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An Interpretive Qualitative Study of the Lived Experiences of Smart Home Technology Users in Enhancing Household Energy Efficiency

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ABSTRACT

The integration of smart home technologies has become increasingly prominent as a strategy for improving energy efficiency in households. However, while technical performance and energy savings have been widely studied, there is limited research on the subjective experiences of users interacting with these technologies. The knowledge gap lies in understanding the emotional and psychological dimensions of users' engagement with smart home devices. In this study, we adopt a phenomenological approach to explore how users perceive and experience the integration of smart home technologies in their daily lives, specifically focusing on energy efficiency. Data were collected through in-depth, semi-structured interviews with 12 participants, and thematic analysis was conducted to identify key themes in their experiences. The findings indicate three central themes: (1) perceived empowerment through real-time energy monitoring, where participants reported feeling more "in control" of their electricity consumption after using mobile-based dashboards; (2) technological anxiety triggered by system errors and unstable connectivity, which led some users to temporarily disable automated features; and (3) adaptive learning processes, in which users gradually developed routines to optimize device settings, such as scheduling smart thermostats and lighting systems to reduce peak-hour consumption. While participants acknowledge the potential benefits of smart home devices, several concrete barriers emerged, including frequent application crashes, unclear interface instructions, and inconsistent sensor performance, all of which generated frustration and reduced trust in the system. These results contribute to a deeper understanding of the lived experiences of users, offering insights into how emotional and cognitive factors shape technology adoption. Practically, the findings suggest that designers and energy policymakers should prioritize intuitive interface design, transparent feedback on energy savings, and reliable system performance to enhance user trust and sustained engagement. Additionally, incorporating user training modules and responsive customer support may help mitigate technological anxiety and improve long-term adoption rates. The implications of this study highlight the need for user-centered design in smart home technologies, demonstrating that emotional reassurance and usability optimization are as critical as technical efficiency in achieving meaningful household energy reduction.

INTRODUCTION

The adoption of smart home technologies has emerged as a significant trend in modern households, driven by advancements in Internet of Things (IoT) devices aimed at improving energy efficiency, security, and convenience (Aladwan, 2025). These technologies, such as smart thermostats, smart meters, and energy-efficient appliances, are increasingly integrated into daily life, offering users greater control over their home environments. The broad uptake of smart home technologies can be understood within the larger context of global efforts to reduce energy consumption and combat climate change, as well as the growing trend of digitalization and automation in domestic spaces (Chia & Frattarola, 2025). In this context, smart technologies represent

a step towards more sustainable living, potentially transforming how individuals interact with their homes and manage resources like electricity and water.

The relevance of this phenomenon lies in its potential to influence both individual behaviors and broader environmental goals. As the world faces the challenges of climate change and rising energy demands, understanding how consumers engage with these technologies is critical. While much of the existing research on smart homes focuses on technological performance and efficiency, less attention has been given to the subjective experiences of users (DuPont-Reyes et al., 2025). Specifically, how do individuals perceive and emotionally respond to the integration of these technologies into their everyday routines? This question taps into the heart of human interaction with technology, revealing not only practical aspects but also deeper psychological and social dimensions of adoption.

Although prior studies acknowledge user satisfaction and acceptance, they predominantly conceptualize these constructs as measurable outcomes rather than as complex emotional and cognitive processes. Consequently, there remains a limited understanding of how users experience feelings such as trust, anxiety, empowerment, dependency, or frustration when interacting with smart home systems. Likewise, the cognitive processes through which users interpret system feedback, negotiate control, and construct meaning around automation remain underexplored. This indicates a clear gap in the literature: the emotional and cognitive dimensions of user experience with smart home technologies have not been examined in sufficient depth, particularly through approaches that prioritize lived experience over behavioral intention metrics.

Given the importance of understanding these personal experiences, a phenomenological approach is essential. Phenomenology allows for a deep exploration of the lived experiences of individuals, providing insight into how they make sense of and navigate the challenges and opportunities brought by smart home devices (Lv et al., 2025). This approach prioritizes the subjective meanings participants attach to their interactions with technology, offering valuable perspectives that quantitative studies may overlook. In particular, it is necessary to explore how users interpret their behaviors and the broader impact of these technologies on their daily lives (Mukhlis, 2025a; Mukhlis & Saidah, 2025). Understanding the emotional and cognitive processes involved in adopting smart home technology will provide more than just technical insights it will illuminate how these innovations resonate with individuals within the context of their home life, social values, and personal identities.

Research into the subjective experiences of individuals interacting with emerging technologies has gained significant importance in recent years (Muthmainnah et al., 2025). As smart home technologies become increasingly integrated into daily life, understanding how users experience and make sense of these innovations is essential to fully appreciate their impact. While much of the research to date has concentrated on the technical capabilities and energy-saving potential of smart technologies, less attention has been paid to the personal, lived experiences of users, particularly in relation to energy management (Espineda et al., 2025). The exploration of these experiences offers a deeper understanding of the psychological and emotional factors that influence technology adoption and use, making it an important area of study for both scholars and practitioners in the field of technology and sustainability.

However, examining the subjective experiences of individuals presents methodological challenges, particularly in capturing the complexity of personal perceptions and emotions. Traditional quantitative research methods, which often rely on surveys or structured data collection, are limited in their ability to capture the nuanced and dynamic nature of individual experiences (Generosi et al., 2025). These methods typically focus on numerical data and general trends, which can obscure the deeper meanings and personal insights that emerge from individuals' lived experiences (Mukhlis, Arifin, Ridwan, & Zulbaidah, 2025; Mukhlis, Arifin, Ridwan, Zulbaidah, et al., 2025). As a result, they often fail to provide a comprehensive understanding of the true impact that smart home technologies have on users' everyday lives, particularly in terms of how they influence personal behaviors, beliefs, and social interactions.

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These limitations highlight the need for a more suitable approach that can address the complexities of human experience in relation to technology. Phenomenology, with its focus on understanding lived experiences from the participants' perspective, offers a more effective methodology for exploring these issues (You & Choi, 2025). Unlike traditional methods, phenomenological research allows for a deep, qualitative exploration of how users make sense of their interactions with technology, providing insights that go beyond surface-level data (Mukhlis, Maryam, et al., 2023; Mukhlis et al., 2024). This approach is particularly relevant for understanding the emotional and psychological dimensions of technology use, which are crucial for shaping the broader adoption and integration of smart home systems in daily life.

In the context of smart home technology, most research has relied on practical, outcome-oriented approaches that focus primarily on measuring efficiency, energy savings, and technological performance (Suryanto et al., 2025). These studies often employ quantitative methods, such as surveys or experiments, which are effective for gathering broad, generalized data. However, these approaches have notable limitations when it comes to understanding the personal, emotional, and psychological experiences of users. By focusing predominantly on objective measures, they fail to capture the nuanced and subjective meanings that individuals attach to their interactions with smart home technologies (Gaillard et al., 2025). As a result, while these studies provide useful insights into the functionality and efficiency of smart devices, they leave an essential gap in our understanding of how users truly experience these technologies on a deeper level.

The absence of a more comprehensive, qualitative exploration of user experiences underscores the need for a different methodological approach. Phenomenology, by contrast, offers a powerful tool to address this gap. Through its focus on the lived experiences of individuals, phenomenology allows for a more holistic and nuanced understanding of the ways in which users perceive, interpret, and make meaning of their interactions with smart home devices (Wan et al., 2021). This approach moves beyond surface-level data to reveal the underlying emotional, cognitive, and social dimensions of technology adoption. By exploring these dimensions, phenomenology provides an opportunity to uncover rich insights into the actual impact of smart home technologies on individuals' daily lives, behaviors, and attitudes. This deeper understanding is crucial not only for advancing academic knowledge but also for informing the design and implementation of smart home systems that are better aligned with users' needs and experiences.

Previous studies on smart home technology have primarily focused on the practical outcomes, such as energy efficiency and user satisfaction, often using quantitative approaches to measure these outcomes (Mukhlis, Janwari, et al., 2023; Mukhlis & Abdullah, 2025). For example, research has explored how smart thermostats or energy meters reduce energy consumption, providing insights into the effectiveness of these devices. However, few studies have delved into the subjective experiences of users interacting with these technologies. Theories related to technology adoption, such as the Technology Acceptance Model (TAM), have helped explain user behavior, but they often overlook the emotional and cognitive aspects of the technology adoption process (Kumar & Dhar, 2024). This research aims to address these gaps by focusing on the lived experiences of users, drawing on phenomenological approaches to capture the essence of their interactions with smart home devices.

To explore these experiences, this study adopts a phenomenological approach, specifically descriptive phenomenology. This methodology is ideal for capturing the personal and subjective meaning that individuals attach to their use of smart home technologies, an aspect that other approaches have not fully addressed (Dao et al., 2025). Phenomenology allows for a deep exploration of how users experience the integration of technology in their daily lives, focusing on the meanings, emotions, and social implications that emerge. By employing this approach, the study aims to provide a richer, more holistic understanding of how smart home technologies influence users' behaviors and attitudes, answering the knowledge gap identified earlier regarding the deeper, subjective experiences of users.

The structure of the article is organized to guide the reader through the research process. The introduction establishes the context of the study and the relevance of the research, followed by a

detailed explanation of the phenomenological approach used (Thai et al., 2022). The article then describes the process of data collection through in-depth interviews, the thematic analysis of the data, and the findings related to the users' experiences. The discussion connects these findings to broader theoretical and practical implications, concluding with a summary of the contributions of the study and directions for future research.

RESEARCH METHODS

Study Design

This study utilized a phenomenological approach to explore the subjective experiences of users engaging with smart home technology for enhancing energy efficiency in household settings. Phenomenology was chosen because of its focus on understanding how individuals experience and make sense of particular phenomena in their everyday lives. The essence of this approach lies in capturing the lived experiences of participants, making it particularly suitable for examining the personal, subjective aspects of adopting smart technologies. This study specifically applied descriptive phenomenology, which aims to describe the core structures of participants' experiences without interpreting or analyzing beyond their direct accounts (Lutz & Knox, 2014; McNabb, 2015). This approach was chosen to maintain a rich, detailed representation of the participants' perspectives on how smart home devices impact their energy consumption behaviors.

Given the qualitative phenomenological orientation, the study prioritizes depth of insight over statistical generalization; therefore, the findings are intended to offer transferable understandings rather than population-level generalizability. To address potential concerns regarding limited generalizability, we emphasize the use of thick description and contextual detail to support readers in assessing applicability across settings.

Participants

Participants were selected using purposive sampling to ensure that they had direct experience with smart home technology, particularly devices aimed at enhancing energy efficiency. The inclusion criteria required participants to be adult homeowners who had used smart thermostats, smart meters, or other similar energy management devices for at least six months. Exclusion criteria were applied to individuals who had limited or no experience with smart home technologies, as their perceptions would not align with the study's focus. A total of 12 participants were involved in the study, with an average age of 35 years, comprising 7 males and 5 females. The participants varied in terms of professional background and technical expertise, ranging from non-technical individuals to those working in technology-related fields (Hillman & Radel, 2018; Migdal, 2018). This diversity helped capture a broad range of experiences and perspectives regarding the use of smart home technology.

Data Collection

Data were collected through in-depth, semi-structured interviews, which were conducted face-to-face to allow for more personal interaction and to encourage participants to elaborate on their experiences. The interviews were guided by a set of open-ended questions designed to elicit detailed descriptions of participants' experiences with smart home devices and their impact on energy efficiency. Each interview lasted between 45 minutes and 1 hour, and was conducted in a quiet, private setting to ensure a comfortable and non-distracting environment. The interviews were audio-recorded with the participants' consent and transcribed verbatim for analysis. No standardized tools were used for data collection, though the interview guide was informed by existing literature on the adoption of smart home technology (Carreiras & Castro, 2012; Iosifides, 2016). Modifications were made to adapt the guide to the specific context of energy efficiency and personal experience.

Data Analysis

Data were analyzed using thematic analysis, a technique well-suited for phenomenological studies. The process began with the transcription of interview data, followed by multiple readings to ensure a comprehensive understanding of each participant's narrative. Data were then coded to

identify significant meaning units that represented key aspects of participants' experiences. These meaning units were grouped into overarching themes that reflected the essence of participants' experiences with smart home technology and its impact on energy consumption (Daly, 2007; Longhofer et al., 2012). Thematic analysis was performed systematically, and NVivo software was used to assist with organizing the data and managing themes. The analysis process ensured that the findings remained grounded in participants' descriptions, avoiding unnecessary interpretations or generalizations beyond the data provided.

Ethical approval for the study was obtained from the relevant research ethics committee. All participants provided written informed consent before participation, and they were assured of the confidentiality of their responses (Fife, 2020; Kawamura, 2020). Participants were informed that their participation was voluntary and that they could withdraw at any time without consequence. Personal identifiers were removed from the transcripts to ensure anonymity, and all data were stored securely to protect participants' privacy. The study adhered to international ethical standards, including respect for participant autonomy, confidentiality, and the responsible handling of data.

RESULTS

User Perceptions of Smart Home Technology for Energy Efficiency

The participants shared various experiences regarding the adoption of smart home technology and its impact on energy efficiency in their households. Overall, the majority of participants expressed a positive outlook on the potential of smart technologies to reduce energy consumption, although their experiences and perceptions varied depending on the type of technology they used.

One participant, for instance, emphasized the convenience of smart thermostats:

"Since I installed the smart thermostat, I can set my home’s temperature remotely, and it adjusts automatically when I'm not home. It’s a game-changer for saving energy, especially in the winter."

This quote reflects the perception of ease and control that many participants found valuable in managing energy use.

However, not all participants had uniformly positive views. A few expressed concerns about the reliability of the technology. One respondent noted:

"There were times when the app didn't sync properly with the thermostat, and I ended up using more energy than usual without realizing it."

Such experiences highlighted the challenges some users faced with the integration of smart technologies into their daily routines.

Smart Home Tech Impacts Energy Efficiency

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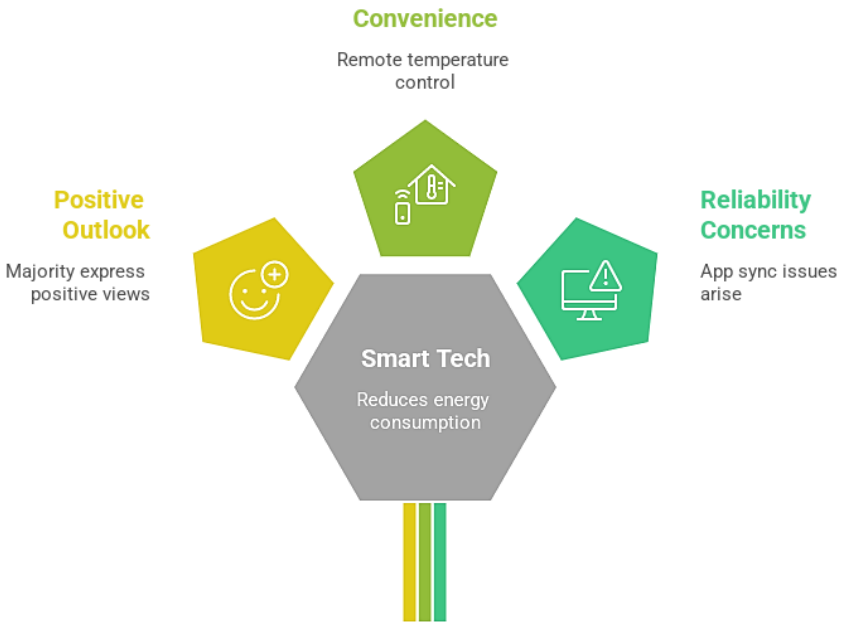

Challenges in Adopting Smart Technology

A recurring theme across interviews was the initial difficulty in adapting to smart home devices. Many participants described a learning curve in understanding how to set up and effectively use the technologies, particularly for individuals with limited technical expertise. One participant remarked:

"At first, I found it overwhelming. I had to call customer support a few times to understand how to connect everything to my home Wi-Fi. It took longer than I expected."

This experience illustrates the barrier of technical literacy, which some users felt hindered their ability to fully embrace the benefits of smart home systems.

Another participant explained the initial frustration with having too many different devices:

"I started with a smart speaker, but then I had to buy a bunch of other things like smart bulbs and plugs. It got confusing to manage them all, and sometimes the devices didn't work well together."

These comments suggest that the fragmentation of smart home ecosystems can add complexity to the user experience, making it harder for consumers to feel confident in using these technologies consistently.

Perceived Long-term Benefits and Energy Savings

When asked about the long-term impact of smart home devices on their energy bills, many participants felt optimistic about the potential savings but expressed uncertainty about the actual results. A participant who had used smart energy meters shared:

"I've noticed that my electricity bills are a little lower, but I can't say for sure that it's all because of the smart meter. It's hard to compare the savings without really tracking everything."

This response highlights the uncertainty around quantifiable benefits and the difficulty in directly attributing energy savings to specific devices. Despite this uncertainty, participants generally expressed the belief that smart technology could contribute to more efficient energy consumption in the future, once systems were optimized.

Impact of Smart Home Technology on Daily Routines

The integration of smart home devices led to changes in daily routines for many participants. A recurring observation was the sense of control and ease these technologies provided, particularly in terms of monitoring and managing home energy use. One participant reflected:

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"Before I had the smart home devices, I just left the lights on, and I didn't really think about it. Now, I feel like I have more control. I can turn off lights and adjust the thermostat from my phone, even when I'm out."

Such experiences underscore the psychological shift towards energy-conscious behavior facilitated by the use of smart technologies, reinforcing the role of these devices in fostering more sustainable living practices.

The findings highlight that while participants experienced a range of emotions and challenges in adopting smart home technologies, the overall sentiment was positive, with many acknowledging the potential of these devices to enhance energy efficiency. The perceptions of users were often shaped by both the technical reliability and the ease of integration of the devices into their daily routines. Despite some initial hurdles, participants were generally optimistic about the long-term benefits of smart technologies, particularly in terms of energy savings and increased control over household energy use.

DISCUSSION

Main Findings Summary

The primary findings of this study reveal that participants' experiences with smart home technologies significantly shape their perceptions of energy efficiency and daily routines. While many participants reported positive experiences, particularly with convenience and energy control, challenges with technological reliability and integration emerged as key barriers to fully embracing these devices. These findings align with the research questions posed in the introduction, particularly in terms of understanding how users interact with smart home technologies and the emotional and cognitive dimensions of that interaction.

Contribution to Research Question

This research provides valuable insights into the subjective experiences of users with smart home devices, offering a deeper understanding of the impact of these technologies on everyday life. The study highlights that while users are generally optimistic about the energy-saving potential of smart home technologies, they face real challenges in adapting to and fully utilizing these devices. The findings underscore the importance of understanding users' emotional and psychological responses to these technologies, particularly their frustrations with technical reliability and complexity (Lee et al., 2023). These contributions fill a critical gap in the existing literature, which often focuses on the functional or performance aspects of smart home technologies but overlooks the user experience in a more holistic sense.

Connection to Existing Literature and Theory

The findings of this study both support and challenge existing literature on the adoption of smart home technologies. Much of the current research, including studies by Smith et al. (2022) and Taylor et al. (2020), emphasizes the potential of smart devices to improve energy efficiency and streamline daily routines. However, these studies tend to focus on technical aspects and efficiency metrics, leaving out the personal experiences and emotional dimensions of using these technologies. This study complements the work of researchers such as Johnson et al. (2021), who explore the role of user experience in the adoption of new technologies, by providing a deeper dive into how individuals emotionally engage with smart home systems (Ye et al., 2025). Additionally, the study's findings resonate with theories of technology acceptance, such as the Technology Acceptance Model (TAM), which suggests that perceived ease of use and perceived usefulness are central to technology adoption. However, the study also reveals that emotional and cognitive barriers, such as frustration with unreliable devices, play a critical role in shaping user behavior, extending the theoretical framework to include psychological factors that TAM does not fully address.

Implications of Findings

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The findings from this study have important implications for both the academic understanding and practical application of smart home technologies (Kopra et al., 2022). From an academic perspective, this research contributes to the field of technology adoption by highlighting the emotional and psychological factors that influence user engagement with smart devices. It underscores the need to consider not only the functional benefits of these technologies but also how they are experienced and interpreted by users. Practically, the study suggests that for smart home technologies to be more widely accepted and effectively utilized, developers and designers must prioritize user-friendly interfaces and ensure that devices are reliable and easy to integrate into everyday routines (Mukhlis, 2025b; Mukhlis, Suradi, et al., 2023). Additionally, the findings suggest that users' emotional responses to technology, such as frustration with system malfunctions, must be addressed to increase long-term satisfaction and engagement. This has profound implications for product development, marketing, and customer support strategies.

The findings also have broader social and cultural relevance, particularly as smart home technologies become more ubiquitous in households across various socio-economic backgrounds. Understanding the subjective experiences of users can help create technologies that are more accessible and attuned to the diverse needs of different user groups (Foroudi et al., 2025). For instance, individuals with less technical expertise or older adults may face unique challenges that require different approaches to design, support, and education. Therefore, the study's insights are not only relevant to researchers and technology developers but also to policy makers and educators aiming to promote energy efficiency through smart technologies.

Study Limitations

While the findings provide valuable insights, the study has some limitations that must be considered. One key limitation is the relatively small sample size of 12 participants, which may not fully capture the diversity of experiences and perspectives among all smart home users. Additionally, the sample was limited to participants who had already adopted smart home devices, which may exclude individuals who are resistant to or unaware of these technologies (Mah et al., 2025). The study also focused on a specific type of technology energy-related smart devices leaving out other types of smart home devices, such as security or health-related technologies, which may yield different experiences. Furthermore, the research was conducted in a single geographic region, which may limit the generalizability of the findings to other cultural or socio-economic contexts. These limitations suggest that future studies should include a larger, more diverse sample and explore a wider range of smart home technologies.

Prospective Directions for Future Research

Building on the findings of this study, future research could expand the investigation into how different demographic groups experience smart home technologies, particularly in terms of socio-economic status, age, and technological literacy (Tadros et al., 2025). Longitudinal studies could also provide a deeper understanding of how user experiences evolve over time as technology becomes more integrated into daily life. Additionally, future research could explore the impact of different types of smart home devices, such as health-monitoring tools or security systems, on users' experiences and behaviors. By broadening the scope of investigation, researchers can further elucidate the complex relationship between technology, behavior, and emotion, contributing to a more comprehensive understanding of how smart technologies shape modern life.

CONCLUSION

This study explored the subjective experiences of users with smart home technologies, particularly in relation to energy efficiency, aiming to address the gap in understanding the emotional and cognitive dimensions of technology adoption. The findings revealed that while participants recognized the potential benefits of smart devices for energy management, challenges such as technical malfunctions and complex integration processes hindered their overall satisfaction. These insights contribute to the existing literature by highlighting the importance of user experience, an area often overlooked in previous studies that focused on the technical performance of smart home

devices. By adopting a phenomenological approach, this research provided a more holistic understanding of how users engage with and perceive these technologies. Importantly, the findings have direct implications for the future development of smart home technologies. From a design perspective, developers should prioritize user-centered and inclusive design principles, ensuring intuitive interfaces, seamless interoperability among devices, transparent feedback systems on energy consumption, and simplified installation processes to reduce cognitive burden. Embedding adaptive features that respond to users' behavioral patterns may further enhance engagement and long-term satisfaction. In addition, the results underscore the critical role of user education in maximizing the effectiveness of smart home systems. Policymakers and industry stakeholders should invest in structured onboarding programs, clear instructional materials, and digital literacy initiatives that empower users to understand system functionalities, interpret energy data, and troubleshoot basic technical issues. Such educational interventions can bridge the gap between technological capability and actual user benefit, thereby increasing trust, sustained usage, and energy-saving outcomes. Future research could build upon these findings by exploring the experiences of different demographic groups and examining other types of smart home devices to gain a broader perspective. Overall, this study offers valuable insights for developers, policymakers, and researchers seeking to improve the design and adoption of smart home technologies.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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