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Clustering and exploring university students' knowledge and attitude toward energy sustainability

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Abstract

An investigation of the attitudes and understanding of Indian university students, who are considered the country's future workforce, was conducted to see if they could be classified into subgroups depending on their energy attitudes. The surveyed population was divided into four unique "personas", each with a different level of engagement and a different perception of energy, using Hierarchical Cluster analysis. "Agents of Change", "Mindful wanderer", "Big talker", and "Indifferent onlooker" were the four clusters identified. Energy knowledge was studied for fundamental energy themes, and the correlation test found a substantial positive relationship between energy knowledge and a person's energy attitude. It also investigates how the findings on subgroups or personas can influence the construction of energy education curricula at different educational levels.

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Keywords: Attitude; Behavior; Clustering; Energy; Knowledge sustainability

1. Main text

Sustainable development has evolved into an all-encompassing notion that spans economic, social, and environmental concerns. It is a pattern of economic growth in which resources are used to meet human needs while also sustaining the environment. Among the several resources that make up a country's backbone, energy is regarded as critical to alleviating poverty, boosting human welfare, and thereby raising living standards. [IAEA, 2007]. Around 82% of the total energy supply is derived from fossil fuels such as oil, coal, and natural gas [1]. The current increase in environmental issues such as climate change or global warming is due to the rise in the overall atmospheric temperature caused by the greenhouse effect as well as carbon emissions, which is the result of a 70% increasing

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human activity [2,3]. Energy generation places enormous strain on the ecosystem, as resources are scarce and quickly depleted. Energy sustainability is concerned with ensuring that energy is both reliable and inexpensive, while also meeting social and environmental needs [4]. The Kyoto Protocol's primary objective, which was negotiated in December 1997 in the Japanese city of Kyoto and entered into force on February 16th, 2005, is to combat global warming through a variety of measures, including energy-efficient alternatives [5]. One way to reduce total usage is to urge people to conserve energy. Globally, communities and governments are confronted with the challenge of meeting escalating energy demands in an environmentally and economically appropriate manner.

Materials & Methods

The study took place in colleges throughout Kerala, India. Undergraduate students enrolled in colleges associated with the University of Kerala formed the sample for the study. The National Energy Literacy Survey Questionnaire, designed and implemented by the National Energy Foundation in the United States of America, was adapted for usage in India by modifying and culturally adapting it. The questionnaire was structured around five core energy topics. It covered topics such as knowledge, attitude, and behavior. The survey questionnaire was adapted to incorporate questions on demographics, behavior, knowledge, and attitudes. The tool featured five questions that inquired about demographic information such as age, gender, residence area, annual family income, and topic of study. The section on behavior included questions on energy-related acts and behaviors. The knowledge component, which addressed energy literacy ideas, contained questions on fundamental energy concepts, energy sources and types, energy trade-offs and implications, and energy consumption, efficiency, and conservation. Among the fundamental energy concepts were definitions, laws, and energy transformations. Energy use is concerned with consumer energy consumption, energy consumption trends, and energy safety. Energy trade-offs and implications included the following topics: quality of lie, energy resource constraints, and energy development limits. The primary energy topic was the impact and behavior of technology, specifically energy efficiency and conservation. Finally, the topic sources and types of energy covered both renewable and non-renewable energy sources. The questionnaire, which was based on the Likert scale, contained 22 questions aimed at eliciting respondents' attitudes on energy conservation, use, and management.

Treatment Details & Experimental Design

The survey instrument was distributed to students in July 2018 using an online Google form. The survey sought to elicit information about respondents' knowledge of energy concepts, their attitudes toward personal energy use and management, and their personal energy management choices. The data gathering took place at a single university in India. The population consisted of first-year undergraduate students in colleges of engineering, arts and sciences, and teacher education. Even though 400 replies were obtained, 16 were discarded due to being incomplete. The data were scored and tabulated according to a predetermined pattern; this was done to calculate scores and comparison data to arrive at conclusions and outcomes. The topic sources and forms of energy were discussed. The questionnaire, which was based on the Likert-type scale, contained 22 questions aimed at eliciting respondents' attitudes on saving energy, consumption, and management.

2. Research result & reflections

2.1. Energy attitude

The survey contained 22 questions about attitudes toward energy use and consumption, as well as 15 questions about undergraduate students' perspectives on energy. Cluster analysis was performed to examine individual similarities and differences and to group comparable individuals into clusters. The pattern of respondents' responses was studied using the Ward method of hierarchical cluster analysis. The squared Euclidean distance was used to calculate the distance between the variables as a similarity-difference measure. The analysis results are given in the form of a dendrogram (see Fig. 1).

The dendrogram (see Fig. 2) graphically depicts the cluster solutions obtained during analysis. The diagram analysis offers four cluster solutions. As a result, this idea was advanced during the study's subsequent discussions. The study classified the sample into four clusters or groups, each with a unique set of perception and attitude characteristics. ANOVA was performed to determine whether the clusters were substantially different from one another in terms of the cluster analysis variables.

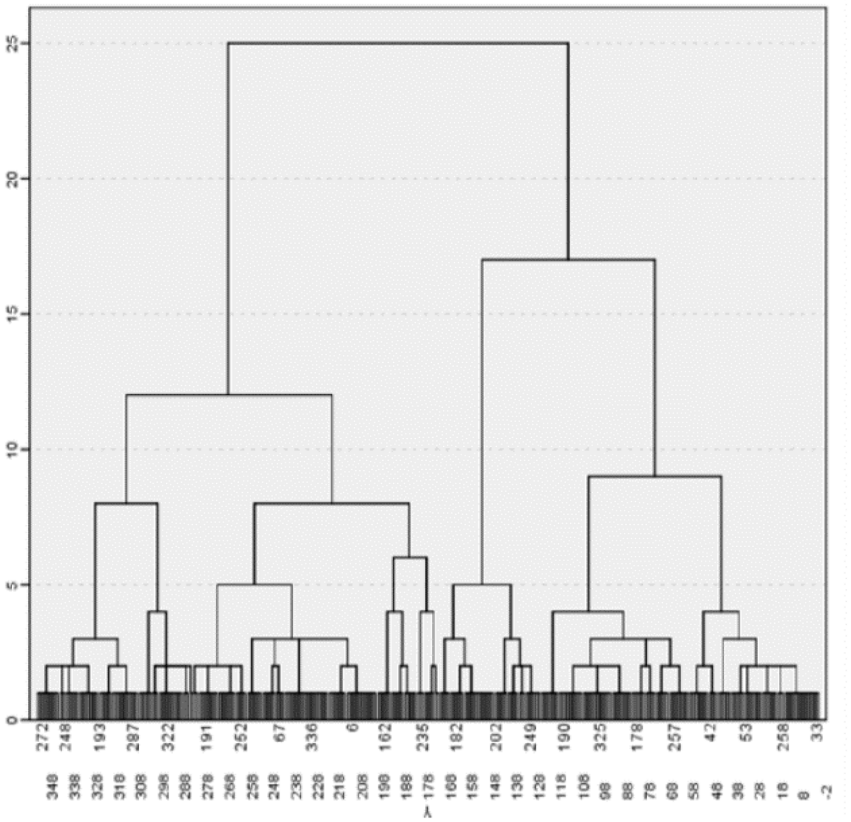

Fig. 1. Dendrogram of the cluster analysis on the frequency of the levels of attitude and perception.

The cluster groups formed consisted of four distinct personas. Each persona demonstrates a different amount of participation and a different impression of energy. As a result of their conduct and perception, these personas were dubbed agents of change, big talkers, mindful wanderer, and indifferent onlooker (n.d.) [6]. The majority (32.77 percent) of the sample is composed of mindful wanderers, who understand the importance of energy but are unaware of the ways and means to make a difference on their own, whereas agents of change, who consistently prioritize energy conservation and management and are constantly engaged in resolving energy-related issues, are in short supply (17.51 percent). The big talker (25.98 percent) believes that energy is critical but is unwilling to change their energy-related behavior or lifestyle to conserve or manage energy. Finally, an indifferent onlooker accounts for approximately 23.73 percent of the sample. They were never concerned about energy or energy-related issues and always placed their comfort first [7].

2.2. Energy knowledge

The analysis of the data related to energy knowledge of the four cluster groups concerning the five core energy topics discussed earlier is presented graphically.

2.3. Energy knowledge & energy attitude — Correlation analysis

Pearson's correlations among energy knowledge and attitude of university students show small positive but significant relationships ($r = 0.375$, $p = 0.000$) (Table 1). The highest correlation values were found for Indifferent onlooker ($r = 0.430$, $p = 0.000$) and Agents of change ($r = 0.410$, $p = 0.001$) Additionally, the Mindful Wanderer ($r = 0.165$, $p = 0.077$) and the Big Talker ($r = 0.167$, $p = 0.111$) demonstrate a positive relationship

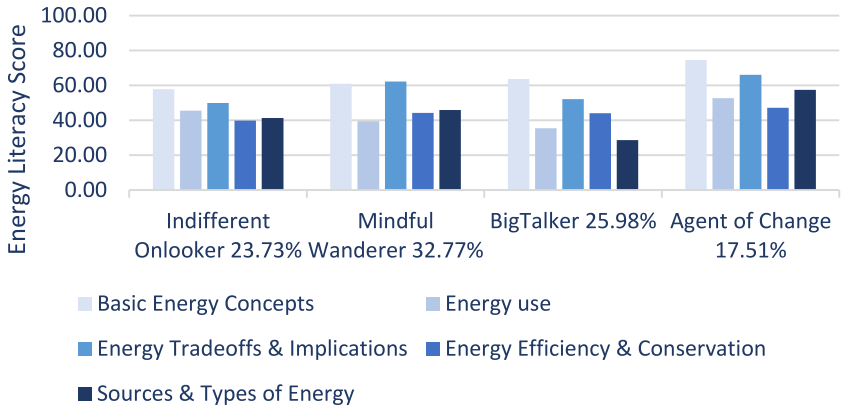

Fig. 2. Energy knowledge across categories and groups.

Table 1. Profile of the respondents.

Profile		Frequency	Percentage (%)
Gender	Male	120	34
	Female	234	66
Bachelor's degree	Engineering	106	30
	Arts & Science	125	35
	Education	123	35
Income (INR)	200,00	249	70
	200,000 to 500,000	66	19
	500,001 to 1,000,000	32	9
	1,000,000	7	2

between knowledge and attitude toward energy. Yet even knowing that turning off television through the use of the equipment button eliminates stand-by consumption and saves energy correlates only weakly with that specific behavior ($r = 0.157$, $p = 0.024$) (see Tables 2 and 3).

3. Conclusion

The findings of this study indicate that students who score higher on energy knowledge have a more optimistic attitude toward energy, and vice versa. These two variables exhibit a statistically significant positive relationship. Agents of change with a favorable attitude toward energy obtained the highest score of knowledge on energy content (59.6). The matching drop in the value of content knowledge for the mindful Wanderer (50.6), the Big Talker (44.8), and the Indifferent Onlooker (46.9) demonstrates the relationship between energy knowledge and attitude toward energy. Ana et al. [8], Murat and Mustafa [9], and Divya et al. [7] have conducted similar studies and concluded that there is a favorable association between energy knowledge and attitude. As a result, it is evident that to overcome energy-related difficulties, it is vital to increase people's energy literacy and hence their attitude toward energy conservation and management. The findings from the preceding research underscore the critical role of information and attitudes regarding energy in fostering informed decision-making in novel circumstances. Additionally, it implies the importance of an integrated or multidisciplinary approach that connects formal education to real-world energy and environmental issues, enhancing attitudes and awareness about how individuals utilize energy in their daily activities. The survey results indicate that there are genuine chances to improve energy education through curriculum revision. Efforts should be made to strengthen energy-related curricula to educate students at all levels of education, from primary to higher education. Learning methodologies must be altered to focus not only on raising awareness or expanding knowledge, but also on giving chances for students to engage in real-world energy-related challenges, to develop a positive attitude toward energy, and to translate energy understanding into energy action.

Table 2. Mean, standard deviation, and ANOVA of the attitude scores for the four clusters.

Statements	Cluster 1 Mean (STDV)	Cluster 2 Mean (STDV)	Cluster 3 Mean (STDV)	Cluster 4 Mean (STDV)	ANOVA F(p)
Energy-saving and conserving are simply not a priority for me.	5 (0)	4.45 (0.77)	1.5 (0.85)	4.78 (0.7)	512.909 (0.000)
I don't have time to worry about how much energy I use.	4.42 (1.11)	3.33 (0.99)	3.22 (1.18)	3.73 (1.25)	15.853 (0.000)
Reducing my energy consumption would be too inconvenient for my daily routine.	4.82 (0.5)	3.17 (1.06)	2.99 (1.07)	4.4 (0.85)	84.499 (0.000)
Whenever I'm at home, I take steps to save electricity.	1.03 (0.18)	1.76 (1.8)	1.59 (0.84)	1.91 (0.92)	17.751 (0.000)
There isn't much I can do in my own house to save electricity.	4.44 (0.84)	3.64 (1.39)	2.72 (1.46)	2.97 (1.4)	24.73 (0.000)
My energy conservation initiatives will have a beneficial effect on the environment.	4.81 (0.51)	4.08 (1.09)	4.18 (0.9)	4.46 (0.89)	9.725 (0.000)
I will not compromise my comfort to save electricity at home.	1.37 (0.66)	1.88 (1.06)	2.59 (1.4)	1.72 (1.16)	16.698 (0.000)
My family and colleagues prefer to discuss energy conservation and efficiency.	4.31 (1)	3.24 (0.67)	3.48 (1.03)	3.11 (1.14)	21.367 (0.000)
Our country's economy relies heavily on energy efficiency.	4.87 (0.71)	3.99 (1.01)	4.47 (0.75)	4.95 (0.22)	34.859 (0.000)
I owe it to myself and my family to limit my energy consumption.	4.03 (1.58)	3.57 (0.94)	4.09 (0.9)	4.11 (1.16)	4.430 (0.005)
I am prepared to compromise with those whose opinions on energy are opposed to mine.	2.58 (1.29)	2.67 (0.92)	1.95 (1)	2.7 (1.35)	8.671 (0.000)
Reduced energy use will have a significant, favorable impact on my finances.	4.77 (0.61)	3.94 (1.3)	4.43 (0.8)	4.54 (0.91)	10.540 (0.000)
We have to expand our sources of renewable energy, even if it means rising the price of energy.	4.58 (0.74)	3.31 (0.82)	4.38 (0.72)	4.14 (1.24)	27.564 (0.000)
Our nation's energy conservation and efficiency measures are strongly influenced by the government.	4.52 (0.92)	3.62 (1)	4.46 (0.75)	4.78 (0.42)	38.988 (0.000)
Climate change is a critical issue that needs addressing.	4.76 (0.53)	3.58 (0.89)	4.33 (0.88)	4.74 (0.48)	50.507 (0.000)
Every day, I keep up with the latest developments in local and national energy policy.	4.16 (0.96	2.85 (0.7)	4.16 (0.89)	3.6 0.98)	42.658 (0.000)
I think I have a say in how energy policies are made.	4.5 (0.74)	3.08 (0.75)	4.23 (0.88)	4 (1.01)	39.059 (0.000)
It is more important to have clean energy than to have reliable and cheap energy.	4.26 (0.77)	3.4 (0.68)	4.43 (0.68)	4.15 (0.97)	27.294 (0.000)
It is more vital to have affordable energy than to have clean and reliable energy.	3.98 (0.97)	2.93 (0.86)	2.34 (1)	2.12 (1.06)	54.019 (0.000)
We, as a nation, must increase our financial and human resources to achieve complete energy independence as fast as possible.	4.47 (0.72)	3.2 (0.88)	4.12 (0.69)	4.81 (0.39)	98.439 (0.000)
It is critical for our economic development and national security that we achieve energy independence.	4.66 (0.65)	3.27 (0.83)	4.26 (0.64)	4.55 (1.1)	45.105 (0.000)
India should prioritize maximizing the use of all available energy sources.	3.65 (1.03)	3.6 (0.71)	4.18 (0.78)	3.59 (1.71)	5.264 (0.001)

Table 3. Pearson correlation between energy knowledge and energy attitude.

	Energy attitude-total sample	Agents of change-energy attitude	Mindful wanderer-energy attitude	Big talker-energy attitude	Indifferent onlooker-energy attitude
Energy knowledge-total sample	$r = 0.375^{**}$ $p = 0.000$ $N = 354$				
Agents of change-energy knowledge		$r = 0.410^{**}$ $p = 0.001$ $N = 62$			
Mindful wanderer-energy knowledge			$r = 0.165$ $p = 0.077$ $N = 116$		
Big talker-energy knowledge				$r = 0.167$ $p = 0.111$ $N = 92$	
Indifferent onlooker-energy knowledge					$r = 0.430^{**}$ $p = 0.000$ $N = 84$

**Correlation is significant at the 0.01 level.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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