaluate the respondents' performance in the three groups. The difficulty level measures the proportion of respondents who answered the questions correctly, indicating the level of knowledge assessed in various areas such as general, technical, environmental, and country-specific knowledge. A value of p above 0.5 indicates that more respondents answered correctly than incorrectly. The same criteria were applied to assess the difficulty level in the post-pandemic survey as in the pre-pandemic survey.

Table 3 shows the findings of the cognitive questions' level of difficulty (p) for all three occupant groups. The values for all groups were above 0.5, indicating an improvement in occupants' energy knowledge post-pandemic compared to pre-pandemic. Students showed a significant improvement of 15 % in their responses where the value of p was (M = 0.43, SD = 0.21) in pre-pandemic and became (M = 0.58, SD = 0.11) in post-pandemic. Overall, the increase in knowledge levels observed in the study can be attributed to various factors, including increased availability of educational resources, awareness campaigns, and the impact of the pandemic on people's lifestyles, which allowed them to spend more time educating themselves, including energy literacy. Faculty and staff showed a minimal increase in their energy literacy levels, possibly because they had higher levels than students in the pre-pandemic. The faculty group's increase is only 4 % (M = 0.78, SD = 0.09), and the staff group's increase is only 2 % (M = 0.70, SD = 0.12). The study found

Table 2
Respondents' demographic characteristics.

	Percentage	Frequency	Total
Gender			
Male	43.7 %	121	277
Female	56.3 %	156	
Occupation			
Student	57.04 %	158	277
Faculty	24.19 %	67	
Staff	18.77 %	52	

Table 3
The index of difficulty (*p*), index of discrimination (*D*), and point of biserial correlation overall means and standard deviations (r_{pbis}).

Group	*p*		D		r_{pbis}	
	Mean	SD	Mean	SD	Mean	SD
Students	0.58	0.11	0.52	0.15	0.41	0.21
Faculty	0.78	0.09	0.45	0.14	0.43	0.11
Staff	0.70	0.12	0.42	0.13	0.40	0.13
Overall	0.69	0.11	0.46	0.14	0.41	0.15

that students showed the most improvement in their energy General Knowledge (GK) and energy Technical Knowledge (TK), while faculty and staff showed the most improvement in General Knowledge (GK) and Country-Specific Knowledge (CSK), respectively. This suggests that different occupant groups may have varying levels of interest and engagement with different aspects of energy literacy, and educational interventions should be tailored accordingly to maximize their effectiveness. The idea that different occupant groups may have varying levels of interest and engagement with different aspects of energy literacy is supported by previous research. Hsu et al. [63], for example, discovered that students were more interested in learning about renewable energy sources, while building managers and facility professionals were more interested in energy-efficient building design and operations. Similarly, a study by Reis et al. [64] revealed that building occupants with different education and income levels had varying levels of interest and willingness to pay for energy-efficient features in buildings.

The study found that the students' discrimination power (D) increased post-pandemic, indicating that they became more competent in answering energy literacy questions, suggesting an improvement in their competency of answering energy literacy questions. This finding supports the observation that the pandemic positively impacted enhancing students' energy knowledge levels. In contrast, there was only a slight change in the D values of faculty and staff. The students had higher D values than the faculty and staff, possibly due to their lower pre-pandemic knowledge levels. The study also used biserial correlation (r_{pbis}) to confirm that respondents who answered questions correctly did so based on competence rather than random guessing. The *D* value of student group increased from ($M = 0.38$, $SD = 0.24$) in the pre-pandemic to ($M = 0.52$, $SD = 0.15$) in the post-pandemic. Moreover, the r_{pbis} values were positive for all groups and constructs, indicating a strong relationship between high cognitive scores and accurate responses, as shown in Table 4.

4.1.1.3. Item analysis of the affective and behavioral part. a. Measurement Model Assessment: To maintain an unbiased and equal testing process, all groups were made with an equal number of respondents by randomly selecting responses from the collected samples. Thus, each group consists of 52 responses in all subsequent analyses. Multiple statistical tests were implemented to ensure the validity and reliability of the results generated, similar to the cognitive part. First, factor analysis was used to obtain standardized factor loadings to determine whether any variables were not contributing much to the model and could therefore be eliminated to increase data reliability. Table 5 displays the standardized factor loadings of the model's variables, ranging from 0.798 to 0.911, all of which are above the threshold of 0.7 [65], indicating that all survey questions strongly influence and contribute to the constructs they represent in the model. Questions EB4 and EB5 have an alpha value greater than 0.9, hence indicating that they are measuring the same construct. Accordingly, question EB5 has been eliminated from the statistical tests of MICOM to ensure better validity and to eliminate any cause of redundancy in responses. Second, α was generated to test the scale's reliability, and CR was obtained to measure the model's internal consistency. A reliable construct is considered to have any value for CR and CA greater than 0.7 [66]. Table 5 displays the values of α and CR, ranging from 0.759 to 0.827, indicating that all constructs are highly reliable. Third, AVE was calculated to assess the convergent validity, which indicates the extent to which a measure is correlated to another measure and how much it can predict it [67]. Table 5 displays AVE values ranging from 0.720 to 0.772, with all values above 0.50 and significant at $p > 0.05$, indicating acceptable validity.

Finally, overall discriminant validity is calculated as the $\sqrt{AVE}$ values shown in the diagonal of Table 6. Each value is more

Table 4
The index of difficulty (*p*), index of discrimination (*D*), and point of biserial correlation overall means and standard deviations (r_{pbis}) for each group.

Group	Characteristic	N	*p*		D		r_{pbis}	
			Mean	SD	Mean	SD	Mean	SD
Students	GK	357	0.65	0.1	0.55	0.17	0.46	0.23
	TK		0.61	0.12	0.56	0.15	0.42	0.21
	CSK		0.52	0.12	0.45	0.15	0.39	0.22
	EK		0.52	0.11	0.53	0.13	0.37	0.16
Faculty	GK	163	0.78	0.13	0.43	0.14	0.41	0.14
	TK		0.74	0.07	0.47	0.17	0.43	0.11
	CSK		0.83	0.12	0.44	0.13	0.39	0.11
	EK		0.75	0.05	0.47	0.11	0.49	0.09
Staff	GK	152	0.66	0.11	0.41	0.12	0.39	0.12
	TK		0.68	0.08	0.41	0.13	0.36	0.11
	CSK		0.78	0.13	0.42	0.14	0.45	0.14
	EK		0.69	0.14	0.45	0.14	0.40	0.15

Table 5
Correlations, reliability coefficients, and average variance reliability and validity measures (AVE).

Main Constructs	Items	λ (>0.7)	CA (>0.7)	AVE[a] (>0.5)	CR[b] (>0.7)
AT Attitude	AT1	0.896	0.852	0.720	0.866
	AT2	0.865			
	AT3	0.843			
	AT4	0.822			
	AT5	0.899			
IN Intention	IN1	0.810	0.818	0.772	0.875
	IN2	0.824			
	IN3	0.867			
	IN4	0.884			
ECB	EB1	0.833	0.884	0.742	0.896
	EB2	0.867			
	EB3	0.798			
	EB4	0.911			
	EB5	0.901			

[a] $AVE = \sum \lambda_i^2 / (\sum \lambda_i^2 + \sum Var(\varepsilon_i))$.
[b] $CR = (\sum \lambda_i)^2 / ((\sum \lambda_i)^2 + (\sum \varepsilon_i)), where: \lambda_i = factor\ loading\ of\ each\ item, \varepsilon_i = error\ variances.$

Table 6
Overall discriminant validity.

FL Criterion	AT	IN	EB
AT	0.85		
IN	0.43	0.88	
EB	0.35	0.42	0.86

significant than any correlation among any other two constructs, as shown in Table 6 [68].

b. Assessment of the Structural Model: Before implementing multigroup analysis (MGA) among the selected groups pre- and post-pandemic, it is essential to verify discriminant and convergent validity within each group to utilize its findings in the analysis. Hence, the same reliability and validity tests are conducted on each group separately (students, faculty, and staff) of the sample selected. The pre-pandemic sample was verified, and the results were satisfactory [69]. Table 7 and Table 8 demonstrate that all convergent and discriminant validity requirements are met, indicating that the results collected from the sample can be used in MGA.

c. Multigroup analysis (MGA): An important step in the cross-group investigation using multigroup analysis is to ensure measurement invariance of the composite model (MICOM). Therefore, this research ascertains measurement invariance prior to executing an MGA to examine the path coefficients between occupants' group's pre- and post-COVID-19 pandemic. MICOM is a three-stage procedure that initiates with configural invariance in step 1, followed by compositional invariance in step 2, ending with equality of composite mean values and variances in step 3. These three steps must be completed in sequence, and the prerequisite conditions must be fulfilled to progress to the second step. Step 1: Configural Invariance, this step is divided into three sub-steps - configurational invariance, compositional invariance, and equality of mean values and variances. In this phase, the variables are randomly assigned to a specific position in the configuration space. Step 2: Compositional Invariance involves a single assignment resulting in a unique position distribution. The randomized positions are then organized into groups within each unit cell to become equal in size or have an equal number of cells. In Step 3: Equality of Mean Values and Variance, a computer algorithm is used to produce the positions for all the unit cells in which each cell has an equal number of points. The process is repeated until all cells have been assigned numbers. Table 9 shows the results of steps 1 and 2. All requirements of steps 1 and 2 are met as per Table 9 results.

Once both configural and compositional invariance are confirmed, the third step can be executed by examining the equality of composite mean values and variances. To fulfill step three, each construct's mean value difference must fall within the 95 % confidence

Table 7
Convergent validity by group.

Sample	Variables	Items	CA	AVE	CR
Students (STD)	AT	5	0.845	0.729	0.833
	IN	4	0.758	0.596	0.801
	EB	5	0.766	0.705	0.833
Faculty (FCL)	AT	5	0.875	0.652	0.754
	IN	4	0.887	0.537	0.824
	EB	5	0.863	0.863	0.842
Staff (STF)	AT	5	0.707	0.694	0.785
	IN	4	0.768	0.661	0.859
	EB	5	0.845	0.549	0.717

Table 8
Discriminant validity by group.

Sample	Fornell-Larcker Criterion	AT	IN	EB
STD	AT	0.85		
	IN	0.54	0.77	
	EB	0.42	0.45	0.84
FCL	AT	0.81		
	IN	0.53	0.73	
	EB	0.24	0.57	0.93
STF	AT	0.83		
	IN	0.63	0.81	
	EB	0.36	0.34	0.74

Table 9
Results of MICOM step 1 and 2.

Construct	Faculty Pre C19 - Faculty Post C19				Student Pre C19 - Student Post C19				Staff Pre C19 - Staff Post C19			
	CR c-value	ED[a]	p	CI	CR c-value	ED	p	CI	CR c-value	ED	p	CI
AT	0.989	0.986	0.529	Valid	0.992	0.918	0.492	Valid	0.996	0.973	0.632	Valid
IN	0.999	0.985	0.618	Valid	0.987	0.966	0.711	Valid	0.998	0.991	0.517	Valid
EB	0.998	0.987	0.511	Valid	0.991	0.983	0.478	Valid	0.998	0.989	0.528	Valid

[a] Empirical Distribution.

interval. Table 10 displays all CMV values within the confidence interval (5 %). Moreover, all CMV values for the three groups of occupants fall within the confidence interval, demonstrating a significant difference between the groups at $p > 0.05$. Additionally, all permutation p-values in Table 11 are greater than 0.05, indicating that the constructs have passed the measurement invariance test. Path coefficients were assessed to evaluate the significance of the theoretical model for the three groups since the composite means and variances are identical. The data has been collected and analyzed independently for each group.

To test for significant differences in path coefficients between the pre-pandemic and post-pandemic groups, original path coefficients are first generated for each sample group. The differences in these coefficients are then calculated, and a permutation test is conducted in SmartPLS to determine whether the groups are statistically and significantly different. The results of this test are presented in Table 12.

There is a statistically significant difference at the 10 % level between the groups of students, faculty, and staff who participated in the survey pre-pandemic and post-pandemic. All p-values are less than 0.10, indicating that the differences are significant. Furthermore, the path coefficients in the post-pandemic groups are found to be more significant than in the pre-pandemic groups, indicating stronger correlations and a stronger relationship between the dependent and independent variables.

The path coefficient values shown in Fig. 5 indicate that all coefficients were higher post-pandemic than pre-pandemic, indicating a stronger relationship between predicting and predicted variables after the pandemic. Moreover, all path coefficients were positive, signifying a positive relationship between variables. This implies that an increase in the predicted variable would positively impact the predicted variable. The study discovered that post-pandemic changes in attitude had a greater positive effect on intention than pre-pandemic. Similarly, the effect of intention on behavior was found to be stronger post-pandemic. These results applied to all three groups but with varying percentages. For example, a one-unit increase in attitude would result in a 62.1 % increase in intention for student's pre-pandemic, while post-pandemic, this percentage rose to 67.9 %.

The study discovered that the student group has the highest increase, with a path coefficient value of almost 17 %, specifically in the relationship between intention and behavior. The relationship between attitude and intention in students also increased by almost 10 %. Conversely, the faculty group showed only a 7 % increase in both relationships between pre-pandemic and post-pandemic. Additionally, the study revealed that the student group had the least increase of 5 % between intention and behavior.

The model and hypotheses are presented in Fig. 3. Meanwhile, Fig. 5 displays all path coefficients, where values in parentheses represent post-COVID path coefficient values, while those outside the parentheses indicate pre-COVID path coefficients. All values are significant at the 0.1 level. The results in Fig. 5 reveal the strongest relationship between intention and behavior in the faculty group (β

Table 10
Part I of the MICOM step 3 results: CMV.

	Faculty Pre C19 - Faculty Post C19				Student Pre C19 - Student Post C19				Staff Pre C19 - Staff Post C19			
	DCMV[a]	CI	p	EMV[b]	DCMV	CI	p	EMV	DCMV	CI	p	EMV
AT	0.168	−0.230; 0.267	0.308	Yes	0.120	−0.215; 0.246	0.238	Yes	0.134	−0.232; 0.262	0.315	Yes
IN	0.173	−0.261; 0.281	0.130	Yes	0.158	−0.229; 0.232	0.163	Yes	0.155	−0.241; 0.249	0.119	Yes
EB	0.165	−0.223; 0.267	0.269	Yes	0.124	−0.231; 0.248	0.275	Yes	0.177	−0.225; 0.288	0.266	Yes

[a] Difference of Composite's mean value;
[b] Equal mean values.

Table 11
Part II of the MICOM step 3 results: CI.

	Faculty Pre C19 - Faculty Post C19				Student Pre C19 - Student Post C19				Staff Pre C19 - Staff Post C19			
	LCVR[a]	CI	p	EMV	LCVR	CI	p	EMV	LCVR	CI	p	EMV
AT	−0.239	−0.365; 0.367	0.567	Valid	−0.213	−0.367; 0.381	0.124	Valid	−0.203	−0.381; 0.349	0.470	Valid
IN	−0.149	−0.373; 0.352	0.492	Valid	−0.180	−0.358; 0.338	0.441	Valid	−0.114	−0.343; 0.338	0.480	Valid
EB	−0.164	−0.323; 0.362	0.593	Valid	−0.119	−0.328; 0.326	0.518	Valid	−0.197	−0.354; 0.343	0.559	Valid

[a] Logarithm of Composite's variance ratio.

Table 12
Results of permutation test in SmartPLS.

Sample	Relation	Path Coefficient Pre-C19	Path Coefficient Post- C19	Path Coefficient Difference	Path Coefficient Permutation	CI	Permutation p-values (<0.1)
STD	AT/IN	0.621	0.679	0.058	0.002	−0.259; 0.287	0.072
	IN/EB	0.541	0.631	0.090	0.001	−0.274; 0.267	0.012
FCL	AT/IN	0.648	0.694	0.046	0.002	−0.246; 0.222	0.032
	IN/EB	0.723	0.775	0.052	0.003	−0.285; 0.255	0.004
STF	AT/IN	0.628	0.685	0.057	0.000	−0.290; 0.241	0.018
	IN/EB	0.561	0.593	0.032	0.001	−0.263; 0.228	0.001

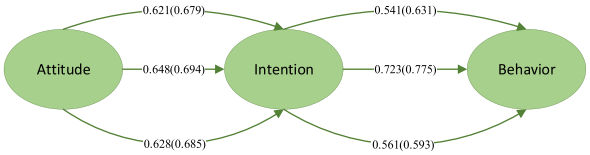

Fig. 5. The tested model with path coefficients pre C19 and post C19.

= 0.775). This could be due to the impact of the pandemic on the participants' perceptions and experiences, leading to changes in their attitudes and behaviors. The COVID-19 pandemic has led to an increased awareness of the relationship between environmental degradation and the occurrence of pandemics, which has motivated individuals to adopt more behaviors. This is supported by the findings of various studies, including those by Daryanto et al. [17], Zebardast et al. [19], McColl et al. [70], and Massari et al. [71]. These studies suggest that learning experiences, particularly those related to crises and disasters, can significantly impact individuals' environmental knowledge and behavior.

To further investigate and analyze group-specific effects, a nonparametric resampling method called "bootstrapping" has been used to analyze the statistical significance of several PLS-SEM results, namely the path coefficients (β) values. Table 13 displays the results of SmartPLS using the bootstrapping method. Findings from bootstrapping also confirmed results generated by the permutation test. All the structural model relationships are significantly different.

Table 13 presents the t-statistic results for each path coefficient between the predictor and response variables. The t-statistic value indicates the strength of the relationship between the two variables, precisely the effect of attitude on intention and intention on

Table 13
Results of PLS-MGA in SmartPLS and hypothesis testing.

Sample	Hypothesis	Relation	Path Difference	MGA Test	Parametric Test		Welch-Satterthwait Test	Significantly Different?
				p value	*t* value	p value	p value	
STD	H1(std)	AT/IN	0.058	0.002	1.234	0.007	0.004	Yes
	H2(std)	IN/EB	0.090	0.001	1.163	0.000	0.000	Yes
FCL	H1(fcl)	AT/IN	0.046	0.000	2.639	0.001	0.003	Yes
	H2(fcl)	IN/EB	0.052	0.004	2.546	0.002	0.001	Yes
STF	H1(stf)	AT/IN	0.057	0.001	1.863	0.001	0.003	Yes
	H2(stf)	IN/EB	0.032	0.000	1.246	0.000	0.001	Yes

behavior for the three groups. All hypotheses were significant at the 0.1 level, with p-values <0.1. These findings suggest that the predictor variable significantly impacts the response variable for all three groups, supporting the study's hypotheses.

4.2. Qualitative analysis

The study employed the focus group method to engage participants in a guided discussion about their experiences with energy use and conservation during the pandemic, and subsequently transcribed the discussions for analysis. The aim was to understand the participants' experiences and perceptions regarding energy use and conservation during the pandemic and its impact on their energy literacy. This qualitative approach allowed for detailed insights into the participants' experiences and complemented the quantitative survey data. In addition, unstructured interviews with students and faculty members were conducted to explore how COVID-19 has affected energy literacy knowledge and behavior. The interviews allowed for a more personalized and in-depth exploration of the experiences of individuals in different occupant groups and revealed specific details about participants' experiences during the pandemic. The interviews also provided an opportunity for participants to share their ideas and suggestions for improving energy literacy in the future. The researchers used NVivo 12, a qualitative data analysis software, to analyze the interview data to identify factors and sources that influence energy literacy knowledge and behavior. The researchers developed two "conceptual code maps" to visualize the relationships between different factors and sources and identify the key factors and sources influencing energy literacy knowledge and behavior. The maps were developed hierarchically based on the codes that emerged from the data. They helped the researchers identify the key factors and sources that influence energy literacy knowledge and behavior systematically and rigorously. Overall, the use of NVivo 12 and the development of conceptual code maps allowed the researchers to gain valuable insights into the impact of the pandemic on energy literacy and to inform future strategies for promoting energy conservation.

4.2.1. Qualitative results

The researchers developed two "conceptual code maps" using NVivo 12. These maps were used to visualize the relationships between different factors and sources and identify the key factors and sources influencing energy literacy knowledge and behavior. The first map represented the factors influencing energy literacy knowledge, while the second map represented the sources influencing energy conserving behavior. By creating nodes in NVivo 12, which are similar to categories, the researchers arranged the nodes hierarchically to represent the relationships between different factors and sources. This allowed them to identify the key factors and sources that influence energy literacy knowledge and behavior systematically and rigorously.

The first map, which focused on the factors that influence energy literacy knowledge, included nodes such as "education and awareness", "energy-related knowledge and skills", "culture and social norms", and "access to information and resources". These nodes were organized hierarchically to represent the relationships between different factors. The influence of education and awareness on energy-related knowledge and skills was the most referenced node from the qualitative data collected.

The second conceptual code map aimed to identify the sources influencing energy literacy behavior. The map included nodes such as "personal motivation and values", "peer pressure and social norms", "faith and religiosity", "government policies and regulations", "media and communication", "technology and infrastructure," and "social and cultural influence." These nodes were hierarchically arranged to illustrate the relationships between different sources. The qualitative data collected indicated that personal motivation and

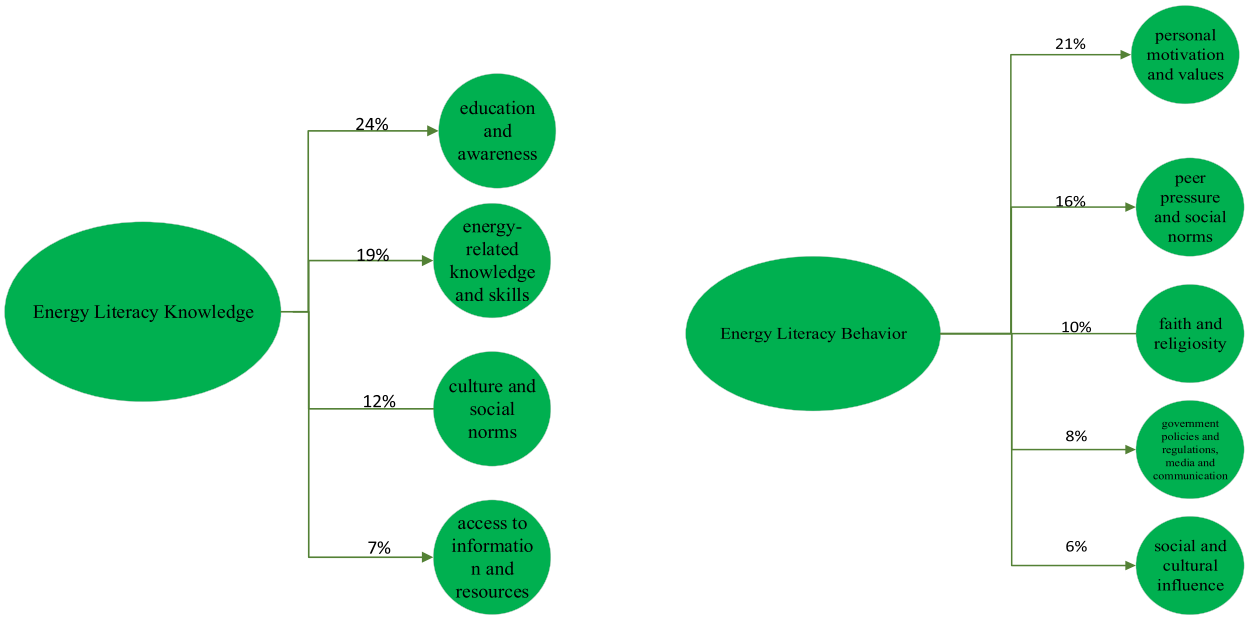

Fig. 6. Two code maps for knowledge and behavior.

values were the most influential factor in energy behavior. The nodes of "peer pressure and social norms" and "faith and religiosity" also impacted energy literacy behavior significantly. Fig. 6 shows the two code maps extracted from the qualitative data analyzed on NVivo 12.

In qualitative research, nodes are used to organize and analyze data. A node is considered the most referenced when it has the highest percentage of mentions based on the frequency of a word or its context in the interview and focus group transcripts. In this study, the researchers used nodes to represent the various factors and sources influencing energy literacy knowledge and behavior. For instance, in the first map, "education and awareness" encompassed formal and informal educational activities and awareness-raising initiatives related to energy literacy, while "culture and social norms" referred to societal beliefs and norms surrounding energy conservation. In the second map, "personal motivation and values" referred to an individual's personal beliefs and values related to energy conservation. In contrast "technology and infrastructure" referred to the physical infrastructure that supports energy conservation and efficiency.

In this study, the researchers used conceptual code maps to synthesize the data collected from the interviews and focus groups and identify the key factors and sources that influence energy literacy knowledge and behavior. By organizing the nodes hierarchically, they could identify the relationships between different factors and sources and develop a systematic and visual representation of the data. Through this analysis, the researchers found that education and awareness are important factors in promoting energy literacy knowledge with a percentage coverage from the qualitative data collected and coded as 24 %, as shown in Fig. 6. In comparison, personal motivation and values are important sources for promoting energy conservation behavior with percentage coverage from the qualitative data collected and coded as 21 % as shown in Fig. 6. In addition, energy-related knowledge and skills have been extracted as an important node with 19 % coverage. They also found that the culture of conservation and access to information play a significant role in influencing energy conservation behavior, with a percentage of 12 % and 7 %, respectively. Similarly, each node in the energy literacy behavior code map has a specific percentage coverage equivalent to how important this factor is on behavior.

The study further revealed that COVID-19 significantly impacted the participants' attitudes, beliefs, and experiences towards energy literacy. The focus group discussions and interviews highlighted several significant themes related to energy use and conservation behavior during the pandemic. Overall, using conceptual code maps in this study presented a comprehensive understanding of the complex relationships between different factors and sources that influence energy literacy knowledge and behavior. The findings could inform the development of targeted interventions and policies to promote energy literacy and conservation in the context of COVID-19 and beyond.

Among the emergent themes was an increased awareness of the significance of environmental protection, which led to a shift towards more sustainable practices. The pandemic also highlighted the link between environmental degradation and crises, such as pandemics, instigating a greater responsibility towards safeguarding the environment. This is supported by the findings of various studies, including those by Zebardast et al. [19], Zhong et al. [72], Hsu et al. [63] and Ababneh et al. [73]. These studies suggest that learning experiences, particularly those related to crises and disasters, can significantly impact individuals' environmental knowledge and behavior. This cognitive, emotional, and behavioral response can potentially foster more positive and sustainable environmental practices in the future.

Another noteworthy theme was the significance of promoting environmental education and awareness to foster long-term sustainable behaviors. This highlights that providing resources and tools to individuals is just one aspect of a comprehensive strategy to encourage sustainable behaviors. The analysis of the focus group discussions indicates that COVID-19 has brought a shift in behavior towards more sustainable practices and increased people's awareness about the importance of environmental protection. Moreover, the pandemic has underscored the relationship between environmental degradation and the occurrence of crises, such as pandemics, which has resulted in a heightened sense of responsibility towards protecting the environment. This result is supported by several studies by Capstick et al. [74]. This cognitive, emotional, and behavioral response may lead to more positive and sustainable environmental practices in the future.

Participants in this study emphasized the importance of religious values and teachings in promoting energy conservation in Kuwait. By emphasizing the importance of energy conservation from an Islamic perspective, individuals may view it as a moral duty and take steps to reduce their energy consumption. It is significant to consider the religious beliefs and values of the Kuwaiti population when developing energy conservation programs and campaigns. This finding is consistent with another study [75] that found religiosity to be a significant driver of sustainable consumption behavior in Muslim consumers, with perceived knowledge of COVID-19 directly motivating sustainable consumption behavior. Another study in Ghana [76] highlighted the need to strengthen energy education and improve monitoring culture to assess the appliance stock and status for the need for an appliance upgrade in faith-based organizations.

Finally, the study found COVID-19 significantly impacted participants' energy conservation and sustainability perceptions. Participants reported feeling more aware of the importance of sustainability and conservation during the pandemic, as they saw the immediate impacts of their behavior on their energy and the environment. The studies by Pop et al. [40], Matiiuk et al. [77], Li et al. [78] provide further support for the idea that COVID-19 has had a significant effect on people's perceptions of energy conservation and sustainability.

Overall, this study found that COVID-19 significantly impacted participants' attitudes, beliefs, and experiences regarding energy literacy and conservation. The study's findings provide valuable insights into the factors that influence energy literacy and conservation behavior during a pandemic and can inform the development of targeted interventions to promote sustainable energy use.

Based on the qualitative results of the study, there are several recommended measures to enhance energy literacy in academic buildings:

- Tailored educational interventions: Targeted educational interventions should be developed to address the needs of different occupant groups, such as students and faculty members. These interventions should increase awareness of the importance of energy conservation and promote sustainable energy use practices.
- Foster a culture of conservation: Social norms and culture are significant factors that affect energy literacy knowledge and behavior. Sustainable behavior should be promoted in schools, workplaces, and communities to create a conservation culture. Incentives should be provided to businesses that adopt sustainable practices.
- Provide access to information and resources: Access to information and resources on energy literacy, such as energy-conservation tips and online tools, can help individuals become more aware of their energy use and adopt energy-conservation behaviors.
- Promote community engagement: Community engagement is important in promoting energy conservation practices. Therefore, community-based initiatives and social networks should be used to promote community engagement.
- Religiosity: Promoting religiosity and faith in energy conservation from an Islamic point of view can be an effective way to raise awareness and encourage action in Kuwait. Religious values and teachings can help to raise awareness and encourage action for energy conservation in Kuwait. By emphasizing the importance of energy conservation from an Islamic perspective, individuals may view it as a moral duty and take steps to reduce their energy consumption. Considering the religious beliefs and values of the Kuwaiti population is essential when developing energy conservation programs and campaigns.
- Policy and Infrastructure: Participants highlighted the importance of policy and infrastructure in promoting energy literacy, such as government policies and regulations. Enhancing energy literacy requires a multifaceted approach that addresses the unique needs and challenges of different occupant groups, promotes technology adoption, and fosters community engagement. By implementing these measures, sustainable energy use practices can be promoted, and energy literacy can be enhanced in academic buildings.

5. Discussion

This research project aimed to examine changes in energy literacy among different occupant groups in academic buildings in Kuwait after the pandemic. Additionally, the study aimed to explore the factors that influence energy literacy and conservation behavior, with a particular focus on the effect of the pandemic on attitudes, intentions, and behaviors related to energy conservation. The study employed both qualitative and quantitative methods to collect data from students, faculty, and staff at an Australian university in Kuwait. The findings suggest that education, awareness, personal motivation, values, culture, and religiosity are critical factors in promoting energy literacy and conservation behavior. The study also found that COVID-19 significantly impacted participants' attitudes, intentions, and experiences regarding energy literacy and conservation.

This quantitative study investigated changes in energy literacy among different occupant groups after the pandemic. The findings indicated that students made significant progress in General Knowledge and Technical Knowledge, while faculty and staff showed improvement in General Knowledge and Country-Specific Knowledge. The study highlighted the need to tailor educational interventions to specific occupant groups. Post-pandemic, there was a stronger relationship between the variables, with significant increases in the relationship between attitudes, intentions, and behavior. Students exhibited the highest increase in the relationship between intention and behavior, while the faculty group had a smaller increase in both relationships. These findings emphasize the impact of the pandemic on attitudes, intentions, and behaviors related to energy conservation.

These findings have important implications for policymakers, building managers, and educators promoting sustainable energy practices. The statistically significant differences between pre-pandemic and post-pandemic groups highlight the potential for leveraging the increased awareness during the pandemic to encourage individuals to adopt more sustainable energy behaviors. Building managers and educators can tailor their interventions and educational programs to capitalize on this heightened awareness, focusing on factors such as education, awareness, personal motivation, and values. Policymakers can use these findings to develop effective policies and regulations that promote energy conservation and sustainability in academic buildings, fostering a culture of conservation and positively impacting energy consumption behavior.

This study employed qualitative methods, such as focus group discussions and unstructured interviews, to gain insights into the effect of COVID-19 on energy literacy, participants' experiences, and perceptions of energy use and conservation. The main objective was to comprehend the pandemic's effect on energy literacy and to identify strategies to enhance it. The findings suggest that education, awareness, personal motivation, values, culture, and religiosity are critical factors promoting energy literacy and conservation behavior. To enhance energy literacy in academic buildings, the researchers suggest several measures. One key strategy is to develop tailored educational interventions to meet the specific needs of different occupant groups. This could involve targeted training sessions, workshops, or other activities designed to enhance understanding of energy use and conservation. Additionally, a culture of conservation should be fostered through awareness campaigns, incentives, and other measures that promote sustainable behavior in schools, workplaces, and communities. Access to information and resources on energy literacy, such as energy-saving tips and online tools, can help individuals become more aware of their energy use and adopt energy-conserving behaviors. Community engagement is also critical and should be promoted through community-based initiatives and social networks to build a strong and sustainable conservation culture that can positively impact the environment and society.

The study highlights the potential of promoting energy conservation in Kuwait from an Islamic perspective by leveraging religious values and teachings to encourage action for energy conservation. The findings suggest that religious beliefs and values may shape attitudes and behaviors related to energy use and conservation. Therefore, considering the Kuwaiti population's religious context when developing energy conservation programs and campaigns is essential. The study recommends incorporating religious perspectives into educational interventions and outreach efforts to enhance energy literacy and promote sustainable energy consumption behavior.

The study underlines government policies and regulations' role in promoting sustainable energy consumption practices and shaping energy consumption behavior. It recommends that policymakers and stakeholders collaborate to develop and implement effective policies and regulations that encourage energy conservation in Kuwait. A multifaceted approach is necessary to enhance energy literacy, which addresses the unique needs and challenges of different occupant groups, promotes technology adoption, and fosters community engagement. Implementing these measures can promote sustainable energy use practices and enhance energy literacy in academic buildings.

To enhance our understanding of energy literacy and behavior, future research can explore the effectiveness of different educational interventions and the role of social and cultural factors in shaping energy consumption practices. The significance of the present study is its contribution to the energy literacy and conservation field by identifying the specific challenges and opportunities within academic buildings in Kuwait. The study's findings have important implications for policymakers, building managers, and educators committed to promoting sustainable energy consumption behavior in academic settings. Overall, this study provides insights into energy literacy and conservation behavior in the context of unexpected events such as pandemics, with practical implications for policy and practice. The findings suggest that educational interventions should be tailored to the unique needs and challenges of different occupant groups, and that policies and infrastructure should be designed to support a culture of conservation. Individuals and organizations can also take steps to improve their energy literacy and conservation behavior by being aware of their energy consumption, setting goals for reducing their energy consumption, making changes to their habits and behaviors, using energy-efficient appliances and products, and supporting energy-efficiency initiatives. Moreover, the study highlights the need to continuously evaluate energy literacy interventions to ensure their efficacy and inform future efforts. Also, the study emphasizes the critical importance of developing tailored educational interventions that address different occupant groups' specific needs and challenges. By fostering a culture of conservation and promoting sustainable behavior in schools, workplaces, and communities, these interventions can effectively enhance energy literacy and encourage sustainable energy consumption. Furthermore, the study recommends incorporating religious perspectives into energy literacy interventions in Kuwait, recognizing the influence of religious beliefs and values on attitudes and behaviors related to energy use and conservation. This approach can enhance energy literacy and promote sustainable energy consumption behavior by aligning with the cultural and religious context of the Kuwaiti population. This study makes a contribution to the growing literature on energy literacy and sustainability, providing significant insights for future research and practice. Policymakers, building managers, and educators can benefit from these findings to develop effective policies, interventions, and educational programs that foster sustainable energy consumption behavior in academic buildings in Kuwait and other settings. Subsequent studies could further investigate the effectiveness of diverse educational interventions and explore how social and cultural factors shape energy literacy and behavior.

6. Conclusion

This study examined the changes in energy literacy among different occupant groups in academic buildings in Kuwait after the pandemic. The study also investigated the factors that influence energy literacy and conservation behavior, particularly emphasizing the pandemic's impact on attitudes, intentions, and behaviors linked to energy conservation. The evaluation found that COVID-19 significantly impacted participants' attitudes, intentions, and behavior regarding energy literacy and conservation. More specifically, the student group observed a notable improvement in the strength of the relationship between their intentions and behaviors, whereas the faculty group demonstrated a strong correlation between intention and behavior. These findings may be used by policymakers to create and implement efficient energy-saving measures.

The research also found that several key factors are essential for fostering energy literacy and conservation behavior, including education, awareness, personal motivation, values, religiosity, and culture. These findings have significant implications for policymakers, building managers, and educators who are seeking to encourage sustainable energy consumption in academic buildings. The investigation highlights the need for continuous evaluation of energy literacy programs and the promotion of energy conservation behavior in educational settings. It recommends implementing initiatives in teaching and fostering a culture of conservation to enhance energy literacy in academic buildings. These initiatives may include providing knowledge and resources, fostering community engagement, and improving regulations and facilities. The study also emphasizes the critical importance of developing tailored educational interventions that address different occupant groups' specific needs and challenges. By fostering a culture of conservation and promoting sustainable behavior in schools, workplaces, and communities, these interventions can effectively enhance energy literacy and encourage sustainable energy consumption. Furthermore, the study recommends incorporating religious perspectives into energy literacy interventions in Kuwait, recognizing the influence of religious beliefs and values on attitudes and behaviors related to energy use and conservation. This approach can enhance energy literacy and promote sustainable energy consumption behavior by aligning with the cultural and religious context of the Kuwaiti population.

The paper makes recommendations for future studies on topics that could further improve energy literacy and conservation behavior. For example, investigating the efficacy of various learning programs could help to determine which strategies have the greatest impact. Additionally, a greater understanding of these variables could be gained by examining how social and cultural factors affect energy literacy and behavior. This work contributes to the growing energy literacy and sustainability literature, providing significant insights for future research and practice. Policymakers, building managers, and educators can benefit from these findings to develop effective policies, interventions, and educational programs that foster sustainable energy consumption behavior in academic buildings in Kuwait and other settings.

7. Limitations and future study

Some limitations of the study include the restricted sample of university students from a specific region, which may limit the generalizability of the findings. The use of self-report measures introduces the potential for bias or inaccuracies. As the study focuses on academic buildings, it may not be applicable to other types of structures or contexts. The study's use of a mixed-methods strategy may pose methodological hurdles in terms of data integration and interpretation.

Future research can address these limitations by exploring the effectiveness of various educational interventions, investigating the relationship between energy literacy and actual energy consumption behaviors, considering the influence of social and cultural factors, and identifying strategies to promote energy literacy and sustainable behavior among diverse populations.

Data availability statement

The data that has been used is confidential.

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CRediT authorship contribution statement

Majdi M. Alomari: Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Hania EL-Kanj:** Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Data curation, Conceptualization. **Ayse Topal:** Writing – review & editing, Writing – original draft, Project administration, Investigation, Formal analysis, Data curation, Conceptualization. **Nafesah I. Alshdaifat:** Writing – review & editing, Writing – original draft, Software, Resources, Project administration, Methodology, Data curation.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Majdi M. Alomari reports financial support was provided by Kuwait Foundation for the Advancement of Sciences.

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Appendix A. Supplementary data

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