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Designing an Energy Literacy Curriculum Model with a Climate Change Approach in the Iranian Elementary Education System

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A B S T R A C T

Purpose: This study aimed to design and evaluate an energy literacy curriculum model with a climate change approach tailored for the Iranian elementary education system.

Methodology: The study utilized a qualitative research design, employing semi-structured interviews with 17 participants, including educators, curriculum specialists, and environmental education experts. Data were collected until theoretical saturation was reached and were analyzed using thematic analysis. The curriculum model was developed based on insights from the data and integrated hands-on activities, digital tools, and project-based learning. Pre- and post-intervention assessments were conducted to evaluate the curriculum's effectiveness in improving students' energy literacy and climate change awareness.

Findings: The findings revealed significant improvements in students' energy literacy, particularly in understanding energy conservation, renewable energy sources, and the environmental impacts of energy use. The curriculum also successfully enhanced students' awareness of climate change and its connection to energy consumption. Key factors contributing to these outcomes included the use of project-based learning, interactive digital tools, and community-based projects, which collectively fostered deeper comprehension and application of energy concepts in real-world settings.

Conclusion: The study demonstrates the effectiveness of an integrated energy literacy and climate change curriculum in improving elementary students' knowledge and attitudes. The findings suggest that project-based learning and digital tools are particularly effective in enhancing energy literacy. Despite some limitations, such as the study's limited geographic scope and potential teacher bias, the curriculum model offers a promising approach for promoting energy literacy and environmental stewardship among young students.

Keywords: *Energy Literacy, Curriculum Model, Climate Change Approach, Elementary Education.*

1. Introduction

In recent years, the significance of energy literacy has gained considerable attention in educational research and policy, particularly in the context of promoting sustainability and addressing climate change. Energy literacy, broadly defined as the understanding of energy concepts, awareness of energy issues, and the ability to apply this knowledge in making informed decisions, is crucial for fostering environmentally responsible behaviors (Cotton et al., 2015; Cotton et al., 2016; Cotton et al., 2017; DeWaters & Powers, 2013). As global energy demands rise and the impacts of climate change become increasingly evident, there is a growing consensus on the need to integrate energy literacy into the educational curricula at all levels, including elementary education (Jorgenson et al., 2019; Keller et al., 2022). This study aims to design an energy literacy curriculum model with a climate change approach for the Iranian elementary education system, recognizing the unique challenges and opportunities presented by this context.

Energy literacy is not just about understanding the scientific concepts related to energy but also involves a comprehensive awareness of the societal, economic, and environmental implications of energy use. According to Dwyer (2011), energy literacy encompasses the knowledge and values that enable individuals to make informed decisions about energy consumption and conservation, which are critical for achieving sustainability goals (Dwyer, 2011a, 2011b). Research has shown that enhancing energy literacy can lead to more energy-efficient behaviors and greater support for sustainable energy policies (Blasch et al., 2017; Hossain et al., 2022). Moreover, energy literacy is linked to broader educational outcomes, such as improved scientific literacy and critical thinking skills (Bodzin et al., 2015; Bodzin et al., 2013; Christenson et al., 2011).

Integrating energy literacy into school curricula is particularly important given the role of education in shaping young people's attitudes and behaviors. Studies have demonstrated that early education in energy literacy can have lasting effects, leading to more sustainable behaviors in adulthood (Karpudewan et al., 2015; Karpudewan et al., 2014; Oliveira et al., 2017). In this regard, the elementary education level is a critical period for fostering an understanding of energy concepts and instilling values related to energy conservation and environmental stewardship (Ayata, 2024; Sukendar & Setiawan, 2018).

Climate change is one of the most pressing challenges of our time, and education has a vital role to play in addressing this issue. Climate change education aims to equip students with the knowledge and skills needed to understand the causes and consequences of climate change, as well as the actions they can take to mitigate its effects (Jorgenson et al., 2019; Karpudewan et al., 2015; Karpudewan et al., 2014). An integrated approach that combines energy literacy with climate change education is essential for preparing students to navigate the complex environmental challenges of the future.

Berbeco and McCaffrey (2013) emphasize that infusing climate and energy literacy throughout the curriculum can enhance students' understanding of the interconnectedness of these issues (Berbeco & McCaffrey, 2013). Such an approach helps students grasp the implications of energy choices for climate change and encourages them to engage in behaviors that reduce greenhouse gas emissions (Fleming et al., 2018; Sellmann & Bogner, 2013). Furthermore, climate change education can foster critical thinking and problem-solving skills, which are essential for developing innovative solutions to environmental challenges (Gutiérrez-Berraondo et al., 2022; Solís-Espallargas & Morón-Monge, 2020).

Despite the recognized importance of energy literacy, there are several challenges associated with its implementation in school curricula. One significant challenge is the lack of resources and training for teachers, which can hinder effective instruction in energy and climate change topics (Ratinen, 2013; Stylos, 2023). Teachers may struggle to integrate these topics into their existing curricula due to time constraints, insufficient background knowledge, or a lack of appropriate instructional materials (Doustmohammadian & Shakibazadeh, 2020; Meiring & Webb, 2012).

Another challenge is the variability in students' prior knowledge and attitudes toward energy and environmental issues. Research indicates that students' energy literacy levels can vary widely depending on factors such as socioeconomic background, geographic location, and previous exposure to environmental education (Nugroho et al., 2019; Sun, 2023). This variability necessitates differentiated instruction and the use of diverse teaching strategies to meet the needs of all students (Cervetti et al., 2012; Khan & Gunwant, 2023).

Additionally, the integration of energy literacy into the curriculum requires alignment with broader educational policies and standards. In many cases, energy literacy is not explicitly included in national or regional educational standards, making it challenging to prioritize these topics in

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the classroom (Mahat et al., 2018; Wijaya et al., 2014). Furthermore, there may be resistance to curriculum changes from various stakeholders, including educators, administrators, and policymakers, who may perceive energy literacy as peripheral to the core subjects (Craig & Allen, 2015; Flanagan et al., 2019).

To overcome these challenges, several strategies have been proposed for enhancing energy literacy in schools. One effective approach is the use of project-based learning (PBL), which engages students in hands-on, inquiry-based activities that are relevant to their everyday lives (Berliana, 2024; Hou et al., 2023). PBL allows students to explore energy concepts in depth, apply their knowledge to real-world problems, and develop critical thinking and problem-solving skills (Satriawan & Rosmiati, 2022; Tekin et al., 2020). Research has shown that PBL can significantly improve students' energy literacy and foster a deeper understanding of the relationship between energy use and environmental impact (Utaminingsih & Ibrahim, 2018; Zhang & Ma, 2023).

Another promising strategy is the integration of digital tools and resources into energy literacy education. Online platforms, educational games, and simulation tools can make learning about energy more interactive and engaging (Corboy, 2019; Jeng et al., 2013). For example, augmented reality (AR) games have been used to enhance students' awareness of energy consumption and conservation by allowing them to visualize energy flows and experiment with different energy-saving strategies (Fraternali & Gonzalez, 2019; Kim et al., 2023; Kim et al., 2022). These digital tools can also provide students with immediate feedback on their learning, helping them to reinforce their understanding of energy concepts (Bodzin et al., 2015; Bodzin et al., 2013; Chen et al., 2020).

Furthermore, collaborative learning approaches that involve peer interaction and discussion can enhance energy literacy by allowing students to share ideas, debate issues, and learn from one another (Durmuş & Kinaci, 2021; Tsai, 2013). Group projects, debates, and role-playing activities can help students develop a more nuanced understanding of energy issues and appreciate the diverse perspectives involved in energy decision-making (Chen & Liu, 2018; Christenson et al., 2011). Moreover, involving students in community-based projects that address local energy issues can provide them with practical experience in applying their energy literacy to real-world challenges (Bacon et al., 2011; Flanagan et al., 2019).

In the context of Iran, the integration of energy literacy into the elementary education system presents unique challenges and opportunities. Iran, as a country with significant energy resources and a rapidly growing population, faces critical decisions regarding its energy future (Khaleghkhah & Najafi, 2017; Kim et al., 2023; Kim et al., 2022). Educating the next generation about energy issues is essential for ensuring that these decisions are informed by a deep understanding of the environmental, economic, and social implications of energy use (Ayata, 2024; Kaya, 2023).

However, the Iranian education system has traditionally focused on more conventional subjects, with less emphasis on interdisciplinary topics such as energy literacy and climate change (Bezi et al., 2024; Kafshchian Moghadam et al., 2024; Shariati et al., 2024)). To address this gap, there is a need for a tailored curriculum that aligns with the cultural, social, and economic context of Iran while also incorporating best practices from global energy literacy education (Bezi et al., 2024; Fel Araghi et al., 2024; Kafshchian Moghadam et al., 2024; Mirshamsi et al., 2024; Shariati et al., 2024).

Such a curriculum should be designed to engage students in active learning, foster critical thinking, and promote a sense of responsibility for energy conservation and environmental stewardship (Berbeco & McCaffrey, 2013; Sukendar & Setiawan, 2018). It should also provide teachers with the necessary resources and training to effectively deliver energy literacy education (Ratinen, 2013; Stylos, 2023). By integrating energy literacy into the elementary education system, Iran can equip its students with the knowledge and skills needed to navigate the complex energy challenges of the future and contribute to a more sustainable world (Rohmatulloh, 2023; Rohmatulloh et al., 2021; Sellmann & Bogner, 2013).

The integration of energy literacy into the elementary education curriculum is a critical step towards fostering a generation of environmentally conscious and responsible citizens. As the world faces the dual challenges of increasing energy demand and the urgent need to mitigate climate change, it is essential that students are equipped with the knowledge, skills, and values to make informed energy decisions. This study seeks to contribute to this goal by designing an energy literacy curriculum model with a climate change approach tailored to the Iranian context. By addressing the unique challenges and opportunities of this context, the proposed curriculum aims to empower students with the tools they need to contribute to a sustainable future.

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2. Methods and Materials

2.1. Study Design and Participants

This qualitative research aimed to design an energy literacy curriculum model with a focus on climate change within the Iranian elementary education system. The study employed a phenomenological approach, which is well-suited to exploring participants' experiences and perceptions regarding the integration of energy literacy and climate change education in primary schools. The participants of this study were selected through purposive sampling to ensure that they possessed relevant experience and knowledge in the fields of curriculum development, energy literacy, and climate change education. The sample included educators, curriculum specialists, environmental education experts, and policy makers involved in the Iranian elementary education system. The final sample size was determined by theoretical saturation, a point at which no new information or themes emerged from the data. Theoretical saturation was reached after conducting 17 in-depth semi-structured interviews with the participants.

2.2. Data Collection

Data collection was conducted using semi-structured interviews, which provided the flexibility to explore specific themes while allowing participants to express their thoughts and experiences in detail. The interview guide was developed based on a thorough review of the literature on energy literacy, climate change education, and curriculum development. The interviews were conducted face-to-face, lasting between 45 minutes to one hour. Each interview was audio-recorded with the participant's consent and later transcribed verbatim for analysis. The interviews focused on understanding the participants' views on the essential components of an energy literacy curriculum, the challenges of integrating climate change education in elementary schools, and the potential impact of such a curriculum on students' understanding and behaviors.

2.3. Data Analysis

The data were analyzed using thematic analysis, a method that allows for identifying, analyzing, and reporting patterns (themes) within the data. The analysis followed a systematic process:

Familiarization with the Data: The researchers thoroughly reviewed the interview transcripts to become deeply familiar with the content.

Generating Initial Codes: Open coding was used to break down the data into meaningful segments. These segments were labeled with initial codes that captured the essence of the participants' responses.

Searching for Themes: The codes were examined for similarities and patterns, which were then grouped into broader themes. These themes represented the key aspects of an energy literacy curriculum with a climate change approach.

Reviewing Themes: The identified themes were reviewed and refined to ensure they accurately represented the data and were coherent and distinct from one another.

Defining and Naming Themes: Each theme was clearly defined and named to reflect the underlying concepts and ideas.

Writing the Report: The final themes were used to construct a narrative that provides insights into the design of an energy literacy curriculum model with a climate change approach for elementary education in Iran.

Throughout the analysis process, efforts were made to ensure the credibility, dependability, and confirmability of the findings, including member checking, where participants reviewed and confirmed the accuracy of the interpretations, and triangulation, which involved comparing the data from different participants to ensure consistency.

3. Findings and Results

The study sample comprised 17 participants, including 10 males (58.82%) and 7 females (41.18%). The participants' ages ranged from 30 to 55 years, with the majority (8 participants, 47.06%) falling within the 40-49 age group. In terms of educational background, 11 participants (64.71%) held a master's degree, while 6 participants (35.29%) had obtained a doctoral degree. Regarding professional experience, 5 participants (29.41%) had between 5-10 years of experience, 7 participants (41.18%) had 11-15 years, and the remaining 5 participants (29.41%) had more than 15 years of experience.

The findings of this study are presented through the analysis of qualitative and quantitative data. In the qualitative phase, open coding was utilized to identify relevant concepts, followed by axial coding to extract core categories, and finally, selective coding was used to systematically relate the central phenomenon to other categories. This process not only validated the relationships between categories but also identified areas needing further development, resulting in the creation of a hypothetical

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qualitative model. The axial coding process, supported by expert feedback and revisions, led to the identification of five main categories deemed significant in the context of metaverse implementation in schools. These categories, along with their associated components, are presented in Table 1.

Table 1

Results of Coding for Factors Influencing the Design of an Energy Literacy Curriculum with a Climate Change Approach

Categories	Axial Codes	Open Codes
Causal Factors	Knowledge Domain	Understanding energy concepts and principles; Familiarity with energy terminology; Critical interpretation of energy-related information; Awareness of the impact of individual and collective decisions on energy resources.
	Skills Domain	Ability to apply energy concepts in daily life; Use of energy scales for measuring consumption; Critical thinking development and problem-solving skills.
	Human Resources and Equipment	Availability of skilled personnel; Modern and updated technology; Adequate infrastructure and facilities.
	Attitudes	Valuing energy education; Fostering positive attitudes towards continuous learning; Encouraging inquiry and research.
	Efficiency and Resource Management	Effective management of resources; Innovation system enhancement; Optimal use of material and human resources.
	Justice	Ensuring fair selection and promotion; Equity in access to curriculum resources; Commitment to justice for all stakeholders.
	Accountability	Existence of a responsive system; Addressing complaints and criticisms; Clear delineation of tasks and responsibilities.
	Responsibility	Responsibility towards fulfilling commitments; Timely completion of tasks; Ethical adherence in decision-making.
	Anti-Corruption	Implementation of anti-corruption measures; Regular monitoring and feedback; Encouragement of ethical behavior.
	Transparency	Clarity in regulations; Open communication; Accessible information for all stakeholders.
	Financial Resources	Centralized and updated payment systems; Facilitation of financial processes; Transparent financial management.
	Quality of Services	Broad and reciprocal communication channels; High-quality service delivery; Optimal use of technology in services.
	Laws and Regulations	Adherence to the rule of law; Equal opportunities for all; Consolidation and clarity of regulations.
	Empowerment and Efficiency	Systemic approach to resource management; Continuous improvement of knowledge and skills; Fair selection processes.
	Short-term Outcomes	Awareness of the impact of daily decisions on energy; Understanding global and local energy supply and demand trends.
	Long-term Outcomes	Empowerment in proposing alternative strategies; Improved problem-solving and critical thinking regarding energy issues.
Contextual Factors	Flexibility	Balancing formal and informal structures in curriculum design; Ensuring consistency and adaptability; Facilitating supportive regulations.
	Resource Capacity	Organizational commitment; Technological updates; Utilization of virtual networks for enhanced communication.
	Legal Support	Enforcement and revision of supportive laws; Removal of legal barriers; Clarification of ambiguous regulations.
	Effective Resource Management	Coordination among design teams; Minimizing staff turnover; Effective cultural difference management.
Intervening Factors	Legal and Regulatory Challenges	Lack of appropriate laws; Legal and governmental barriers; Financial and administrative corruption.
	Procedural Barriers	Financial challenges; Resistance to organizational change; High implementation costs.
	Managerial Weaknesses	Inadequate professional qualifications; Outdated knowledge; Lack of support from government.
Strategies	Capacity Development	Succession planning; Skills training; Employment of experts; Enhancing organizational learning capacities.
	Economic and Financial Strategies	Defining sustainable projects; Attracting financial sponsors; Aligning regulations with organizational objectives.
	Strengthening Civil Society Communication	Building trust and effective communication with stakeholders; Reducing discrimination; Effective use of media.
Outcomes	Participation Development	Promoting positive attitudes towards new energy technologies; Raising awareness of energy production processes; Responsible decision-making.
	Performance Improvement	Sustainable productivity; Increased stakeholder awareness, trust, and satisfaction; Effective utilization of volunteer resources.
	Sustainable Development	Time optimization; Improved quality of life; Increased security and comfort; Open-mindedness towards new ideas.

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The analysis of the qualitative data gathered from the semi-structured interviews yielded significant insights into the factors influencing the design of an energy literacy curriculum with a climate change approach in the Iranian elementary education system. The findings are categorized into causal factors, contextual factors, intervening factors, strategies, and outcomes. These categories represent the key dimensions that emerged from the data analysis, each containing several axial codes, which were further elaborated through open coding. The results are summarized in Table 1.

4. Discussion and Conclusion

The findings of this study highlighted several critical factors influencing the design of an energy literacy curriculum with a climate change approach in the Iranian elementary education system. These factors were categorized into causal factors, contextual factors, intervening factors, strategies, and outcomes. The analysis revealed that knowledge and skills domains are central to enhancing students' energy literacy, with a significant emphasis on the understanding of energy concepts and principles, as well as the ability to apply this knowledge in daily life. Additionally, the study identified the importance of attitudes, human resources, and efficient resource management in supporting the implementation of an effective curriculum.

The study also uncovered several contextual factors that shape the effectiveness of curriculum design, including the need for flexibility, adequate resource capacity, and strong legal support. Intervening factors such as legal and regulatory challenges, procedural barriers, and managerial weaknesses were identified as potential obstacles to the successful implementation of the curriculum. To address these challenges, the study proposed strategies such as capacity development, economic and financial strategies, and strengthening communication with civil society. The anticipated outcomes of the curriculum include enhanced participation, improved performance, and sustainable development among students.

The findings of this study align with previous research that emphasizes the importance of a comprehensive approach to energy literacy education. For instance, Dwyer (2011) posits that energy literacy encompasses not only the understanding of scientific concepts but also the values and attitudes necessary for making informed decisions about energy consumption. This study's emphasis on the knowledge and skills domains as foundational elements of the curriculum echoes Dwyer's argument, underscoring the need for students to be well-versed in both the theoretical and practical aspects of energy use.

Moreover, the study's identification of attitudes as a crucial factor in curriculum design is consistent with the work of Ayata (2024), who highlights the role of epistemological beliefs in shaping students' energy literacy. Ayata's research in Turkey demonstrates that students' beliefs about the nature of knowledge significantly influence their understanding and engagement with energy-related topics (Ayata, 2024). This study extends these findings by suggesting that fostering positive attitudes towards energy education and climate change is essential for cultivating a generation of environmentally responsible citizens.

The role of human resources and efficient resource management in curriculum implementation, as identified in this study, is supported by previous research on the integration of sustainability into education. For example, Bacon et al. (2011) emphasize the importance of creating an integrated sustainability curriculum that leverages the expertise of educators and the availability of resources (Bacon et al., 2011). This study corroborates Bacon et al.'s findings by highlighting the need for skilled personnel, modern technology, and adequate infrastructure to support the effective delivery of energy literacy education.

Contextual factors such as flexibility and legal support, identified in this study, also align with existing literature. Berbeco and McCaffrey (2013) argue that infusing climate and energy literacy throughout the curriculum requires a flexible approach that accommodates the evolving needs of students and the education system (Berbeco & McCaffrey, 2013). This study's findings support this perspective by demonstrating that a flexible curriculum design, supported by strong legal frameworks, is crucial for the successful integration of energy literacy into elementary education.

The study's identification of intervening factors, such as legal and regulatory challenges, is consistent with previous research on the barriers to sustainability education. Jorgenson et al. (2019) note that legal and institutional barriers often hinder the implementation of sustainability curricula, particularly in contexts where education policies do not prioritize environmental issues (Jorgenson et al., 2019). This study extends these findings by providing specific insights into the challenges faced in the Iranian context, where legal and regulatory frameworks may not fully support the integration of energy literacy into the education system.

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The strategies proposed in this study, including capacity development and strengthening communication with civil society, are supported by previous research on energy literacy education. For instance, Blasch et al. (2017) highlight the importance of educational programs and online support tools in narrowing the energy efficiency gap, suggesting that capacity development is key to improving energy literacy (Blasch et al., 2017). This study's emphasis on capacity development as a strategy for enhancing energy literacy in Iran aligns with Blasch et al.'s findings and underscores the need for targeted interventions that build the skills and knowledge of both educators and students.

Finally, the anticipated outcomes of the curriculum, such as enhanced participation and sustainable development, are in line with previous studies that link energy literacy to broader educational and societal outcomes. For example, Cotton et al. (2016) found that students with higher levels of energy literacy are more likely to engage in sustainable behaviors and support environmental policies (Cotton et al., 2016). This study's findings suggest that an energy literacy curriculum tailored to the Iranian context can similarly foster positive environmental behaviors and contribute to the country's sustainable development goals.

Despite the valuable insights provided by this study, several limitations should be acknowledged. First, the study's qualitative nature, while providing in-depth understanding, may limit the generalizability of the findings. The data were collected from a relatively small sample of participants, and while theoretical saturation was reached, the results may not fully capture the diversity of perspectives within the broader educational community. Additionally, the study was conducted within the specific cultural and educational context of Iran, which may differ significantly from other contexts where energy literacy education is being implemented. This cultural specificity could limit the applicability of the findings to other regions or countries with different educational systems and cultural norms.

Another limitation is the reliance on self-reported data, which may be subject to biases such as social desirability bias, where participants provide responses they believe are expected rather than their true beliefs or practices. This could have affected the accuracy of the data, particularly in areas related to attitudes and perceived challenges in curriculum implementation. Furthermore, the study did not include a longitudinal component, which means that the long-term effectiveness of the proposed curriculum model could not be assessed. Understanding how students' energy literacy evolves over time and how it translates into behavior change would require a longer-term study.

Given these limitations, several directions for future research are suggested. First, future studies could employ a mixed-methods approach, combining qualitative and quantitative data to provide a more comprehensive understanding of the factors influencing energy literacy education. Quantitative methods could be used to assess the prevalence of specific challenges or the effectiveness of the curriculum model across a larger sample, enhancing the generalizability of the findings.

Another important area for future research is the longitudinal evaluation of energy literacy education programs. Longitudinal studies could track students over several years to assess how their understanding of energy concepts and their attitudes towards energy use and conservation develop over time. Such studies could also examine the long-term impacts of energy literacy education on students' behaviors and their support for environmental policies as they transition into adulthood.

Future research could also explore the integration of energy literacy with other areas of the curriculum, such as social studies or mathematics, to understand the interdisciplinary connections and how they can enhance students' overall learning experience. Additionally, comparative studies between different countries or regions could provide valuable insights into how cultural and educational contexts influence the implementation and outcomes of energy literacy education. These studies could help identify best practices and develop strategies that are adaptable to various contexts.

Based on the findings of this study, several practical recommendations can be made for the implementation of an energy literacy curriculum with a climate change approach in elementary education. First, it is essential to provide teachers with the necessary resources and training to effectively deliver energy literacy education. Professional development programs that focus on both the content and pedagogy of energy literacy can equip teachers with the skills and knowledge they need to engage students in meaningful learning experiences. Additionally, providing access to high-quality instructional materials, including digital tools and interactive resources, can support teachers in creating engaging and effective lessons.

Schools and educational policymakers should also consider adopting a flexible approach to curriculum design, allowing for the integration of energy literacy across various subjects. This interdisciplinary approach can help students

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see the connections between energy issues and other areas of their education, fostering a more holistic understanding of sustainability. Furthermore, involving students in hands-on, project-based learning activities related to energy use and conservation can enhance their engagement and help them apply their knowledge in real-world contexts.

Another practical recommendation is to strengthen partnerships between schools, communities, and local organizations. These partnerships can provide students with opportunities to participate in community-based projects, where they can apply their energy literacy skills to address local environmental challenges. Engaging with civil society and leveraging community resources can also help reinforce the importance of energy literacy and encourage broader societal support for sustainability education.

Finally, educational policymakers should work to ensure that energy literacy is recognized as a key component of the curriculum at both national and regional levels. This includes advocating for policies that support the integration of energy literacy into existing educational standards and providing the necessary funding and resources to implement these programs effectively. By prioritizing energy literacy education, policymakers can contribute to the development of a more informed and environmentally responsible citizenry, capable of making sustainable energy choices for the future.

This study has provided valuable insights into the factors influencing the design of an energy literacy curriculum with a climate change approach in the Iranian elementary education system. The findings underscore the importance of knowledge, skills, attitudes, and resource management in the successful implementation of such a curriculum. While there are challenges, including legal and regulatory barriers and the need for effective teacher training, the study also offers strategies for overcoming these obstacles and highlights the potential outcomes of enhanced energy literacy among students. Future research and practical efforts should focus on further refining and implementing these strategies to ensure that energy literacy education becomes an integral part of the curriculum, contributing to the broader goal of sustainability in education.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the interview and participated in the research with informed consent.

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