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Article

Energy literacy among young adults in the European countries

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Abstract: Energy literacy is an essential prerequisite for informed and sustainable energy consumption habits. Our paper focuses on factors influencing young adults' attitudes and behaviours and their knowledge of sustainable energy consumption practices. The research was conducted in five European countries, Austria, Croatia, Greece, Slovenia and Poland, and data were collected from 219 young adults between the ages of twenty-nine and thirty-nine. The methods used are statistical analyses, including principal component analysis, a technique for analysing large data sets and identifying influencing factors. We used a statistical software package (SPSS) for the analyses. Our analysis revealed five significant factors influencing the energy literacy of young adults. The key factors were education and awareness, investment in energy efficiency, age and gender, climate change and environmental protection, sustainable lifestyle and social environment. Policymakers, educators and other stakeholders can work towards creating a more energy-literate and sustainable society by understanding the key factors that influence energy literacy.

Keywords: energy literacy; energy consumption; awareness raising; sustainability; survey; energy-related behaviour

1. Introduction

To mitigate the adverse impacts of climate change, we must limit the rise in global temperature to 2 K compared to the pre-industrial era. The energy sector is the primary contributor to anthropogenic global warming, making the shift towards low-carbon energy sources a central aspect of the green transition [1]. However, the direction of our energy trajectory depends on various factors, not only on the technological leaps or policy interventions but also on the behavioural changes of members of society who make energy-related choices in their day-to-day lives [2]. This is highlighted by the fact that in 2020, households represented 27.4% of the final energy consumption in the EU, with most of the energy being utilised for heating [3].

Key barriers to reduction in residential energy consumption are inadequate information, including policy awareness, low incentives for energy savings, insufficient tax measures and decision-making heuristics [4]. The intangibility of energy and its supply often results in consumers overlooking or failing to grasp their ongoing consumption. This detachment is further exacerbated by the primary indicator of electricity usage: the bill, which is frequently perceived as complex and unengaging. Recognising these challenges, various initiatives such as education programs, media campaigns, and energy-related products (e.g., smart displays and smart meters) seek to bridge this knowledge gap and improve energy literacy [5]. On top of that, extensive media coverage, increasing frequency of extreme weather events, and the mobilisation of political and social movements heightened awareness of climate change among the general population [6].

However, behavioural changes are often unobserved, even with moderate knowledge and positive attitudes toward environmental preservation [7]. As a result, there is a growing interest in deepening the understanding of energy literacy and promoting its behavioural aspect among the general population and particularly among young adults, of whom many have transitioned to managing their households and, consequently, face practical challenges of adopting a climate-friendly lifestyle [8].

While there is some empirical research measuring energy literacy, including a survey among secondary students in New York State [9], a survey among household energy users, consumers and businesses in Denmark [10], survey among citizens of Mashhad [11], comparative survey among students in UK and China [12], survey among Portuguese university members [13], survey among students in Taiwan [14], and survey among Swiss households [15], a notable gap exists in research focused on energy literacy among young adults aged 29–39 in EU countries. Motivated by this gap, we conducted empirical research targeting the practical factors influencing energy literacy, specifically targeting young adults in Slovenia, Croatia, Austria, Poland, and Greece. We collected data via a questionnaire survey and utilised SPSS for factor analysis to pinpoint the primary factors affecting energy literacy. Deriving from DeWaters and Powers [16,17] definition of energy literacy, we hypothesised that there is a close interrelationship between one's energy knowledge and energy-related behaviours.

2. Literature review

There has been a significant increase in researchers' interest in energy literacy due to the increasing need for a green energy transition, including changing individuals' behaviour regarding how they consume energy. Many studies focus on cognitive, affective, and behavioural dimensions of energy literacy [16,18,19]. The cognitive dimension of energy literacy refers to an individual's knowledge and understanding of energy, its sources, forms, transformations, uses, and knowledge of energy-related concepts (e.g., energy efficiency). The affective dimension to energy literacy adds societal context, values, locus of control, sense of personal responsibility and attitudes toward energy conservatism. The third dimension involves energy-savings-related actions and behavioural outcomes [19]. Additionally, Martins et al. [17] also emphasise the influence of financial literacy on energy literacy since it is needed to calculate the lifetime cost of household appliances or energy-efficient investments. Similarly, Brent and Ward [20] highlight the importance of financial literacy as an essential factor influencing investment in energy efficiency.

Despite expanding our understanding of the determinants of energy literacy, there remains a notable gap in research systematically examining the behavioural consequences of increased energy-related environmental awareness [6]. Moreover, no clear evidence suggests a causal relationship between any dimensions of energy literacy.

For instance, a German case study by Venghaus et al. [6] found that despite a marked positive attitude towards climate protection and a rise in environmental consciousness, there wasn't a notable shift in behaviour. Similarly, Ramos et al. [21] researched whether pro-environmental attitudes lead to investments in energy efficiency in Spain and discovered that positive attitudes are not a reliable predictor of whether households would take concrete steps to reduce their energy consumption. [2] research reinforced this, illustrating how individuals frequently underinvest in energy-efficient technologies, often irrationally. DeWaters and Powers [9] contributed with another exciting finding that despite exhibiting superior cognitive and affective competencies, high school students in the USA displayed significantly lower scores on the behavioural subscale than their younger middle school counterparts. This paradox suggests enhanced knowledge and sentiments don't necessarily translate to improved energy conservation practices.

On the other hand, a body of research indicates a tangible relationship between different dimensions of energy literacy. Sayarkhalaj and Khesal [11] survey among citizens of Mashhad reveals a significant link between knowledge and energy consumption behaviour, suggesting knowledge as a precondition for behaviour. Additionally, Brent and Ward [20] highlighted that households with higher levels of financial literacy are more likely to adopt energy-efficient measures, indicating that energy-related financial literacy can lead to energy conservation behaviour. Similarly, a study from Kahn [22] shows that more environmentally conscious residents in California tend to make eco-friendly transportation choices. They are more likely to invest in hybrid vehicles and prefer public transport, controlled for urban/suburban differences. DeWaters and Powers [16] emphasise the geographic and cultural context of eco-friendly attitudes and behaviours, with the critical factor being energy-saving alternatives' availability and affordability. They also see energy literacy (consisting of energy-efficient behaviour) as a result of learner empowerment and behaviour change as the final measure of effectiveness. Findings from Martins et al. [13] highlighting gender differences also show the interesting connection between the energy literacy dimensions. For instance, findings indicate that although women may have lower levels of knowledge, they often demonstrate a more positive attitude and exhibit more appropriate energy-related behaviours. This suggests that knowledge alone isn't the sole driver of behaviour and attitudes. Similarly, Lee et al. [14] show that attitudes toward energy savings are a stronger predictor of energy-saving behaviour than factors such as one's knowledge about energy or gender.

In addition, recent studies expand our understanding of energy literacy in different contexts. Lee et al. [23] investigated the energy literacy of high school students in Vietnam. They found that while students' knowledge about energy was low, their perceived values, attitudes, intentions and behaviours related to energy conservation were relatively high. This study highlights the indirect effects of energy knowledge on behaviour, which are mediated by values and attitudes. Similarly, Keller et al. [24] investigated students' energy literacy in Austria. They found that energy education workshops effectively increased cognitive, affective and behavioural energy literacy, significantly impacting students' energy consumption behaviour.

In Poland, Białynicki-Birula et al. [25] investigated the energy literacy of university students and identified important factors such as gender, experience of energy poverty and self-efficacy. Their findings highlight the importance of addressing emotional and behavioural areas in energy education. In Malaysia, Alia et al. [26] emphasised the role of informal learning and visual representation of data in improving energy literacy among university students to bridge the gap in awareness of energy conservation measures.

Ramachandran et al. [27] provided a comprehensive overview of energy literacy in educational contexts and emphasised its role in environmental and sustainability education. This review emphasised the multifaceted nature of energy literacy and its crucial role in supporting the energy transition. Papavasileiou et al. [28] focused on primary school students in Greece and showed that effective early education can lead to high levels of energy-related knowledge and positive energy-saving behaviour.

In addition, Martins et al. [29] investigated gender differences in energy literacy among Portuguese university students. They found that despite their lower level of knowledge, women displayed more positive attitudes and behaviour towards energy saving. Cerović et al. [30] conducted a similar study among Croatian business students and emphasised the need for public policies integrating education, regulation and stakeholder collaboration to improve energy literacy. Chandrasenan et al. [31] analysed energy literacy among Ethiopian university students. They emphasised the urgent need to promote energy literacy in formal and informal learning environments to meet the country's energy needs and sustainability goals.

3. Methods

The survey was conducted on a national level in five different countries, namely Slovenia, Greece, Austria, Croatia and Poland, with the additional possibility that the respondent lives in another country.

A random sample of n = 219 completed questionnaires was used for further analysis. The sample was predominantly female, with a small proportion of male respondents (71.1% and 28.9% respectively). Most participants reported owning their house/flat (48.4%), followed by renting a house/flat, cohabiting or other option (30.6%, 18.7% and 2.3%, respectively). In addition, a minority of respondents reported having a secondary school qualification, while the majority had a higher education qualification (16.4% and 83.6% respectively).

The questionnaire initially consisted of seven general questions, followed by 27 thematic questions. The thematic questions aimed to explore participants' energy literacy and were based on a five-point Likert scale (1 for 'I strongly disagree' to 5 for 'I strongly agree'). We used the Statistical Package for the Social Sciences (SPSS) version 28.0 to analyse the collected data.

To better understand the results obtained, we used principal component analysis (PCA) to analyse the underlying correlations between the variables and identify a few factors that best explained the variance. PCA was chosen for its ability to simplify complex data sets. It effectively reduces dimensionality, especially when processing many interrelated variables.

The principal components are expressed as a linear combination of the original variables, and their total variance is preserved. The first principal component is created to account for the most significant possible variance of the original variables. Each subsequent principal component is independent of its predecessors and aims to explain most of the variance not yet accounted for. Successive principal components are arranged in decreasing order of variance. If the original variables are sufficiently related, the subsequent principal components explain a smaller proportion of the total variance and can be neglected [32].

The principal component model can be described by Equation (1) [33]:

$$z_1 = a_{11}F_1 + a_{12}F_2 + \cdots + a_{1k}F_k$$
$$z_2 = a_{21}F_1 + a_{22}F_2 + \cdots + a_{2k}F_k \quad (1)$$
$$z_k = a_{k1}F_1 + a_{k2}F_2 + \cdots + a_{kk}F_k$$

where z_i is the standardised value of the i-th observed variable for i = 1, …, k; F_j represents the j-th principal component or factor for j = 1, …, k; and a_{ij} is the factor weight of the i-th variable for the j-th factor.

The square of the factor weight (a_{ij}^2) for the i-th variable quantifies how much of the variance in the i-th observed variable is explained by the j-th factor. The so-called commonality of a given variable is obtained by summing the squared factor weights across all extracted factors for that variable as seen from Equation (2) [33]:

$$h_i^2 = a_{i1}^2 + a_{i2}^2 + \cdots + a_{im}^2 \quad (2)$$

On the other hand, the sum of the squares of the factor weights for the j-th factor across all k original variables is the eigenvalue of factor j. The eigenvalues express the proportion of the total variance of all k variables together explained by the j-th factor, as seen from Equation (3) [33]:

$$\lambda_1 = a_{1j}^2 + a_{2j}^2 + \cdots + a_{kj}^2 \quad (3)$$

Eigenvalues determine principal components. They are established sequentially to capture the largest proportion of the unexplained variance. Hence, the eigenvalue is most substantial for the first factor, as demonstrated in Equation (4) [32]:

$$\lambda_1 > \lambda_2 > \cdots > \lambda_k \quad (4)$$

We retained principal components with eigenvalues of 1 or greater in the factor analysis. Furthermore, our model aimed to account for at least 60% of the total variance across all variables to ensure meaningful representation and insights from the data.

4. Results

The results indicated that no value surpassed the maximum permissible threshold, validating the use of an orthogonal rotation. Given our study’s requirements and objectives, we further narrowed our choice to the Varimax rotation, a popular orthogonal rotation method aiming to maximise the variance of factor weights.

After this selection, we sought to verify the suitability of our data for factor analysis by employing two widely recognised statistical tests: the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett’s Test of Sphericity. The KMO measure was above the 0.6 threshold, suggesting that our sample was adequate. Simultaneously, Bartlett’s Test of Sphericity was significant, indicating that our variables were correlated enough for factor analysis [32]. The results are portrayed in **Table 1**.

Table 1. KMO and Bartlett's Test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**0.828**
Bartlett's Test of Sphericity	Approx. Chi-Square	2935.634
	df	561
	Sig.	0.000

Before factor extraction in our analysis, the initial communalities for each variable are set at a value of 1. Extraction commonalities, which tell us what proportion of each variable's variance is now explained by the factors we extracted, are shown in **Table 2**.

Table 2. Extraction communalities.

Variables	**Extraction communalities**
V1	0.647
V2	0.582
V3	0.674
V4	0.660
V5	0.690
V6	0.574
V7	0.526
V8	0.667
V9	0.687
V10	0.678
V11	0.773
V12	0.691
V13	0.596
V14	0.543
V15	0.635
V16	0.677
V17	0.736
V18	0.647
V19	0.605
V20	0.695
V21	0.413
V22	0.629
V23	0.623
V24	0.583
V25	0.680
V26	0.600
V27	0.648
V28	0.483
V29	0.576
V30	0.699

Table 2. (*Continued*).

Variables	Extraction communalities
V31	0.752
V32	0.714
V33	0.602
V34	0.609

Table 3 provides a detailed breakdown of the factor analysis results. As shown, 9 viable components were extracted, cumulatively accounting for 63.523% of the total variance in the dataset.

Table 3. Total variance explained.

Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Total	**% of variance**	**Cumulative %**	**Total**	**% of variance**	**Cumulative %**	**Total**	**% of variance**	**Cumulative %**
7.719	22.702	22.702	7.719	22.702	22.702	3.735	10.985	10.985
3.797	11.168	33.869	3.797	11.168	33.869	3.669	10.791	21.776
1.891	5.562	39.431	1.891	5.562	39.431	3.457	10.167	31.943
1.837	5.402	44.833	1.837	5.402	44.833	2.355	6.928	38.870
1.595	4.690	49.523	1.595	4.690	49.523	2.181	6.414	45.285
1.419	4.173	53.696	1.419	4.173	53.696	1.871	5.504	50.788
1.257	3.697	57.394	1.257	3.697	57.394	1.689	4.968	55.756
1.058	3.111	60.505	1.058	3.111	60.505	1.418	4.170	59.926
1.026	3.018	63.523	1.026	3.018	63.523	1.223	3.597	63.523
0.906	2.664	66.187						
0.859	2.526	68.713						
0.800	2.354	71.067						
0.771	2.267	73.334						
0.745	2.191	75.525						
0.708	2.082	77.607						
0.688	2.025	79.632						
0.641	1.885	81.518						
0.582	1.712	83.230						
0.569	1.674	84.904						
0.529	1.556	86.459						
0.494	1.453	87.913						
0.468	1.376	89.289						
0.462	1.360	90.649						
0.403	1.186	91.835						
0.379	1.116	92.950						
0.362	1.066	94.016						
0.337	0.992	95.008						
0.319	0.937	95.946						
0.294	0.864	96.810						

Table 3. (*Continued*).

Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Total	**% of variance**	**Cumulative %**	**Total**	**% of variance**	**Cumulative %**	**Total**	**% of variance**	**Cumulative %**
0.262	0.770	97.580						
0.247	0.728	98.308						
0.209	0.615	98.923						
0.201	0.591	99.514						
0.165	0.486	100,000						

To understand the relationships between these 9 identified viable components and the original variables, we've employed Varimax rotation with Kaiser Normalization. **Table 4** displays the Rotated Component Matrix, indicating how strongly each variable is associated with the extracted components through their factor loadings. A factor loading close to 1 or −1 indicates a strong correlation, while a loading close to 0 suggests a weak correlation.

Table 4. Rotated component matrix.

	Component								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
V23	0.690								
V30	0.676			0.314					
V33	0.638		0.354						
V13	0.560		0.346						
V20	0.530						0.497		0.337
V8	0.498	0.351				0.302			−0.304
V22	0.492	0.354							
V14	0.454		0.426			0.314			
V21	0.394			0.358					
V25		0.788							
V19		0.716							
V24		0.670							
V27		0.652						−0.359	
V16		0.552			0.549				
V15		0.525		0.310	0.480				
V28	0.396	0.439						0.305	
V11			0.844						
V12			0.814						
V10	0.327		0.734						
V9	0.320		0.708						
V32			0.350	0.717					
V31				0.691	0.316				
V29				0.639					
V17					0.767				

Table 4. (*Continued*).

	Component								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
V18		0.450			0.609				
V2				−0.372	−0.401				
V4						−0.766			
V6						−0.652			
V1	0.402			−0.311		0.484			
V5							−0.743		
V7						0.337	0.595		
V3								0.788	
V26									0.612
V34							0.371		−0.472

5. Discussion

For Factor 1, several variables highlight individuals' awareness and understanding of energy efficiency and its implications. The variable V23, which represents awareness of risks associated with inefficient household appliances, demonstrates the highest factor loading at 0.690. This is closely followed by V30 and V33, which represent the implementation of energy-efficient behaviours into daily life and an acute awareness of global climate change issues related to energy.

Variables V13, V22, V14, V20, and V8 collectively highlight respondents' self-awareness, knowledge, and understanding of sustainable energy practices, including policy implications on personal life. In contrast, V21 offers a distinct perspective, focusing on respondents' views on their households' energy efficiency and again touching on energy-efficient behaviour. These variables suggest that Factor 1 represents a dimension capturing individuals' comprehensive energy knowledge and behaviour.

Factor 2 prominently features variables V25, V19, V24, V16 and V15, all centred around knowledge and familiarity with national energy schemes, directives, and strategies. V27 describes the capability to calculate potential returns on energy efficiency investments, hinting at the dimension of energy-related financial literacy. Meanwhile, V28 captures knowledge of sustainable energy use. This factor can be interpreted as encapsulating knowledge about energy-related incentives, directives and strategies.

Factor 3 is most significantly linked to V11, describing that climate change poses a real threat to society. Other important variables for this factor include the importance of environmental protection (V12), the importance of energy literacy for the reduction of living expenses (V10) and the importance of energy literacy in decreasing energy footprint (V9). Variables together describe the dimension of environmental attitudes.

In Factor 4, V32 highlights respondents' inclination to engage with new trends or innovations tied to sustainable lifestyles. This is complemented by V31, which signifies efforts to sway others towards sustainable choices, and V29, which indicates an upbringing focused on energy-efficient consumption habits. These variables suggest that the factor emphasises proactive energy efficiency attitudes and behaviours.

Factor 5 predominantly reflects an individual's commitment to European-level energy discourse. Interestingly, V2, the respondents' country of origin, has a negative factor loading, indicating that country of origin influences interest in these topics. This suggests that cultural and national contexts significantly shape individuals' engagement with broader energy issues.

Factor 6 connects variables representing the type of housing (V4), awareness of the monthly household energy invoice amount (V6), and age groups (V1). This factor highlights how different living conditions and awareness of energy costs, combined with demographic characteristics, can influence energy literacy.

Factor 7 encompasses information regarding the respondent's place of living and educational background. This suggests that geographic location and educational attainment are important determinants of energy literacy, influencing access to information and resources.

Factor 8 relates to gender identity. This indicates that gender differences may affect energy literacy, potentially affecting attitudes, behaviours, and access to energy-related knowledge and resources.

Factor 9 emphasises proactive behaviours towards energy efficiency and sustainable transport. V26, reflecting plans to invest in household energy efficiency within 1–5 years, has a factor loading of 0.612, indicating solid and forward-thinking decisions. Conversely, V34, which represents a choice against car usage for greener transport options, has a negative loading of −0.472, suggesting the complexities behind people's decision-making regarding aspects of sustainable living. This factor highlights the importance of future-oriented thinking and individuals' challenges in adopting sustainable transportation practices.

Table 5 summarises the 9 identified factors that influence energy literacy most. A closer analysis of these factors revealed that some intersect, whether in content or semantics, e.g., Proactive sustainable lifestyles and Behaviour. Grouping these factors into five overarching themes allows for a clearer conceptualisation and interpretation of their collective impact on energy literacy.

Table 5. Identified and aggregated factors.

Identified factors (F)	Aggregated factors (AF)	Variance explained (in %)
F1: Energy knowledge and behaviour F2: Incentives, directives, and strategies F5: Global trends, directives, strategies	AF1: Comprehensive Energy Knowledge and Behaviour	38.56
F6: Housing, expenditure awareness and age F7: Residence and educational background F8: Gender	AF2: Demographics	10.981
F4: Proactive sustainable lifestyle F9: Behaviour	AF4: Behaviour	8.42
F3: Environmental consciousness	AF3: Environmental attitudes	5.562

5.1. Socio-economic, cultural and geographical differences

Socio-economic factors such as income, level of education and access to resources play a decisive role in the development of energy literacy. People with higher incomes often have better access to energy-efficient technologies and educational resources, which can improve their energy literacy. Conversely, low-income households may prioritise immediate economic concerns over long-term energy-efficient investments despite the potential for cost savings. Education levels also affect energy literacy, as people with higher education are likely to have better access to information and understand complex energy concepts.

Cultural values and norms have a significant impact on energy-related attitudes and behaviour. In cultures prioritising collective well-being and community values, stronger support for energy conservation and sustainable practises may exist. Conversely, cultures that emphasise individualism and economic growth may struggle to promote energy-saving behaviours. Understanding these cultural nuances is critical to designing effective energy education programmes tailored to different cultural contexts.

Geographical location influences energy literacy through climate, availability of renewable resources and regional energy policies. Public awareness and support for sustainable energy practices may be more significant in countries with abundant renewable energy sources. In contrast, changing public attitudes and behaviour towards energy conservation may be more difficult in regions heavily dependent on fossil fuels. In addition, rural and urban areas may have different levels of energy literacy due to differences in infrastructure, access to resources and educational opportunities.

By incorporating these socio-economic, cultural and geographical factors into the analysis, policymakers and educators can develop customised and practical strategies to promote energy literacy among young people. This comprehensive approach ensures that interventions are relevant and effective for different population groups and ultimately contribute to a more energy-literate and sustainable society.

5.2. Recommendations for policymakers, educators and other interested parties

Policymakers should include comprehensive energy literacy programmes in national curricula. These programmes must include cognitive, affective and behavioural dimensions to ensure that students acquire knowledge and develop positive attitudes and behaviours towards energy conservation. In addition, policymakers should develop and promote financial incentives such as grants, subsidies and tax breaks for investments in energy-efficient technologies. It is essential to support initiatives that improve financial literacy related to energy investments and help people understand the long-term benefits of energy efficiency [20]. In addition, it is essential to promote public awareness campaigns. Conducting nationwide campaigns that utilise mass media and social media can effectively reach diverse populations and focus on the importance of energy conservation and the role of individual action in mitigating climate change [6]. Finally, the promotion of sustainable energy policies is crucial. Policymakers should enact and enforce regulations promoting renewable energy sources and energy-efficient technologies and ensure these policies are accessible and understandable to the general public.

Educators should develop comprehensive energy education programmes that cover all aspects of energy literacy, including the technical, environmental and economic impacts of energy use. These programmes should be tailored to different levels of education and include practical, hands-on activities [13]. The use of technology for energy education can significantly enhance the learning experience. Using digital tools such as interactive online platforms, mobile apps, and virtual simulations can make learning more engaging and accessible to a broader audience [23]. In addition, teachers should focus on the behavioural aspects of energy literacy by incorporating modules that emphasise the impact of individual actions on energy consumption and the environment. It is crucial to encourage students to adopt sustainable practices through project-based learning and real-world applications [16]. Providing training and professional development opportunities for educators ensures that they have the necessary knowledge and skills to teach energy literacy effectively. This training should cover the latest developments in energy technologies and policies [24].

Community organisations and groups should engage in activities that promote energy literacy and sustainability. Workshops, seminars and public lectures can effectively educate community members about energy conservation. Encouraging partnerships between educational institutions, government agencies, non-profit organisations and the private sector can improve resource sharing and create a more cohesive approach to energy education. Supporting research and innovation in the field of energy education is also important. Funding research projects that explore new methods and technologies to improve energy literacy and promote sustainable energy practices can lead to more effective education and outreach strategies [27]. Finally, businesses and industries should promote using energy-efficient products and technologies. Marketing campaigns should emphasise these products' environmental and economic benefits and encourage consumers to make informed choices [11].

6. Conclusions

Our study identified four factors influencing energy literacy: Comprehensive energy knowledge and behaviour, demographics, environmental attitudes and proactive sustainable lifestyles. These factors closely align with the three dimensions of energy literacy observed in the literature—knowledge, behaviour and attitudes—with an additional dimension relating to demographics.

Factor 1, which links energy-related knowledge to energy-related behaviour, accounts for 38.56% of the explained variance. This dominance indicates a strong correlation between increased knowledge of energy issues and the likelihood that people will adjust their behaviour accordingly. This finding supports our hypothesis that energy literacy is crucial for sustainable energy consumption practices. However, it is important to note that not all studies consistently observe the relationship between energy efficiency education and behaviour. This shows that further research is needed to understand the underlying mechanisms.

The demographic factor (AF2), which accounts for 10.981% of the variance, emphasises the importance of individual characteristics in shaping energy literacy. This emphasises the need for energy education and policy to address demographic nuances more effectively and inclusively. Targeting educational programmes and policies to specific demographic groups can improve the overall impact of energy literacy initiatives.

The environmental attitudes captured in AF3 emphasise the role of environmental awareness in influencing energy-related behaviours. This factor underlines the need for educational programmes to impart knowledge and promote positive attitudes towards environmental protection and sustainability.

As reflected in AF4, proactive lifestyles highlight the importance of engaging individuals in sustainable practices and promoting proactive behaviours. This factor suggests that promoting a culture of sustainability and providing opportunities for individuals to engage in sustainable activities can significantly improve energy literacy.

Our study provides valuable insights into the multifaceted nature of energy literacy and its determinants. By understanding these factors, policymakers, educators, and other stakeholders can develop targeted strategies to improve energy literacy and promote sustainable energy consumption practices. Future research should further explore the complex interactions between knowledge, behaviour, attitudes and demographic factors to refine and optimise interventions to improve energy literacy.

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