Rezaei M. et al.
April 2027
Urban Economics and Planning
Volume 8, Issue 1

Developing an educational policy model for enhancing energy literacy among housewives in Tehran: A mixed-methods approach

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Original Article

Received: 2026/02/15
Revised: 2026/06/29
Accepted: 2026/07/05

HOW TO CITE THIS ARTICLE

Rezaei M. Kari H. Shobeiri S.M. Safarinia M. Developing an educational policy model for enhancing energy literacy among housewives in Tehran: A mixed-methods approach. *Urban Economics and Planning* 8(1):22-43.

DOI: 10.22034/uep.2026.575765.1844

Abstract

This research was conducted to present and validate an educational policy model for promoting energy literacy (electrical energy) among housewives in the 22 districts of Tehran, using an exploratory mixed-methods approach. In the qualitative phase, experts were purposively selected from among university professors in energy, educational planning, and public policy, as well as specialists and experts from the Ministry of Energy, the Power Research Institute, the Tehran Electricity Distribution Company, and the National Research Institute for Science Policy. Theoretical saturation was achieved after conducting 13 interviews. The statistical population in the quantitative phase consisted of managers and energy specialists in Tehran. The minimum sample size was determined to be 138 based on the power analysis rule. Sampling was performed using a cluster random method. In the qualitative phase, data analysis was conducted using grounded theory and Maxqda, while the quantitative phase utilized the partial least squares (PLS) method in Smart PLS. The results revealed that the coefficients of determination (R^2) for the model's endogenous variables were close to or exceeded the strong range of 0.67. Additionally, all predictive relevance (Q^2) values were positive, indicating the model's favourable predictive power. Furthermore, the GOF index was 0.63, and the SRMR index was 0.098, indicating good model fit. The findings suggest that causal conditions (policy drivers) influence the core phenomenon (educational policy), and the core phenomenon, contextual conditions (context and background variables), and intervening factors (mediating and facilitating factors) affect strategies (strategic actions). In the meantime, the implementation of strategies leads to the formation of outcomes (enhancing energy literacy and achieving sustainable development). Therefore, this model can serve as a roadmap for educational policy-making aimed at promoting energy literacy among housewives in Tehran.

Keywords

Educational policymaking
energy literacy
housewives
model
Tehran city

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1. Introduction

Countries continue to rely heavily on fossil fuels to meet their energy needs. This has resulted in significant consequences, including environmental degradation, intensified climate change, and serious obstacles to achieving sustainable development (Afshan et al., 2022). Among the various energy-consuming sectors, the household and residential sector plays a crucial role in increasing energy demand and greenhouse gas emissions. In recent years, the adverse environmental impacts of household energy consumption have drawn researchers' and policymakers' attention to energy-saving behaviors and consumer preferences (Belaïd, 2024). Concurrently with the escalating global energy crisis, governments have been compelled to accelerate the transition toward low-carbon, sustainable energy systems (Santillán & Cedano, 2023). This transition necessitates fundamental transformations in energy systems (Tarroja et al., 2025). Research has demonstrated that this transition cannot be achieved solely through technological interventions; rather, active citizen participation is pivotal in the success of energy policies (Clavijo-Núñez et al., 2024). Consequently, energy literacy has garnered increasing attention in recent years as a key concept in energy consumption management. Understanding this concept is fundamental for individuals, communities, and policymakers seeking to make informed decisions regarding the appropriate use of energy. By raising awareness and understanding of energy principles, stakeholders can promote more efficient and responsible energy practices (Martins et al., 2020). Studies indicate that enhancing energy literacy has considerable potential to explain and predict energy-related behaviors. Nevertheless, policies and programs based on this concept remain limited and fragmented (Cotton et al., 2021). Moreover, there is still no clear consensus on which factors most strongly influence citizens' energy-related behaviors. A considerable portion of energy policies aimed at reducing household energy consumption has predominantly focused on technological solutions and structural changes, such as smart systems and home automation. At the same time, the role of human, educational, and behavioral factors has been largely overlooked in many of these policies (Van den Broek et al., 2019). Some studies emphasize that sole reliance on technology may undermine individual responsibility and pro-environmental behaviors, consequently diminishing the long-term effectiveness of energy policies (Murtagh et al., 2015). Therefore, in addition to considering technological dimensions, it is essential to address the role of education in shaping sustainable energy behaviors (Strengers et al., 2023). Since energy literacy is influenced by the design of educational programs, content types, learning methods, and institutional mechanisms, addressing it requires a coherent educational policy framework and model that can make educational interventions targeted and coordinated (Hu & Yang, 2024). Thus, educational policy has gained increasing significance as a strategic instrument for responding to social and economic needs (Brooks & Sinclair, 2024). Successful educational policies, particularly those focusing on green skills development, can empower citizens to change their behaviors to increase energy efficiency and reduce their carbon footprint (Appiah et al., 2023). The application of educational policy to promote energy literacy is particularly important, as energy literacy is not limited to knowledge of consumption; rather, it encompasses the ability to analyze energy systems, evaluate the consequences of individual and collective behaviors, and participate in local and national decision-making (Santillán & Cedano, 2023). Consequently, promoting energy literacy requires designing targeted educational frameworks tailored to the characteristics of diverse social groups. Nevertheless, existing studies have paid less attention to developing an indigenous and coherent model specifically focused on educational policy for enhancing the energy literacy of housewives. In this regard, the present exploratory study proposes an educational policy model to promote energy literacy among housewives in Tehran, thereby providing a scientific framework to guide educational decisions and programs in this area. Accordingly, this study seeks to answer the following research questions:

1. What are the components and subcomponents of an educational policy model for improving energy literacy among housewives in Tehran?
2. What is the proposed appropriate model for educational policy aimed at enhancing energy literacy among housewives in Tehran?
3. What is the validity of the proposed model?

2. Theoretical foundations

2.1. Research necessity and significance

According to the 2022 Energy Balance Sheet (the latest official energy balance report published by the Ministry of Energy), Iran's final energy consumption per capita is 1.9 times the global average, while in the household sector this reaches 2.3 times the global

average. Domestically, 31% of the Ministry of Energy's total electricity sales in that year were attributed to the household sector (Energy Balance Sheet for the Year 2022, 2024), underscoring the household sector's decisive role in managing the country's energy consumption imbalance. Energy consumption in the household sector, one of the most critical areas of final energy use, is directly related to household behavioral patterns and everyday domestic routines. Consequently, any intervention aimed at optimizing energy consumption in this sector must inevitably focus on the primary actors of consumption management at the family level. Among these, housewives, due to their continuous presence at home, their central role in shaping household energy consumption patterns, and their influence on the consumption habits of other family members, constitute one of the most significant groups affecting energy consumption patterns in the residential sector. Housewives possess practical knowledge of energy consumption patterns, and their daily behaviors directly and meaningfully impact consumption optimization and energy waste reduction, positioning them as key actors in the transition toward sustainability (Shrestha et al., 2021). Evidence suggests that housewives' knowledge and attitudes toward energy consumption play a determining role in shaping consumption patterns, and educational interventions and behavioral policies can effectively modify these patterns (Abdollahi & Sadeghi, 2024; Keyghobadi et al., 2023). Therefore, providing the necessary education to enhance housewives' awareness, attitudes, and decision-making capacity in the energy domain can be one of the most effective strategies for reforming consumption patterns in the household sector. Although the effectiveness of educational interventions in the energy sector depends on designing programs tailored to the characteristics and needs of the target group, research evidence indicates that a significant portion of energy literacy programs are still designed and implemented generically, without relying on a precise understanding of the behavioral patterns and needs of the audience (Sovacool et al., 2020). However, the main challenge in this area is not limited to the shortage of educational programs on energy consumption; rather, it stems from the lack of a coherent understanding of the factors and mechanisms that can effectively guide the enhancement of energy literacy (Piao & Managi, 2023). Recent findings on urban buildings in Tehran also indicate that optimizing energy consumption depends on diverse contextual and environmental conditions, and uniform, non-targeted policies cannot adequately address the complexity of energy consumption in the city (Amiri Ade et al., 2022). Under such circumstances, we are confronted with a research gap: despite the importance of energy consumption management in the household sector and the influential role of housewives in shaping daily energy consumption behaviors, no coherent and locally adapted model has yet been proposed for identifying, measuring, and explaining the components and educational mechanisms that effectively contribute to enhancing energy literacy among this group. Hence, addressing the issue of energy literacy among housewives in the present study is not merely justified by its conceptual significance, but also by its direct linkage to the challenge of energy imbalance, the considerable share of the household sector in electricity consumption, and the determining role of housewives in managing household energy demand. Therefore, the central problem of this research is to identify the components influencing educational policy-making for enhancing energy literacy among housewives in Tehran and to explain them within a coherent framework.

2.2. Energy literacy

One of the earliest definitions of energy literacy was proposed by Roth (1992). According to Roth, an energy-literate individual is someone aware of basic energy concepts, understands how energy is used in everyday life, comprehends the environmental and societal consequences of energy production and consumption, demonstrates sensitivity and a sense of responsibility toward energy conservation and efficiency, is aware of suitable alternatives to fossil fuels, and understands that personal decisions and choices can affect the environment, the global community, energy resource development, and consumption patterns (Roth, 1992). Subsequently, DeWaters and Powers (2013) introduced energy literacy as a multidimensional concept comprising three main dimensions: knowledge, attitude, and behavior. From their perspective, energy literacy pertains, on the one hand, to individuals' knowledge and awareness of energy production and consumption and their consequences for humans and the environment; on the other hand, it encompasses individuals' attitudes

toward the value of energy conservation and efficiency; and ultimately, it manifests in their practical behaviors toward responsible and efficient energy use (DeWaters & Powers, 2013). More recently, Calver et al (2024) defined energy literacy as a multidimensional concept that includes understanding energy systems, recognizing the environmental and economic consequences of consumption decisions, and the ability to participate consciously in energy policies and emerging energy technologies (Calver et al., 2024). From this standpoint, energy literacy is regarded as an essential prerequisite for promoting sustainable energy behaviors and reducing consumption at both the household and societal levels (Wang et al., 2021). Table 1 presents the findings from selected studies on the dimensions and factors influencing energy literacy.

Table 1. A review of findings from selected studies on the dimensions and factors associated with energy literacy

Row	Source	Findings
1	Piao & Managi, 2023	Household energy consumption increases as income rises; energy-saving behaviors can have a positive effect on reducing energy consumption; purchasing energy-efficient goods and products has a more limited effect on household energy consumption compared with direct energy-reduction behaviors; reducing greenhouse gas emissions at the household level cannot be achieved solely through the purchase of energy-efficient products, but also requires changes in behavioral patterns and everyday energy-consumption practices.
2	Ratner et al., 2022	Inefficiency in improving energy efficiency and the failure to develop appropriate energy-oriented behaviors are not solely attributable to a lack of technology or financial resources; factors such as insufficient knowledge, negligence, social barriers, and institutional weaknesses also contribute to the persistence of undesirable energy-consumption patterns.
3	Cotton et al., 2021	Cultural context, including trust in government, influences energy-saving behaviors. The combination of educational and structural changes will contribute to the transition toward a cleaner world. Transition theorists, employing systems thinking, understand transition as a long-term process involving deep integration among society, technology, institutions, and people. The transition toward sustainability necessitates a fundamental rethinking of social and technological structures
4	Aslani et al., 2018	At the individual level, factors such as comfort-seeking, weak personal responsibility, distrust, and low awareness; at the meso level, the force of habits and everyday routines; and at the macro level, technological developments and energy policies, all influence unsustainable energy consumption practices and their perpetuation in the form of entrenched consumption habits within the family.
5	Talebian et al., 2016	Energy consumption behavior varies with situational conditions, environmental factors, economic status, lifestyle, and consumption norms; environmental and climatic influences have led to significant differences in energy consumption levels and greatly increased the range of variations; any change in sustainable energy consumption behaviors requires necessary changes in attitudes.
6	Zare Shahabadi et al., 2013	Consumption patterns are largely a function of economic, social, and cultural conditions; energy consumption patterns are indirectly influenced by variables such as consumption standards, income, social status, and other household characteristics; economic and technological approaches alone are insufficient for launching energy efficiency programs, particularly in the household sector; without understanding cultural factors, such as values, attitudes, motivations, and beliefs, conventional energy-saving programs will remain inadequate; understanding cultural aspects can serve as a foundation for more targeted utilization.
7	DeWaters & Powers, 2011	Energy-saving behaviors are more strongly correlated with affect than with knowledge.
8	Barr and Gilg, 2007	Behaviors depend not only on individual decision-making and awareness but also on the conditions and context in which individuals live. This has been achieved only through policy intervention and substantial investment in infrastructure to encourage and enable behavioral changes.
9	Kolahi, 2006	Energy literacy is not limited to possessing energy information; rather, it encompasses a set of awareness, attitudes, values, and consumption behaviors; awareness of energy production and consumption, understanding the economic and environmental consequences of electricity use, a sense of responsibility toward preserving energy resources, attention to environmental values, and cultural and religious beliefs related to avoiding waste can all influence individuals' decision-making regarding energy consumption; to enhance energy literacy, particularly among housewives, it is necessary to accurately identify these factors so that educational policy-making moves beyond general recommendations and is designed based on a genuine understanding of the factors affecting energy consumption behavior.
10	Stern, 2000; Jackson, 2005	New approaches in behavior change research have shifted toward social models that view behavior as context-dependent and challenge linear patterns based on rational choice.

2.3. Educational policy-making

Educational policy-making is a set of organized decisions and actions designed to improve the quality of learning, ensure educational equity, and adapt educational systems to social challenges. It determines what content should be taught, to which groups, and through what mechanisms (Dawson-Amoah et al., 2024). Educational policy-making can contribute to the realization of four fundamental objectives of the education system – namely, establishing a democratic society, fostering economic growth, cultivating good citizenship, and achieving sustainable development – through four functional themes: developing civic norms, creating intangible capital, institutionalizing political socialization, and promoting environmental education (Heidari, 2020). Educational policy-making is not merely a technical and administrative process; rather, it is an arena for social and value-based decision-making in which the state, educational institutions, and social actors all play a role in shaping the direction of education. Accordingly, educational policies are effective when they align with society's real needs and the goals of educational equity (Taylor et al., 2013).

2.4. Grounded theory

Grounded theory was developed in 1967 by two sociologists, Glaser and Strauss (Stough & Lee, 2021). Today, this theory is widely used in social science research (Aslipour & Zargar, 2022), as well as in educational research and a broad range of academic disciplines. It is constructed based on data collected from participants who have experienced a particular process (Creswell & Poth, 2023). Grounded theory encompasses various methodological approaches; however, the systematic approach of Strauss and Corbin is considered more practical than other methods because it introduces a step-by-step process known as axial coding (Aslipour & Zargar, 2022). In this approach, coding is conducted through three main stages: open coding, axial coding, and selective coding (Strauss & Corbin, 1998). Within the systematic grounded theory framework, discovering and explaining the relationships among categories, components, and extracted codes requires the application of a coherent paradigmatic model. This analytical structure organizes the relationships among phenomena around causal conditions, contextual backgrounds, intervening conditions, strategies, and consequences, linking them systematically. This approach forms the foundational basis of the structured and systematic orientation in grounded theory (Stough & Lee, 2021). Figure 1 illustrates the paradigmatic model of research based on the systematic approach of Strauss and Corbin's grounded theory.

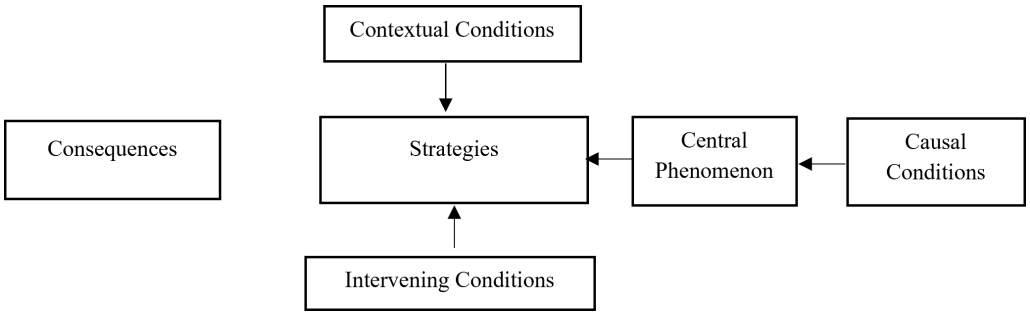

Figure 1. Paradigmatic model of the research based on the systematic approach of grounded theory by strauss and corbin

3. Literature review

Numerous studies have been conducted on the concepts of energy literacy in Iran and worldwide, each examining specific aspects of energy literacy. These studies can be categorized into several main themes: first, studies that have addressed the conceptual explanation and dimensions of energy literacy; second, studies that have empirically and primarily quantitatively investigated the factors influencing energy literacy; and third, studies that have analyzed energy literacy in connection with energy culture and transition to sustainable energy. For instance, in the first category, Van den Broek (2019) introduced four types of household energy literacy, including appliance energy literacy, behavioral energy literacy, financial energy literacy, and multifaceted energy literacy. Within this framework, multifaceted energy literacy is considered the most comprehensive level, as it simultaneously encompasses the knowledge, behavioral, financial, and practical

dimensions of energy consumption. Similarly, Chen et al. (2013) proposed a framework for energy education aimed at institutionalizing energy conservation and carbon reduction concepts in Taiwan. Furthermore, Fox (2022), with the objective of updating the energy literacy landscape in Portugal, emphasized the necessity of establishing a comprehensive and systematic framework for enhancing energy literacy and demonstrated that national energy education programs, energy-oriented research strategies, and the use of consumer data can play a significant role in the transition to renewable energy. The strength of this category of studies lies in providing conceptual and educational frameworks for understanding energy literacy. The second group of studies adopts a predominantly empirical and quantitative approach, examining the factors influencing energy literacy or energy consumption behavior. For example, Ali et al (2023) investigated the relationship between public behavior and energy transition in three regions of Italy. By distributing questionnaires and employing structural equation modeling, they demonstrated that awareness campaigns on social media, incentive schemes, and green educational activities play an important role in promoting renewable energy and accelerating the energy transition. In Iran, Hamidi Razi et al (2021) examined the factors affecting energy literacy within the academic community in the northwest of the country. The results of their study indicated that economic and financial literacy, as well as educational level, have a positive and significant effect on the knowledge and affective dimensions of energy literacy; however, no significant effect was observed on the behavioral dimension. The significance of this category of studies lies in identifying the factors influencing energy literacy and behavior, with their primary focus on measuring relationships among variables. The third category of studies analyzes energy literacy in relation to policy-making, energy culture, and public education. Hu and Yang (2024) demonstrated that society, through long-term interactions, shapes its own energy culture, which can influence the formulation and implementation of national energy policies. They also emphasized the role of energy education in shaping public energy preferences. In a similar vein, Pourelmi (2023) identified the components influencing policy-making for biomass energy development education among farmers and evaluated and validated the resulting model using structural equation modeling, demonstrating that biomass energy education is effective when analyzed in connection with social, cultural, economic, and policy contexts. Methodologically, a considerable portion of studies have employed quantitative, survey-based, and structural equation modeling approaches. Although these approaches are useful for testing relationships among variables, they have limitations in deeply identifying the contexts and factors associated with energy literacy. On the other hand, international studies have largely focused on conceptual frameworks, energy transition, and the role of national policies in enhancing energy literacy. In contrast, domestic studies have primarily focused on measuring factors influencing energy literacy among target groups through field surveys using questionnaire instruments. Despite numerous studies on energy literacy, to date no specialized, independent research has examined the factors and components related to the energy literacy of housewives in Iran and provided a comprehensive model in this area. Previous research has mainly explored the relationship between socio-economic variables and energy literacy or measured and assessed the dimensions of energy literacy among specific target groups, such as school and university students. However, the role of housewives as the primary actors in the daily management of household energy consumption has received less attention. Therefore, the existing research gap indicates that addressing energy literacy in the present study is necessitated not only by its conceptual importance, but also by its direct connection to the issue of energy imbalance, the high share of the household sector in electricity consumption, and the role of daily household behaviors in managing energy demand.

4. Methodology

The present study is an applied-developmental study conducted to design and validate an educational policy model for enhancing energy literacy among housewives in the 22 districts of Tehran. In terms of data collection method, this research falls within the category of sequential mixed-methods studies, meaning that it first draws on the results of qualitative analysis; Results are subsequently analyzed and validated using quantitative methods. In this research, qualitative sampling was initially conducted to identify the model's main construct, its components, and subcomponents. The sampling method in the qualitative phase was purposive and continued until theoretical saturation was achieved. Subsequently, quantitative sampling was employed to validate the

model. In the quantitative phase, the statistical population consisted of managers and energy experts in Tehran, and cluster random sampling was employed. The minimum sample size for the quantitative phase was determined using Cohen's power analysis rule and G*Power software, with a significance level of 0.05, a power of 0.95, and an effect size of 0.15, yielding a required sample of 138 participants (Lakens, 2022). However, to enhance the precision of the analyses, reduce sampling error, and improve the reliability of the results, the final sample size was set at 200 participants. Figure 2 illustrates the minimum required sample size based on Cohen's power analysis rule.

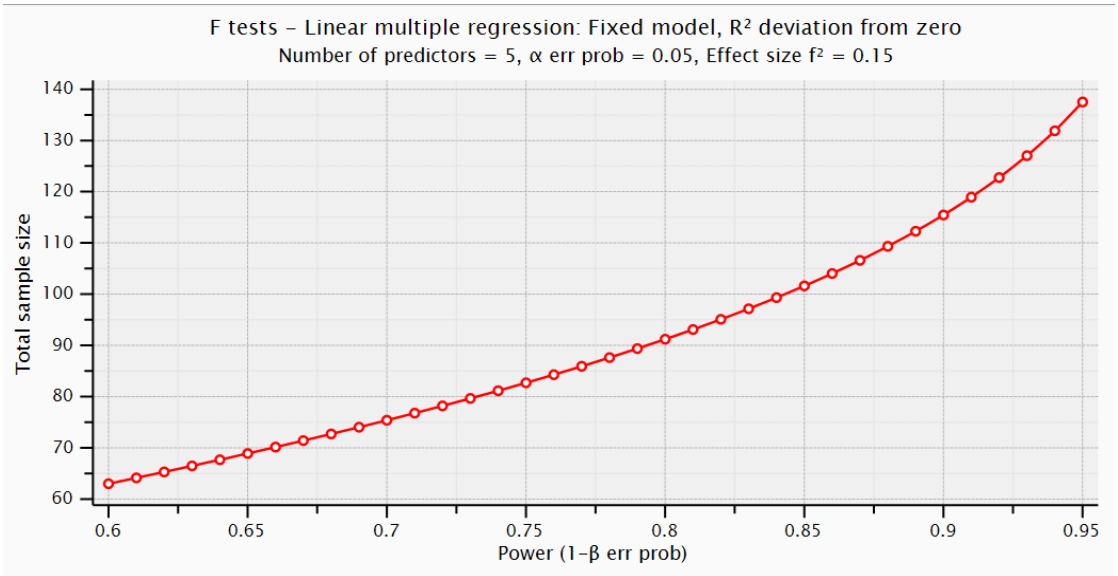

Figure 2. Determining the minimum sample size using Cohen's power analysis rule

To explain the research model, a series of in-depth semi-structured interviews with experts were first conducted in the qualitative phase. The data obtained from the interviews were analyzed using the grounded theory method based on the systematic approach of Strauss and Corbin, with MAXQDA software. The data analysis process was carried out in three stages: open coding, axial coding, and selective coding.

Stage one (open coding)

This stage involves an initial familiarization with the interview transcripts. To this end, the interview texts, imported into the software as text files, were repeatedly read line by line to ensure thorough comprehension, enabling the identification of meaning units and initial codes. This process was repeated with each additional interview until 214 codes were identified, yielding 78 open codes after removing duplicate and synonymous codes.

Stage two (axial coding)

In this stage, the identified open codes were categorized into larger constructs, and linkages were established between the open codes and their components and subcomponents. The central phenomenon in this research was selected as "educational policy-making for enhancing energy literacy among housewives in Tehran."

Stage three (selective coding)

In this stage, the constructs identified in the axial coding phase were organized into causal conditions, the central phenomenon, contextual conditions, intervening factors, strategies, and consequences. Ultimately, employing the systematic approach of grounded theory, six dimensions (causal framework), seven components, 21 subcomponents, and 78 open codes were derived.

To collect the required data, after a scientific and documentary review, semi-structured interviews were conducted with experts. The experts were selected from among university professors in the fields of energy, educational planning, and public policy, as well as specialists and experts from the Ministry of Energy, the Niroo Research Institute, the Tehran Electricity Distribution Company, and the Center for Scientific Policy Research of the Country. Participants in the qualitative phase were selected purposively based on expertise criteria. Inclusion criteria were holding a master's or doctoral degree, having at least 10 years of relevant managerial, executive, educational, or

research experience, familiarity with public policy and energy literacy concepts, and willingness to participate in the interview. Exclusion criteria included insufficient time for the interview, inability to complete the interview, providing overly general, insufficient, or unanalyzable responses, and unwillingness to continue cooperation. In the qualitative phase, data saturation and repetition of results were achieved by the 12th interview; however, to ensure the validity of the research findings and the accuracy of the process analysis, sampling continued up to 13 interviews. Following the interviews, the three stages of open, axial, and selective coding were performed, and the components and subcomponents of educational policy-making for enhancing energy literacy among housewives in Tehran were extracted, leading to the development of the initial model. Subsequently, based on the extracted indicators, a questionnaire was developed and evaluated according to qualitative validation criteria. The validity of the qualitative section was assessed and confirmed based on the four criteria proposed by Lincoln and Guba, including credibility, transferability, dependability, and confirmability (Singh et al., 2021; Isik, 2025), from the perspective of professors and experts. To assess the reliability of the coding stage, the second-coder method was used. For this purpose, four interviews were randomly selected and provided to a university professor with expertise in the research for coding. The reliability percentage in this method is calculated as the total number of codes agreed upon by both parties, divided by the number of codes identified by the researcher, multiplied by 100. A resulting value above 0.8 is considered acceptable (Halpin, 2024). In this study, the coding reliability for the conducted interviews was calculated as 0.807 through this method, indicating that the coding is reliable. After developing the questionnaire and consulting with experts, its face validity was confirmed. Additionally, its overall Cronbach's alpha coefficient was estimated at 0.983 in a pilot study. After distributing the questionnaire, construct validity (outer measurement model), convergent validity, and discriminant validity were evaluated. The average variance extracted (AVE), an indicator of convergent validity for latent variables, should be above 0.5 to confirm validity. Reliability indices were also evaluated using composite reliability (CR) and Cronbach's alpha, which should be above 0.7 (Hair et al., 2025; Cheung et al., 2024). The results of these indices are reported in the findings section of the research. Construct validity (outer model) refers to the relationship between observable variables and latent variables, or in other words, the relationship between items and their main constructs, as indicated by factor loadings. Factor loadings should be greater than 0.6 in all cases, and the t-statistic (which indicates the significance of the relationship between variables) should be greater than 1.96 for the measurement model to have adequate validity (Cepeda-Carrión et al., 2022). The relationships among the main constructs, referred to as the inner model (structural part), are examined based on the significance of path coefficients and t-statistics.

In this research, qualitative data analysis was conducted using the grounded theory method in MAXQDA version 24. For qualntitative data analysis and validation of the conceptual model, structural equation modeling based on the partial least squares (PLS-SEM) method was used in Smart PLS version 4, and descriptive statistical analysis was performed using SPSS version 27. The rationale for choosing PLS-SEM over covariance-based methods was its greater suitability for the objectives and nature of the present study. Since this research adopts an exploratory mixed-methods approach and has an applied-developmental nature, and the proposed model was extracted based on qualitative findings and expert interviews, the aim of the quantitative phase is not merely to test an established theory, but rather to validate, explain, and evaluate the predictive power of the proposed model. Thus, PLS-SEM, as a variance-based approach, is appropriate for model development, analyzing relationships among latent constructs, and predicting dependent constructs. Furthermore, compared to CB-SEM, this method is less dependent on the assumption of normally distributed data and is suitable for complex models with multiple constructs (Hair et al., 2025; Hair et al., 2019).

5. Findings

Table 2 presents the demographic characteristics of the participants in the qualitative phase of the research, based on variables including gender, age, educational level, and years of experience.

Table 2. Demographic characteristics of experts in the qualitative phase of the research

Demographic characteristics		Percentage
Gender	Male	69%
	female	31%
Age	35-40 years	15%
	40-50 years	23%
	51 years and above	62%
Education	Master's Degree	31%
	PhD	69%
Work experience (years)	5–15	23%
	16–24	31%
	25–30	46%

To explain the research model, a series of in-depth, semi-structured interviews were first conducted with experts. The collected data were analyzed using the qualitative grounded theory method based on the systematic approach of Strauss and Corbin, within MaxQDA, through three stages of coding: open coding, axial coding, and selective coding.

Stage one (open coding)

In this stage, initial familiarity with the interview transcripts takes place. To this end, the interview texts, imported into the software as text files, were read line by line and multiple times to enable a thorough understanding, and meaningful units and initial codes were generated. This process was repeated with each interview, until finally 214 codes were identified. After removing duplicate and synonymous codes, 78 open codes were obtained. Table 3 presents examples of the statements extracted from the interviews and the corresponding initial codes.

Table 3. Selected excerpts from interview transcripts and identified codes in the qualitative analysis process

Interviewee	Interview transcript	Identified open codes
1	Currently, training is conducted in a fragmented and piecemeal manner.	Lack of integrated educational policies
3	One of the most important strategies for enhancing housewives' awareness about energy is continuous, ongoing, and uninterrupted education.	Lifelong learning
6	Current energy tariffs and their low prices influence energy consumption levels.	Reform of energy tariffs
7	One of the main challenges in this regard is that many housewives have not yet learned sustainable energy management and lack adequate technical knowledge in this regard; therefore, a structured plan is required.	Underdevelopment of sustainable energy management skills
9	Amending building regulations and enforcing stricter oversight on construction can be considered an appropriate solution.	Reform and updating of building regulations and standards
10	The objectives set in policy-making should be aligned with national macro-level visions	The necessity of paying attention to the national vision document and macro policies of the country

Phase two (axial coding)

In this phase, the identified open codes were categorized into larger constructs, and linkages were established between the open codes and their corresponding components and subcomponents. The central phenomenon in this study was selected as "Educational policy-making for enhancing energy literacy among housewives in Tehran."

Phase three (selective coding)

In this phase, the constructs identified during axial coding were organized into the categories of causal conditions, intervening conditions, the central phenomenon, strategies, and consequences. Ultimately, by employing the systematic approach of

grounded theory, six dimensions (causal framework), seven components, 21 subcomponents, and 78 open codes were derived. Table 4 presents the extracted codes associated with the educational policy-making model for enhancing energy literacy among housewives in Tehran.

Table 4. Codes of the educational policy model for promoting electrical energy literacy among housewives in Tehran

Open coding (items)	Axial coding (sub-components)	Axial coding (components)	Selective coding (causal dimensions)
National vision document and macro policies of the country	Supra-documents and macro policies in the energy sector	Needs assessment and policy analysis (policy drivers)	Causal conditions
National development plans			
Laws and approvals			
International requirements and convention commitments			
Energy consumption growth	Energy security		
High energy intensity			
Depletion of energy resources			
Occurrence of energy imbalances			
Acceleration in the energy transition phase			
Climate change and global warming	Environmental necessities		
Reduction of air pollution			
Reduction of water consumption in energy production processes			
Protection of biodiversity and ecosystems			
Lack of integrated educational policies	Educational needs assessment analysis		
Low energy awareness and knowledge			
Underdeveloped sustainable energy management skills			
Status of educational resources and infrastructure			
Explanation of vision, mission, and macro objectives	Macro policy-making	Educational policy-making for enhancing energy literacy (development of a comprehensive document for energy literacy enhancement)	Central phenomenon
Setting micro-objectives			
Drawing the overall path and roadmap			
Prediction of review and amendment periods for the document			
Prioritization and scheduling of programs	Executive policy-making		
Establishment of sustainable financing mechanisms			
Educational budgeting			
Recruitment and training of specialized human resources			
Determination of educational and informational tools			
Determination of motivational and control mechanisms			
Mental attitudes and beliefs	Social capital	Context and background variables	Contextual factors
Behavioral patterns and habits			
Citizens' trust in responsible institutions			
Income level and economic status of citizens	Demographic characteristics		
Educational level			
Age range			

Open coding (items)	Axial coding (sub-components)	Axial coding (components)	Selective coding (causal dimensions)
Climatic factors	Environmental conditions	Context and background variables	Contextual factors
Physical and architectural characteristics of buildings			
Access to technical infrastructure			
Revision and updating of construction regulations and standards	Legal factors	Intervening and facilitating factors	Intervening factors
Development of standards for energy-consuming appliances			
Reform of energy subsidies and tariffs			
Development of information and communication technology infrastructure	Technology and infrastructure development		
Smartization of the energy network and smart meters			
Development of smart energy-saving technologies			
Development of the platform for the use of renewable energy			
Utilization of media capacities	Stakeholder interaction		
Participation of non-governmental organizations			
Participation of institutions responsible for housewives			
Application of network governance approaches in stakeholder interactions			
Lifelong education	Awareness-based strategies	Strategic actions	Strategies
Content-based education			
Platform-based education			
Creation of a virtual energy literacy hub			
Holding festivals and events	Attitudinal and affective strategies		
Formation of virtual campaigns and movements			
Use of art language in conveying concepts			
Motivational role-making of influential models			
Education based on awareness of the economic benefits of energy-oriented behaviors	Behavior change strategies		
Empowerment and development of practical skills			
Explanation of the operational model of sustainable lifestyle			
Creation of economic and social incentives			
Determination of indicators and conducting qualitative and quantitative evaluation	Evaluation, feedback, and policy revision		
Data analysis and provision of policy improvement proposals			
Feedback and utilization of evaluation results for policy improvement			
Acquiring awareness of energy resources	Awareness and knowledge enhancement	Enhancing energy literacy	Consequences
Understanding the consequences of energy consumption			
Learning sustainable consumption solutions			

Open coding (items)	Axial coding (sub-components)	Axial coding (components)	Selective coding (causal dimensions)
Strengthening beliefs and value criteria	Affective literacy improvement	Enhancing energy literacy	
Increasing responsibility and altruism			
Increasing participatory tendencies			
Development of the use of smart energy-saving equipment	Sustainable behavior improvement		
Development of clean energy			
Implementation of a sustainable lifestyle			
Increasing social participation	Preservation of socio-economic capital	Achieving sustainable development	Consequences
Reduction of energy costs			
Increasing energy security			
Reduction of fossil fuel consumption	Improvement of environmental indicators		
Reduction of air pollution			
Reduction of greenhouse gas emissions			
Sustainability of water resources			

According to the presented results, the final conceptual model of the research is presented in figure 3. The proposed model provides a framework for explaining the factors influencing the enhancement of energy literacy among housewives in Tehran and its expected outcomes.

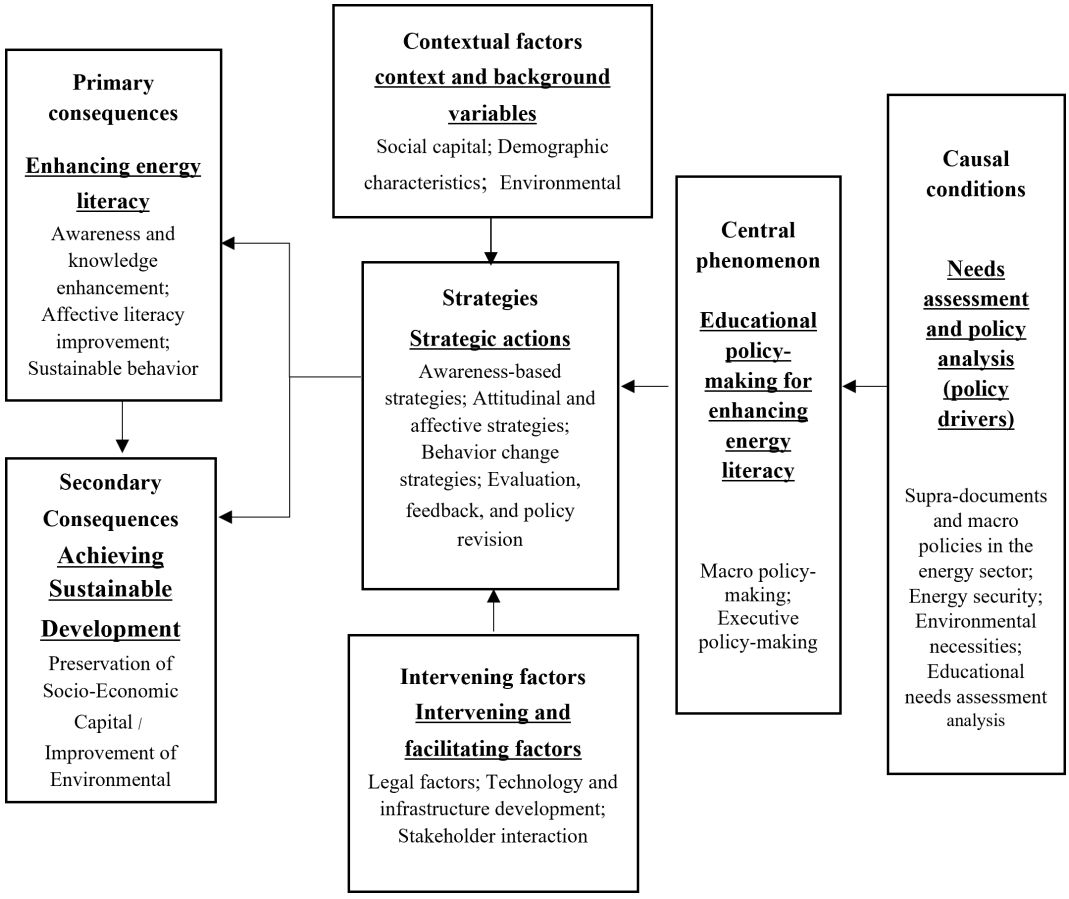

Figure 3. Final conceptual model of the research

After presenting the educational policy model to enhance energy literacy among housewives in Tehran, the partial least squares (PLS) method was employed to validate the model. Figure 4 presents the results of the proposed model in the standard estimation mode. The path coefficients and factor loadings shown in the figure provide a basis for assessing the validation of the research model. Additionally, to evaluate the significance of the relationships, bootstrapping and t-statistic analysis were used, as presented in Figure 5.

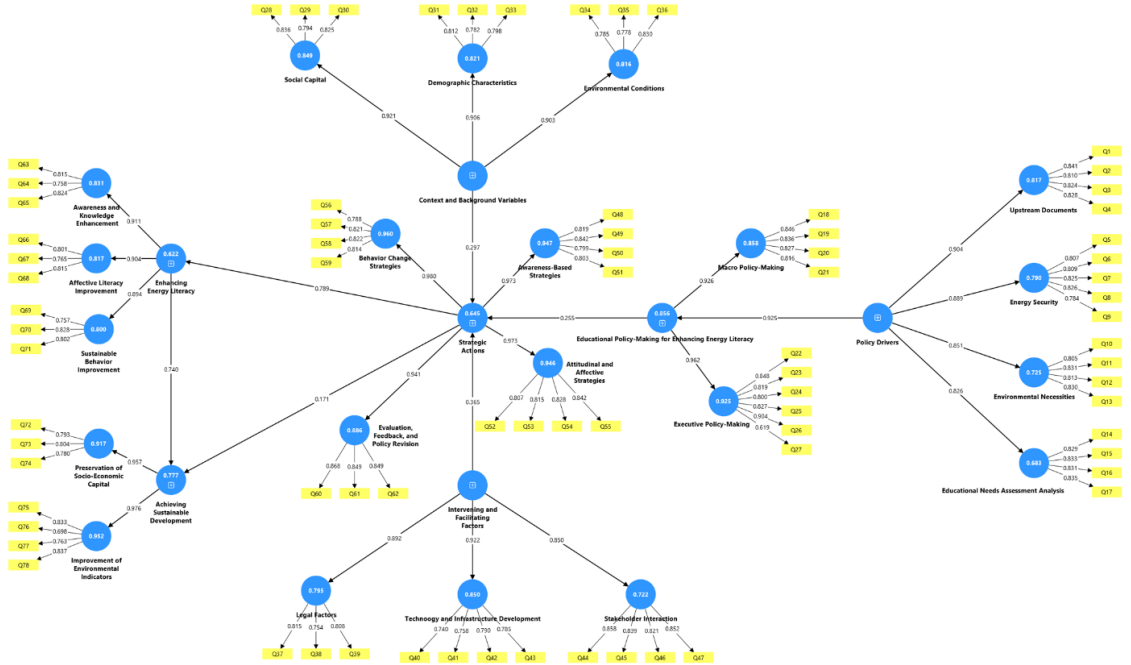

Figure 4. Validation results of the proposed research model

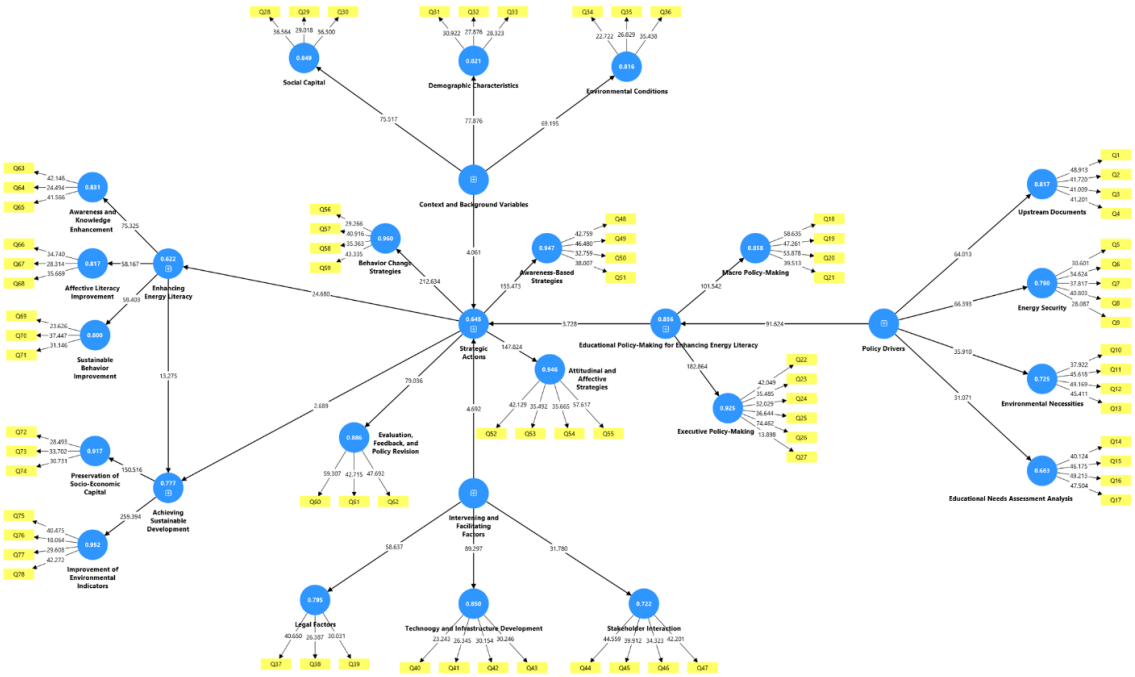

Figure 5. Results of the significance test for the proposed research model

The outer part of the model (measurement model) represents the relationship between observable variables and latent variables. Factor loadings indicate the strength of the relationship between the items and the main constructs. The results presented in Figure 3 show that all factor loadings exceed 0.6, and the t-statistics are all greater than 1.96. Therefore, the measurement part of the model demonstrates adequate validity. For further assurance, the outer model (measurement model) was also evaluated based on convergent validity, Cronbach's alpha, and composite reliability. According to the fit assessment results for the measurement model presented in Table 4, the convergent validity index, measured as average variance extracted (AVE), exceeds 0.5, and both composite reliability and Cronbach's alpha exceed 0.7. Table 5 presents the results of the measurement model evaluation for the research model.

Table 5. Results of the measurement model evaluation for the educational policy model of enhancing energy literacy

Components	Sub-components	Cronbach's alpha	Composite reliability(rho –a)	Composite reliability(rho –c)	AVE
Policy drivers	Upstream documents	0.844	0.846	0.896	0.682
	Energy security	0.869	0.869	0.905	0.657
	Environmental necessities	0.837	0.838	0.891	0.672
	Analysis of the educational situation	0.852	0.852	0.900	0.692
	Overall component indicator	0.940	0.940	0.946	0.509
Comprehensive policy document for energy literacy education	Macro policy-making	0.851	0.852	0.900	0.691
	Executive policy-making	0.890	0.900	0.918	0.652
	Overall component indicator	0.924	0.928	0.937	0.599
Strategic actions	Awareness-based strategies	0.833	0.833	0.889	0.666
	Attitudinal and affective strategies	0.841	0.842	0.894	0.678
	Behavioral change strategies	0.827	0.827	0.889	0.658
	Policy evaluation and revision	0.817	0.818	0.891	0.732
	Overall component indicator	0.959	0.959	0.963	0.637
Contextual and background variables	Social capital	0.753	0.754	0.859	0.670
	Environmental conditions	0.714	0.715	0.840	0.637
	Demographic characteristics	0.714	0.714	0.840	0.636
	Overall component indicator	0.892	0.892	0.912	0.537
Intervening and facilitating factors	Legal factors	0.704	0.706	0.835	0.628
	Technology and infrastructure development	0.769	0.770	0.852	0.591
	Stakeholder interaction	0.864	0.865	0.907	0.710
	Overall component indicator	0.902	0.902	0.918	0.505
Enhancement of energy literacy	Awareness and knowledge enhancement	0.717	0.723	0.841	0.639
	Affective literacy improvement	0.707	0.708	0.837	0.631
	Behavioral improvement	0.711	0.713	0.838	0.634
	Overall component indicator	0.883	0.885	0.906	0.517

Components	Sub-components	Cronbach's alpha	Composite reliability(rho –a)	Composite reliability(rho –c)	AVE
Achievement of sustainable development	Preservation of socio-economic capital	0.704	0.705	0.835	0.628
	Improvement of environmental indicators	0.790	0.796	0.865	0.616
	Overall component indicator	0.879	0.881	0.906	0.581

According to Table 5, the AVE value for all components and subcomponents is greater than 0.5; therefore, convergent validity is confirmed. Additionally, the composite reliability and Cronbach's alpha for all variables are greater than 0.7. Thus, the reliability of all components and subcomponents is confirmed. The HTMT criterion was used to calculate the divergent validity, and the acceptable level of this index should be less than 0.9. The results indicated that for many relationships among the model components, the HTMT index values fell within the acceptable range; of 21 relationships between components, 19 demonstrated satisfactory, acceptable discriminant validity. However, in two relationships, namely, "energy literacy enhancement – achieving sustainable development" and "policy drivers – comprehensive energy literacy educational policy document," the HTMT values exceeded the acceptable threshold. According to Henseler et al. (2015), this finding implies that when certain constructs are conceptually close to one another, the interpretation of discriminant validity results should be done based on the theoretical foundations and the logic underlying the model's formation. Therefore, given that the model constructs have been distinguished based on theoretical foundations, qualitative data analysis, and expert opinions, the observed overlap has been considered an indication of conceptual proximity among some constructs in interpreting the results. The HTMT values are presented in Table 6.

Table 6. HTMT values for discriminant validity

Components	Enhancement of energy literacy	Strategic actions	Contextual & background variables	Comprehensive policy document for energy literacy education	Intervening and facilitating factors	Policy drivers	Achievement of sustainable development
Enhancement of energy literacy							
Strategic actions	0.856						
Contextual and background variables	0.836	0.748					
Comprehensive policy document for energy literacy education	0.744	0.707	0.630				
Intervening and facilitating factors	0.889	0.792	0.763	0.730			
Policy drivers	0.872	0.800	0.757	0.986	0.837		
Achievement of sustainable development	0.992	0.823	0.790	0.751	0.886	0.892	

The relationships among the main constructs (the components) are known as the inner model or structural part. The relationships among the main constructs (structural part) were examined using path coefficients and t-statistics (Hair et al., 2025), with a summary presented in Table 7.

Table 7. Results of the test of relationships among the components of the educational policy model for enhancing energy literacy

Relationship between components	Path coefficient	t-Statistic	Significance	Result
Policy drivers → educational policy for enhancing energy literacy	0.925	91.624	0.000	Confirmation
Educational policy for enhancing energy literacy → strategic actions	0.255	3.728	0.000	Confirmation
Contextual variables and underlying factors → strategic actions	0.297	4.061	0.000	Confirmation
Intervening and facilitating factors → strategic actions	0.365	4.692	0.000	Confirmation
Strategic actions → enhancing energy literacy	0.789	24.680	0.000	Confirmation
Strategic actions → achieving sustainable development	0.171	2.689	0.000	Confirmation
Enhancing energy literacy → achieving sustainable development	0.740	13.275	0.000	Confirmation

Furthermore, using the mediation test conducted through the Bootstrapping method, the effect of the independent variable (strategic measures) on the dependent variable (achieving sustainable development) through the mediator (enhancing energy literacy) was calculated. The analysis results indicated that in the relationship between strategic measures → enhancing energy literacy → achieving sustainable development, a strong mediation relationship is evident. The mediator variable (enhancing energy literacy) explains a significant portion of the relationship between the independent variable (strategic measures) and the dependent variable (achieving sustainable development); that is, strategic measures lead to achieving sustainable development through enhancing energy literacy among housewives. In this case, the mediation is partial, but the relationship is strong (Lating & Aryani, 2024).

The coefficient of determination (R^2) and the predictive relevance (Q^2) indices were also used to evaluate the model's predictive performance. These two indices are calculated for endogenous variables. The coefficient of determination indicates the extent to which independent variables explain the variance in dependent variables. The values 0.19, 0.33, and 0.67 are considered criteria for weak, moderate, and strong fit of the model's structural part, respectively, based on the coefficient of determination (Chin, 1998). The predictive relevance index is also used to assess the model's predictive power. This index was introduced by Stone and Geisser and is estimated using the Blindfolding method. If the Q^2 value is positive, it indicates that the model has adequate predictive power (Panda & Arumugam, 2023). The results of the predictive power evaluation of the research model are presented in Table 8

Table 8. Results of the predictive power assessment of the research model

Components	R2	Adjusted R^2	Q2
Educational policy for enhancing energy literacy	0.856	0.855	0.506
Strategic actions	0.645	0.639	0.407
Enhancing energy literacy	0.622	0.620	0.315
Achieving sustainable development	0.777	0.775	0.446

Based on the results presented in Table 6, the coefficient of determination (R^2) for the endogenous components of the research model is satisfactory. The R^2 values for educational policy-making, strategic measures, energy literacy promotion, and achieving sustainable development were estimated at 0.650, 0.626, 0.619, and 0.777, respectively. This suggests that the model variables can explain a significant amount of the variance in the educational policy model aimed at enhancing energy literacy among housewives in Tehran. The Q^2 index was also positive in all cases, confirming that the model possesses adequate predictive relevance. To assess the model fit, the GOF (goodness of fit) and SRMR (standardized root

mean square residual) indices were employed. For the GOF index, values of 0.01, 0.25, and 0.36 have been suggested as weak, moderate, and strong thresholds, respectively (Lating & Aryani, 2024). For the SRMR index, values below 0.10 are considered acceptable (Purwanto et al., 2023; Yew et al., 2022). The fit indices for the educational policy model for enhancing energy literacy are presented in Table 8.

Table 9. Results of the fit assessment of the educational policy model for enhancing energy literacy among housewives in Tehran

Index	GOF	SRMR
Acceptable value	Above 0.36	Less than 0.1
Estimated value	0.63	0.098

Based on the findings presented, we conclude that the educational policy model is satisfactorily fit for enhancing energy literacy among housewives in Tehran.

Model stability or sensitivity analysis

Model stability or sensitivity analysis was conducted to ensure the robustness of the findings and to examine the model's sensitivity to changes in sample size or items. To achieve this objective, the bootstrapping method with 5,000 resamples was employed in SmartPLS. The results of the bootstrapping analysis indicated that the path coefficients exhibited adequate stability, and all main paths of the model remained significant at the 95% confidence level ($P < 0.05$). Furthermore, the calculated standard errors and confidence intervals demonstrated the model's robustness against potential sampling fluctuations. In terms of item sensitivity, an analysis of the factor loadings for all remaining items in the model showed that all values surpassed the standard threshold. This finding confirms that the model remains stable despite the removal of items, thereby supporting the construct validity of the model. Therefore, the research model possesses acceptable stability and robustness.

6. Discussion and conclusion

Numerous policies have been implemented in the past to increase citizens' awareness and energy literacy, but these policies have not yielded the desired results. Various educational and informational programs have failed to effectively enhance public awareness and knowledge or change energy consumption behaviors. One reason for this failure is the lack of attention to the various dimensions of energy literacy and the absence of public and stakeholder participation in policy implementation. Therefore, the present study aimed to design and validate an educational policy model to enhance energy literacy among housewives in the 22 districts of Tehran.

Based on the research findings, four categories of concepts (including upstream documents and macro energy policies, energy security, environmental necessities, and educational gaps and needs assessments) were identified as sub-components of the "drivers of educational policy-making" component within the causal conditions. Two categories of concepts (macro policy-making and executive policy-making) were identified as sub-components of the "educational policy-making" component within the central phenomenon. Four categories of concepts (awareness-based strategies, attitudinal and affective strategies, behavior change strategies, and policy evaluation and revision) were identified as sub-components of the "strategic actions" component within the strategies. Three categories of concepts (social capital, environmental conditions, and demographic characteristics) were identified as sub-components of the "context and background variables" component within the contextual factors. Three categories of concepts (legal factors, technology and infrastructure development, and stakeholder interaction) were identified as sub-components of the "intermediary and facilitating factors" component within the intervening conditions. Three categories of concepts (increasing awareness and knowledge, improving affective literacy, and improving behaviors) were identified as sub-components of the "energy literacy enhancement" component. Two categories of concepts (preservation of socio-economic capital and improvement of environmental indicators) were identified as sub-components of the "achieving sustainable development" component within the consequences.

According to the research model, the "drivers of policy-making" component influences the "educational policy-making for energy literacy enhancement" component. In this regard, some interview participants particularly emphasized the role of policy drivers.

Interviewee No. (2) stated that upstream documents and mandates have doubled the necessity of formulating an educational policy to improve energy consumption by housewives. Additionally, Interviewee No. (1) stated that environmental factors such as climate change and Tehran's transformation into a heat island, followed by reduced rainfall and snowfall in Tehran, have further highlighted the need for educational policy intervention to optimize energy consumption. Interviewee No. (11) considered the environmental impacts of energy production in power plants, such as water consumption in energy production processes and air pollution from power plants, as significant and emphasized the need for solutions to address them. Furthermore, some participants deemed an educational intervention necessary both in terms of the existing gaps in energy-related knowledge, attitudes, and skills and in terms of the available educational infrastructure. Participant No. (7) acknowledged that policy-making in this area is a direct response to the social demand for equipping citizens with the necessary capabilities to participate in the future energy economy. Interviewee No. (4) stated that if housewives have low energy literacy, the implementation of macro policies, regardless of the method, will face resistance or failure, which aligns with the findings of Torkashvandi et al. (2024), who asserted that lack of awareness is the most critical factor leading to environmental degradation and inefficient use of resources.

According to some interview participants, contextual variables must also be considered for any educational policy-making and planning in the area of energy literacy enhancement. Interviewee No. (2) stated that emotional and value-based factors largely influence women's behaviors at home regarding energy. Interviewee No. (5) stated that with increasing age and education, the tendency to save electricity increases. Interviewee No. (10) acknowledged that older women tend to trust oral recommendations more, while younger individuals are more inclined toward social media. According to Interviewee No. (6), increased education indirectly enhances awareness regarding electricity consumption, leading to greater attention to values in decision-making, which aligns with the findings of Abdollahpour (2025), Hamidi Razi (2021), and Martins et al. (2020).

In the opinion of some participants, applying multiple leverage points will lead to favorable outcomes in enhancing energy literacy. In this regard, Interviewee No. (9) stated that to guide housewives toward correct energy behaviors, revising energy tariffs and pricing is necessary but insufficient, and other leverage points must also be activated for educational policies to be implemented. According to Belaïd (2024), among the main factors influencing the implementation of energy efficiency measures in the French residential building sector are the physical characteristics and age of buildings, energy prices, and socio-economic factors, which are consistent with the results of this study. Interviewee No. (12) emphasized infrastructure development and believed that alongside content preparation and awareness-raising, new technologies such as equipment smartization, which have a significant impact on reducing and managing energy consumption, should also be made available to households.

Some participants emphasized the role of charismatic figures such as celebrities. Interviewee No. (5) stated that for some individuals, especially women who actively follow social media, messages or energy-related content presented by popular figures will receive greater reception and attention. Additionally, Interviewee No. (8) valued the role of non-governmental organizations as intermediaries between citizens and policy-makers and stated that NGOs have a greater capacity to connect with housewives. These findings are consistent with new approaches to energy governance that emphasize integrating coercion-based and social-stimulation drivers for sustainable change. The aforementioned findings align with the research of Kelleher (2022), Bulkeley and Newell (2015), and Saleem and Zhang (2024).

Some interviewees emphasized that in the strategic actions phase, simultaneous attention should be given to the various dimensions of energy literacy. In this regard, Interviewee No. (3) stated that for some individuals, merely knowing a subject is not effective, and emotions and feelings must also be engaged. Interviewee No. (4) stated that for some individuals, all education must be centered around economics, and if it is not economically important, they will not pay attention; therefore, the financial aspects should be emphasized in the education. Interviewee No. (11) emphasized the necessity of empowerment and providing technical solutions on energy consumption and acknowledged that many housewives lack practical skills, such as bill analysis or load management, and various methods can be used to provide them with the necessary training. These results are consistent with the research by Cravinho et al. (2023),

which showed that empowerment and development of practical skills through gamification enhance energy literacy. Some interviewees stated that an evaluation mechanism must certainly be established to assess the actions implemented. Interviewee No. (9) stated that if we do not know how effective the implemented actions have been, we will not achieve a specific outcome. Furthermore, Interviewee No. (12) acknowledged that for future actions, we must definitely examine the results of what has been done by defining indicators and planning accordingly. These research findings are consistent with the studies by Schulte et al. (2022) and Clavijo-Núñez et al. (2024). Additionally, the results of this research align with Brounen et al. (2013), who stated that insights and attitudes, age, income, and housing characteristics influence the behavioral dimensions of energy literacy. Ultimately, the research findings indicate that enhancing the energy literacy of housewives, as an influential group in household consumption decisions and behaviors, can play a significant role in reforming energy consumption patterns and improving environmental, social, and economic outcomes. Therefore, to strengthen the decisive role and participation of housewives in energy management, a set of executive, institutional, and policy measures is proposed:

1. The Ministry of Energy, Tavanir Company, and the Greater Tehran Electricity Distribution Company, in collaboration with the Tehran Municipality, design and implement educational packages based on real-life household energy consumption scenarios. These packages should focus on tangible household situations, daily energy consumption behaviors, consumption reduction methods, and informed decision-making about the use of energy-intensive equipment. The implementation of such programs can begin in the short term, and their effectiveness can be evaluated through pre-test and post-test assessments of household awareness, attitudes, and consumption behaviors.
2. Educational content should be designed in accordance with the social, economic, cultural, and consumption pattern differences across various districts of Tehran. Considering the demographic diversity and differences in energy consumption across 22 districts in Tehran, it is recommended that educational programs be developed and implemented based on the analysis of consumption data and demographic characteristics. Such an approach can increase the relevance of educational interventions to households' actual conditions, thereby enhancing the effectiveness of the programs.
3. Utilizing the capacity of local and social institutions, including cultural centers, neighborhood centers in the Tehran Municipality, and non-governmental organizations, can facilitate more direct and effective access to housewives. These institutions can play a significant role in enhancing household energy literacy by organizing educational workshops, neighborhood-based meetings, family-oriented programs, and interactive activities.
4. To increase the participation of housewives, the design of behavioral and motivational incentives is recommended. These incentives may include citizen points, participation certificates, ranking of low-consumption households, introduction of successful models of optimal energy consumption, and support for families participating in educational programs. The implementation of this measure is feasible in the short to medium-term and can increase the motivation for sustained participation.
5. Qualitative and quantitative evaluation of educational programs should be considered a fixed part of the implementation process. This evaluation can be conducted through surveys, analysis of participant feedback, comparison of energy consumption data before and after program implementation, and assessment of changes in household awareness and consumption behaviors. Establishing a continuous evaluation system enables program revision and enhances the efficiency of educational policies.
6. Given the multi-institutional nature of the energy literacy issue, a network governance approach should be employed in stakeholder interactions. Accordingly, the formation of a joint working group among the Ministry of Energy, Tehran Municipality, National Media, non-governmental organizations, and institutions related to women and the family can contribute to program coordination, prevention of duplication, data exchange, and increased effectiveness of educational interventions.
7. To utilize legal and policy capacities is essential. Revising and updating building regulations and standards, strengthening requirements for energy labels on energy-intensive equipment, and gradually revising energy subsidies and tariffs, while observing social justice considerations, can provide the

necessary institutional foundation for the sustainability of optimal energy consumption behaviors. These measures can be pursued by the Islamic Consultative Assembly, the Ministry of Energy, the National Standards Organization, the Management and Planning Organization, and other legislative bodies, in the medium to long term.

Accordingly, the executive recommendations presented in this research are based on a central premise: housewives, due to their effective role in daily energy consumption decisions and behaviors within the household, can be one of the key groups in reforming energy consumption patterns. From this perspective, the innovation and knowledge contribution of the present study lie in its focus on the energy literacy of housewives, which has received less independent and targeted attention in previous studies, despite the recognized importance of their role in household energy management. Most existing research has focused on energy consumption management, macro energy policies, or general consumer education, while the specific role of housewives as one of the most influential groups in daily energy consumption decisions and behaviors within the family has been less investigated. Therefore, by highlighting the position of housewives in enhancing energy literacy and reforming household consumption patterns, the present study can provide a basis for designing targeted educational programs and formulating practical policies in energy consumption management, in addition to enriching the theoretical literature in this field. Accordingly, the proposed research model has the potential to serve as a guiding framework for enhancing energy literacy among housewives in the 22 districts in Tehran.

6.1. Research limitations

Despite its valuable findings, this research has faced certain limitations that should be considered when generalizing the results:

1. Scope of application: the present study focused specifically on household electricity consumption. This focus was based on findings from the qualitative phase and the experts' emphasis on the necessity of distinguishing energy carriers in educational policy-making. Therefore, generalizing the proposed model to other energy carriers requires further complementary research.
2. Geographical limitation: the data for this study were collected solely from Tehran. Due to differences in lifestyle, access to education, and the cultural, economic, and social conditions of households, the generalizability of the results to other cities in Iran may be limited.
3. Target population limitation: the present study focused exclusively on housewives. Given socio-economic differences, the results are not necessarily generalizable to employed women or other demographic groups.

Authors' Contributions

Mahdieh Rezaei and Hadi Kari: 35%; Seyed Mohammad Shobeiri: 20%; Majid Saffarinia: 10%.

Acknowledgments

The authors express their gratitude and appreciation to all individuals who assisted them in conducting this research. This article is the result of the authors' joint effort and academic endeavor. The research involves no commercial interests, and the authors have received no financial compensation for submitting this work. Furthermore, the study was conducted without any financial or institutional support, and the authors fully covered all expenses. The English translation of this article was partially assisted by artificial intelligence tools, specifically DeepSeek, to enhance linguistic fluency, idiomatic accuracy, and scholarly tone.

Conflict of Interest

The authors declare no conflict of interest regarding the authorship or publication of this article.

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