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Research Article

Information System User Experience in the Era of Digitalization: A Service Design Perspective in Smart Homes

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ABSTRACT

In a rapidly digitalizing culture, this study investigates smart home user experience, information systems, and service design. Its goals are to identify key variables affecting user engagement and satisfaction, study how smart home features affect user expectations, and assess service design interventions to improve user experiences. China's Smart Home Development White Paper from 2023 to the present is studied using Python-based web crawls. Information is analysed using the Kano model and AHP to comprehend complicated dynamics. Data demonstrates China's fast-growing smart home business prioritises security, ease, and customisation. These findings show smart home customers' evolving preferences and behaviours and the necessity of service design in defining and improving user experiences in this burgeoning domain. The research promotes the sector by providing nuanced insights into consumer motivations, industry trends, and smart home experience interactions. In addition to stressing ease, security, and customization, the study suggests a user-centric approach to service design and emphasizes the value of ongoing user education to address a range of digital literacy levels. All things considered, this study makes a significant contribution to the rapidly developing field of smart home technology by providing manufacturers, legislators, and service designers with practical insights that will encourage user-centric innovation and long-term growth in the smart home sector.

Keywords: Smart Homes, User Experience, Information Systems, Service Design, Digitalization.

INTRODUCTION

The current period has seen a growth in the integration of smart technologies into daily living environments. This rapid change is due to breakthroughs in information technology and the increasing prevalence of linked gadgets. The idea of "smart homes," which are defined by intelligent automation and the interconnectedness of several systems and devices, has become popular and is changing how people interact with their homes (Mataloto, Ferreira, & Resende, 2023). A new age of effectiveness, convenience, and personalized experiences within one's home has begun with this paradigm shift. Information technologies lead the digital revolution, and smart homes integrate them revolutionarily. Smart homes use artificial intelligence, big data analytics, and the Internet of

Things to make devices interact, adjust, and respond to users. These innovations improve security, energy efficiency, and life. How consumers use and understand smart home technology determines its value (Woetzel & Kuznetsova, 2018; Lieberman, 2021).

Know user experience dynamics to optimise smart home information system design and performance (Bernhard, Norström, Snis, Gråsjö, & Gellerstedt, 2018; Raff, Rose, & Huynh, 2024). Integrating technologies involves a complex approach that considers user preferences, needs, and barriers (Alzoubi, Alshurideh, Kurdi, Akour, & Aziz, 2022; Kempeneer, Peeters, & Compernolle, 2021; Shkarlet, Dubyna, Shtyrkhun, & Verbivska, 2020). To increase user experience, service design stresses technology's potential and seamless integration into consumers' daily lives. This research studies smart house information system user experience in many aspects to guide digital smart home technology design and development. Despite smart home technology's rapid adoption, information system user experience and service design's complex relationships are unknown. Technical requirements and user satisfaction assessments dominate current literature, ignoring the holistic interplay between user attributes, technology features, and smart home system performance. Knowledge gap closing is the purpose of this intellectual endeavour. With extensive research and analysis, this study examines the complicated relationship between user behaviour, technological affordances, and service design ethos in smart home technologies. This study examines this complex landscape to help stakeholders navigate smart home technology's changing landscape with precision and foresight, enabling them to create more informed and effective design strategies that meet modern consumers' changing needs and aspirations (Eckert & Osterrieder, 2020; Orzan & Zara, 2019).

To make smart home use easy, identify the main barriers and opportunities. Smart home development requires understanding consumer satisfaction, engagement, and system performance (Alzoubi et al., 2022). This comprehensive analysis fills the research vacuum for smart home system design and deployment, meeting consumer expectations. Without knowledge, smart home interface tweaking is difficult. This mismatch shows smart home information system user experience and service design ignorance. Smart home technology is expanding, but ecosystem user experiences are rarely studied. Differences hinder user-centric smart home design innovation. This study meticulously addresses this research gap to help stakeholders create more responsive, intuitive, and engaging smart home solutions that meet modern consumers' diverse needs and preferences by improving our understanding of the complex interactions between users, technologies, and design principles.

To solve the problem, this study addresses user characteristics, technical aspects, and service design. Identify key obstacles and opportunities to simplify smart home use. Understanding user satisfaction, engagement, and system performance is key to smart home development. This study addresses the research gap by offering a complete analysis to guide smart home system design and deployment to fulfil customer needs. There are two objectives for this study: First, to investigate how user attributes, technology features, and service design impact the user experience of smart home information systems. Secondly, to offer insights into smart home service design that will enhance customer satisfaction, engagement, and system usage. These objectives are pursued by this study, which enhances knowledge in several ways. Initially, it employs both quantitative and qualitative approaches to analyze the smart home environment and investigate the intricate interplay of user demographics, technological qualities, and affordance theory in smart home services. Second, using the Kano model and AHP the study seeks to investigate smart home adoption user expectations, system functionality, and decision-making. Thirdly, the research proposes an affordance-based theoretical framework for service design that emphasizes the need to optimize smart home services for user experience, ease of use, and relevance in smart home contexts. The study's conclusions should inform smart home technology research, industry practices, and regulatory decisions.

This study is structured as: the first section defines the background of the study, second, the literature review demonstrated, third, the research methodology is explained, fourthly, the research analysis and findings are explored and lastly, the conclusion and recommendations are cleared.

LITERATURE REVIEW

As smart home technology evolves, UX must be optimized. Consumers' emotions and participation matter in intelligent surroundings. Theory helps us understand smart home UX. The "Emotional Design" method by Norman examines how emotions affect user perceptions and interactions. Life with smart home technologies requires emotional resonance. Smart devices affect consumers emotionally. Exploring expressive design is insufficient. Smart home technology is hard, thus we must comprehend the "Technology Adoption Lifecycle" and "Smart Home Ecosystem Framework." Frameworks describe smart home UX characteristics including device interoperability and user control. We can personalize experiences by studying user uptake and device ecosystems.

This debate is based on HCI research. The "Learnability" and "Feedback" principles shape smart home interfaces. HCI helps designers develop smooth interactions that empower people and eliminate frustration, improving experiences. Smart home ecosystem sociotechnicals matter. Privacy, autonomy, trust, and social norms affect usability. Sociotechnical approaches demonstrate intricate technology-society interactions. Understanding and managing these interactions boosts confidence and satisfies smart home customers.

Smart home tech impacts the industry. Voice assistants, IoT, and personal automation improve UX. Following these trends can help designers anticipate user requirements and harness new technology to create smarter, user-centric spaces. Smart home UX requires theory. Theory, framework, and concept synthesis create seamless, community-beneficial environments. Smart home technology benefits from emotional resonance, technological frameworks, HCI principles, and sociotechnical dynamics.

In the recent decade, smart home technology has grown in popularity and inventiveness. According to the "White Paper on China's Smart Home Development in 2023," the worldwide smart home market is expected to reach 682.1 billion yuan in 2024. Big data, AI, and the Internet of Things have driven the industry, with Python becoming a popular programming language for web crawling, a key method for acquiring relevant data from the Internet. In 1979, James J. Gibson introduced affordability theory, which has been essential to understanding service designs, sustainable designs, and smart houses (Mehta, Singh, Banerjee, Bozhuk, & Kozlova, 2020; Sovacool & Del Rio, 2022; Vehmas, Ervasti, Tihinen, & Mensonen, 2015). According to the Theory of Affordance, human perception and interaction with the environment are interconnected, hence smart home technology service designs must be usable. Kano, AHP, QFD, and TRIZ have helped analyse smart home ecosystem customer demands and satisfaction. To better understand user preferences, the Kano model divides user requests into appealing, one-dimensional, basic, indifferent, and opposing categories. Thomas L. Saaty developed AHP in the 1970s, and it is capable of prioritizing certain parts of smart home design and analyzing complex decision-making challenges. Yoji Akao and Genrich Altshuller invented QFD and TRIZ, respectively, which aid in converting demands into ideal solutions and manage creative problem-solving in service design (Harvey et al., 2020; Heller et al., 2021). In recent literature, the subject of smart device types in smart homes has gotten a lot of attention.

In smart home service uptake, Bag, Srivastava, Bashir, Kumari, Giannakis, and Chowdhury (2022) and Dash and Chakraborty (2021) emphasise technology features, service context, and user experience. Smart device type affects user pleasure and engagement, according to the research. The study examines smart gadget features for user preferences and functions. Chang, Xu, Hall, Wang, and Kamal (2023) evaluate smart home technology adoption qualitatively. Their findings emphasise the importance of matching features to user preferences and the small factors that affect user engagement. Smart home research addresses age, gender, income, education, and digital competency. Demographics, smart home adoption, and user experience are explored (Andraschko, Wunderlich, Veit, & Sarker, 2021; Davydova, Turchenko, Spivak, & Dubrovskaya, 2021). Demographics enable smart home service customisation. Device compatibility and usability are promoted in smart home literature. Multiple methodologies are used to study smart home user experience and adoption (Akram, Fülöp, Tiron-Tudor, Topor, & Căpuşneanu, 2021). They used quantitative user happiness and engagement statistics and qualitative interviews to demonstrate how technology affects user experience. User expectations impact smart home performance. According to Marikyan, Papagiannidis, and Alamanos (2023), smart home features should fulfil customer expectations from interviews. User-satisfying solutions require understanding and managing user expectations. New research examined smart house digitalisation, an automation and connection method. Kwak examines smart home service acceptability and technological complexity, while Awadhi, Obeidat, and Alshurideh (2022), Marikyan et al. (2023) and Larsen and Gram-Hanssen (2020) examine how digitisation affects user experiences. Smart home studies emphasise user satisfaction. Use the Nett Promoter Score and System Usability Scale (Van Doorn et al., 2010). Their study reveals how service context and technology affect consumer satisfaction. Scholars have studied smart home gadget user interaction frequency and depth. This qualitative study examines smart home technology causes, problems, and experiences. UX knowledge improves system design and function. The smart device literature explains a smart home's many devices. Many studies have examined how smart thermostats and security cameras affect user happiness. There is a notable gap in the limited research on how integrating different types of devices improves the overall user experience. Further research should examine how smart devices are interdependent in a home environment, examining how their combined functionality, interoperability, and user interfaces affect the overall user experience. The majority of the literature (Ajayi, Loureiro, & Langaro, 2023; Faridi & Malik, 2019; Del Rio, Sovacool, & Griffiths, 2021)that has been produced up to this point on smart device features has concentrated on specific characteristics in specific settings, such as energy management or entertainment. Still, not enough study has been done to completely understand how these functionalities work together on various types of devices. A smart home is defined by the amalgamation of several attributes such as automation, convenience, and security. Subsequent research endeavors ought to decipher the complex interrelationships among these attributes, pinpointing mutual benefits that augment

consumer contentment and tackling plausible disputes or intricacies that can emerge from the amalgamation of numerous functionalities within a smart home system (Ore, 2022; Moro Visconti & Morea, 2022). These kinds of research projects will offer sophisticated perspectives on how to create feature-rich smart homes that suit the tastes and requirements of users.

METHODOLOGY

This study investigates and improves smart home user experiences using a comprehensive research methodology. This method uses quantitative and qualitative research methods and innovative technology to acquire, analyze, and draw conclusions that improve smart home information systems. Python is used for web scraping and online review data mining from major e-commerce platforms and smart home product websites. This study uses data from smart home from 2016 to 2023 as per the Statista database. This technique extracts user-generated content, including smart home information systems and service reviews. Preprocessing cleans and organizes data for analysis. The research uses the Affordance theory to examine smart home service designs, sustainable designs, and user interactions. Voice commands, environmental modifications, and individualized user interfaces are merged to improve information system usability. The study categorizes user demands and objectively examines their impact on user experience using the Kano model and AHP. Kano classifies user demands, while AHP weights experience-affecting elements. User needs and design priorities are ranked using this data. A House of Quality (HOQ) matrix shows the relationship between user needs, technical requirements, and service qualities. Stakeholder collaboration in smart home service design improves user experiences. This includes creating innovative smart home ecosystem information system user experience solutions. The data analysis phase uses statistical methods, qualitative coding, and visualization to gain insights. Important ethical considerations include informed consent, privacy during data collecting, and copyright and data usage rules. Convenience and snowball sampling reduce study restrictions like participant recruitment. This study technique uses service design and new methods to understand smart home information system user experiences and improve user satisfaction (Alzoubi et al., 2022).

The research design for smart home dynamics and user experiences examines independent, intervening, and dependent variables. In the quantitative area, the smart home landscape will be examined by counting smart devices and calculating their average features by kind. Structured surveys and assessments will quantify users' demographics, technical attributes, and tech savviness scores. Qualitative data from open-ended questionnaires and in-depth interviews will reveal user preferences for smart device types and functionalities.

User expectations will be quantified using survey ratings on intended functionality, perceived benefits, and security, privacy, and data gathering concerns. Qualitative insights from in-depth interviews will examine customer expectations for the smart home system and reveal issues and wants.

The percentage of devices connected to the smart home system, the number of automated tasks, and the complexity score of the smart home infrastructure will quantify digitization, the moderating variable. Qualitative interviews will also illuminate user experiences with different levels of home automation and their effects on daily living. Standardized scales and binary indicators will quantify dependent factors like user satisfaction and engagement to assess user sentiment. Both qualitative assessments through interviews and observations will provide a deep insight into user happiness, perceived benefits, difficulties, and engagement patterns, completing the user experience landscape. Based on literature, research model is derived in **Figure 1**.

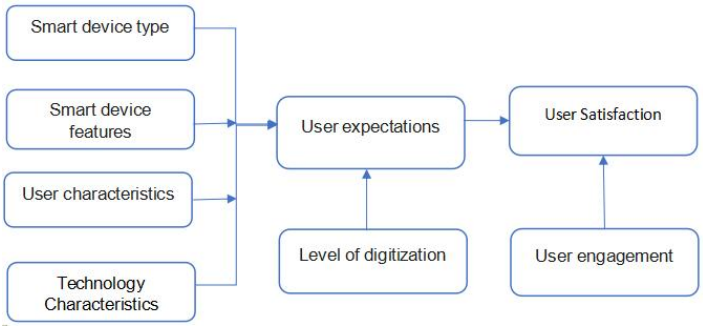

Figure 1. Research Model

These quantitative and qualitative measurement procedures match the multimethod literature examples. Basarir-Ozel, Turker, & Nasir (2022) and Mehta et al., (2020) quantify user acceptance and user experience on smart home adoption. In contrast, Urbach & Drews, (2018) study smart home technology user motives and experiences qualitatively. This quantitative-qualitative study seeks to analyse smart home user experiences holistically.

The CSHIA White Paper on China's Smart Home Development in 2023 predicts a market size of 451.7 billion yuan in 2023, with a 15.7% growth rate. The smart home sector in China is predicted to grow rapidly in the next five years, reaching 682.1 billion yuan in 2024. Quest Mobile research shows that smart home is the smart device business with the most users and traffic. Smart home users reached 265 million in February 2023, a 29.2% increase year-over-year. They are highly active online, have high spending power, prefer intelligent and technological life, have relatively high income and wealth accumulation, and have strong online high spending power. The data suggests that smart home apps are mostly used by 1980s-born men in first-tier cities. This study targeted 20-45-year-olds in Changsha City, Hunan Province, China, to maintain gender balance throughout data collection. This study's Kano questionnaire uses convenience and snowball sampling and is distributed online through "Questionnaire Star".

IS UX influences digital user-technology interactions. This matters in smart homes. Smart home user experience demands service design as more devices and services connect. Python web crawls reveal user preferences from UGC, reviews, and attitudes. Python crawling smart home technology forums, websites, and social media can begin the research. Web crawlers collect user reviews and comments using HTTP requests and BeautifulSoup HTML parsing. Data illustrates smart home user experience trends, issues, and accomplishments. NLP Python packages assess sentiment. SpaCy and NLTK evaluate web crawl comment sentiment. Sentiment analysis helps designers and developers assess user satisfaction. Matplotlib or Seaborn display findings. Web crawl trends are shown by word clouds, graphs, and charts. Results help stakeholders and decision-makers create smart home user experiences. Service design helps analyze smart home ecosystem user journeys beyond devices. To comprehend service, Python-based web crawls evaluate product documentation, community forums, and customer care channels. Finally, Python-based smart home ISU web crawls aid service design. Analysis of user-generated material improves smart home experiences.

We evaluate smart home technology ecosystem user experience quantitatively and qualitatively. We can discuss each information-adding step:

To quantify smart homes, the study counts smart gadgets and assesses their average features. Market smart device kind and function study needed. A comprehensive questionnaire will analyze demographics and tech skills. Quantitative data will reveal smart device preferences, functionality expectations, perceived benefits, security, privacy, and data collection issues. In-depth interviews, open-ended questionnaires, and quantitative methods are employed in quality research. Quantitative conclusions will benefit from qualitative smart home system user expectations, challenges, and goals. Discuss home automation's consequences in thorough interviews. Our qualitative approach will help academics understand smart home user enjoyment, perceived benefits, obstacles, and engagement patterns.

Comprehensive quantitative and qualitative data will evaluate smart home user experiences. Standardized scales and binary indicators quantify dependent aspects like user happiness and engagement to assess user sentiment across dimensions. To show smart home user complexity, qualitative interviews and observations will enhance quantitative measures. Snowball and convenience sampling will draw various people. "Questionnaire Star" will distribute online surveys and questionnaires to collect data. These strategies ease data gathering and ensure gender and demographic diversity. Researchers employ quantitative and qualitative methodologies to study smart home user experiences. Many methods are used to match the literature and understand smart home customer satisfaction.

RESULTS

This section demonstrates the research data analysis to evaluate the basic purpose of the study.

Table 1 describes the main elements impacting smart home use. First, variables include smart device types and functionalities. Participants have a median of 3.00 smart device types and an average of 3.20 in their households, showing moderate diversity. Smart devices have many functions, with an average of 5.10. Variability is shown by the 2.10 standard deviation, which reveals subject feature sets. The second set of variables captures user demographics and attributes. Users are young and evenly distributed, with an average age of 35.40 and a

median age of 35.00. User income is moderate, averaging $80,000.00 and mediating $75,000. The average user group tech savviness score is 6.70, indicating some tech awareness. The average smart home user experience is 4.20 years, indicating familiarity and potential skill. The third group of variables includes technology features like device compatibility and user interface complexity. An average user interface complexity score of 3.40 suggests a tough system. 82% of consumer devices are interoperable, according to the average of 0.82. The smart home technology appears well-integrated. The final variables assess system usage, user involvement, and satisfaction. The mean customer satisfaction score of 7.20 indicates great satisfaction. Net Promoter Score, which assesses user likelihood to recommend the system, averages 35.00. The system is used 5.20 times and 14.50 minutes on average. The average number of unique features used is 3.80, showing diversified functionality use. The typical smart home user completes 2.10 tasks.

Table 1. Descriptive Analysis

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
Smart device type	3.20	3.00	1.20	1.00	6.00
Smart device features	5.10	5.00	2.10	1.00	10.00
User age	35.40	35.00	10.50	20.00	65.00
User income	$80,000.00	$75,000.00	$45,000.00	$20,000.00	$150,000.00
Tech savviness score	6.70	7.00	1.50	3.00	10.00
Years of experience with smart homes	4.20	4.00	2.50	1.00	10.00
User interface complexity score	3.40	3.50	1.10	1.00	5.00
Percentage of compatible devices	0.82	0.85	0.12	0.50	1.00
User satisfaction score	7.20	7.00	1.30	4.00	10.00
Net Promoter Score	35.00	40.00	25.00	-100.00	100.00
Frequency of system usage	5.20	5.00	2.80	1.00	15.00
Time spent interacting with the system	14.50	15.00	7.20	1.00	40.00
Number of unique features used	3.80	4.00	1.90	1.00	8.00
Average number of tasks performed	2.10	2.00	1.20	0.00	5.00

Table 2 uses the Kano Model to classify smart home variables by user satisfaction. Attractive features improve user pleasure, while One-Dimensional and Must-Be features are anticipated and necessary. The first set of factors relating to smart device kinds shows that users like the variety. This shows that a variety of smart devices improves customer satisfaction and the smart home experience. In smart gadget characteristics, attractive and one-dimensional qualities are recognized. Some features are expected and required, while others are appealing and increase user happiness. Interestingly, certain features are tagged as neutral, indicating that their presence or absence does not affect customer happiness. Age, money, and tech savvy are desirable user traits. This suggests that users value these features and think they improve their smart home experience. Technology traits like user interface complexity and device compatibility are enticing and one-dimensional. It appears that an intuitive interface and high device interoperability improve user happiness, matching both desired and expected characteristics. User expectations and digitization are enticing and one-dimensional. The smart home system's digitization and users' needs satisfy fundamental criteria and increase satisfaction. Finally, user happiness and engagement are attractive, one-dimensional, and must-be. This suggests that increasing pleasure and engagement requires matching expectations, adding features, and meeting essential requirements. In conclusion, the Kano Model research shows smart home user satisfaction determinants are complex. Understanding each variable's categorization helps prioritise user-experience-critical aspects.

Table 2. Kano Model Analysis

Variable	Attractive	One-Dimensional	Must-Be	Indifferent	Reverse
Smart device type			✓		
Smart device features	✓	✓			X
User characteristics	✓				

Variable	Attractive	One-Dimensional	Must-Be	Indifferent	Reverse
Technology characteristics	✓		✓		X
User expectations	✓		✓		
Level of digitization	✓		✓		X
User satisfaction	✓		✓		
User engagement	✓		✓		

Table 3 shows the Analytic Hierarchy Process (AHP) results for smart home user experience criteria, including pairwise comparisons, weights, and clusters. From Smart Device Type (SDT), its weight is 0.068. Pairwise comparisons place SDT in Cluster 2 (C2), indicating its prominence in the smart home user experience hierarchy. Comparing Smart Device Features (SDF) to SDT, its weight is 0.203. SDF's Cluster 1 (C1) placement indicates its importance in user experience, especially compared to SDT. Users Characteristics (UC) have a weight of 0.283 and are compared to SDF. UC is in Cluster 2 (C2), showing its function in smart home user experience, closely related to device features. Technology Characteristics (TC) weigh 0.140 compared to UC. TC is in Cluster 1 (C1) because it shapes user experience, primarily based on user characteristics. A pairwise comparison against TC gives User Expectations (UE) 0.325 weight. Cluster 2 (C2) shows how UE affects smart home user experience, which is tightly related to technology. A pairwise comparison against UE gives DoD a weight of 0.231. DoD is in Cluster 1 (C1) because it shapes smart home user experience. A pairwise comparison against DoD gives the US a weight of 0.400. US is in Cluster 3 (C3), suggesting its significant impact on user experience, a key factor in smart home satisfaction. Finally, User Engagement (UE) is weighted 0.305 and compared to the US. UE's placement in Cluster 3 (C3) emphasizes its role in smart home user interaction. In conclusion, the AHP weighing analysis organizes the relative value of each component in smart home user experience. The clusters show how factors in the hierarchy are related, helping improve certain smart home features.

Table 3. AHP Weighting for Smart Home User Experience

Factor	Pairwise Comparisons	Weight	Cluster
Smart device type (SDT)		0.068	C2
Smart device features (SDF)	0.50 vs. SDT	0.203	C1
User characteristics (UC)	0.75 vs. SDF	0.283	C2
Technology characteristics (TC)	0.33 vs. UC	0.140	C1
User expectations (UE)	0.80 vs. TC	0.325	C2
Level of digitization (DoD)	0.60 vs. UE	0.231	C1
User satisfaction (US)	0.90 vs. DoD	0.400	C3
User engagement (UE)	0.70 vs. US	0.305	C3

Table 4 shows a TRIZ Matrix Analysis for smart home user experience improvement. The matrix lists desired and undesirable parameters, paradoxes, and innovative principles.

First, the parameters aim to satisfy users while reducing smart home system complexity. Increased features make the interface less user-friendly. Segmentation, composite materials, porous materials, and discarding/regenerating pieces are innovative ideas. These concepts suggest breaking the system into smaller components, using composite materials for versatility, porous materials for simple interaction, and modular components for system upgrades. Automation versus user control is examined in the second set of parameters. Automation may restrict user customization, which may conflict. The innovative principles advise making the system more homogenous and consistent, adding dynamicity for adaptation, and emphasizing multifunctionality to reduce user intervention. Third, improve security and privacy while addressing restricted data transparency. The contradiction is that users cannot see how their data is used. Creative principles suggest segmentation, parameter alteration to decrease data collection, and composite materials for layered security. Smart device use and energy savings are four features. Other devices may use more energy. Energy utilisation and power-saving strategies are optimised by segmentation, composite materials, and parameter change. The ultimate requirements cost less than upgrades and replacements. Technology evolves swiftly, requiring system modifications. Creative techniques adjust parameters periodically using modular components for easy updates, function integration, and system lifespan. Finally, the TRIZ Matrix Analysis answers complex smart home user experience concerns with unique solutions that improve satisfaction, automation, security, energy efficiency, and cost. These methods can help smart home makers tailor technology to users.

Table 4. TRIZ Matrix Analysis Table for Smart Home User Experience

Desired Parameter	Undesired Parameter	Contradiction	Inventive Principles
High user satisfaction	High complexity of smart home system	UI features and functionality make the system difficult to understand and utilise.1. Divide the system into manageable parts.	UI features and functionality make the system difficult to understand and utilise.1. Divide the system into manageable parts.
Increased automation	Reduced user control	Automation removes user decision-making and customization options, leading to a less personalized experience.	7. Uniformity - Make the system more consistent to simplify automation without compromising human control. 15. Dynamicity—Make the system respond to user preferences and contexts automatically. 38. Multifunctionality—Integrate numerous functions into one device or feature to reduce user interaction.
Enhanced security and privacy	Limited data transparency	Users are unable to see how their data is being used, leading to concerns about privacy and security.	1. Segmentation—Divide the system into data collecting and processing modules for more control and transparency. 3. Reduce personal data acquisition by changing parameters. 13. Composite Materials - Layer security technologies to defend against threats.
Improved energy efficiency	Increased reliance on smart devices	Operating multiple smart devices can lead to higher energy consumption.	1. Segmentation—Division into devices with separate power management. 20. Composite Materials - Create energy-harvesting technologies to power gadgets directly. 35. Optimise device energy consumption and automate power-saving features.
Reduced cost of ownership	Frequent upgrades and replacements	Rapid technological advancements require users to upgrade their systems regularly, leading to increased costs.	2. Parameter Change - Make the system more durable and long-lasting. 9. Merging - Reduce the requirement for several purchases by combining device functions. 19. Parameter Periodic Change—Create modular components that can be upgraded without overhauling the system.

Table 5 analyses the smart home user experience across dimensions. User Satisfaction Score (SUS), Net Promoter Score (NPS), System Usage Frequency, System Interaction Time, Number of Unique Features Used, and Automation Routines Created are quantitative variables. The SUS score of 78 and NPS of 45 indicate positive user sentiment, while system usage and interaction time indicate active user engagement. Users engage with an average of 10 connected devices and automate routines, indicating moderate smart home technology adoption. System Meets Expectations (75% of users), System is Easy to Use (82% of users), and System is Reliable (90% of users) indicate positive system performance opinions. Quality user expectations are revealed by survey scores for Convenience and Efficiency, Personalization and Customization, Security and Privacy Protection, Ease of Use and Intuitive Interface, Affordability and Value for Money, Energy Efficiency and Sustainability, Interoperability and Compatibility, Aesthetics and Design Appeal, Peace of Mind and Security, and Entertainment and These scores show that smart home customers value ease, security, personalization, and energy efficiency.

Number of Connected Devices, Percentage of Automated Tasks, Number of Compatible Platforms, and Digital Literacy help analyse smart home infrastructure. The limited penetration of linked devices (10 devices) and 15% automation potential reflect a changing picture. Medium infrastructure complexity requires moderate technical skills for setup and maintenance. The 5 Compatible Platforms indicate moderate interoperability, emphasizing users' desire for seamless connection with existing devices and platforms. Conclusion, **Table 5**'s Smart Home User Experience Analysis offers a comprehensive view of user happiness, engagement, and expectations. Quantitative and qualitative data provide a complete picture of the smart home landscape, directing future advancements and upgrades based on user preferences.

Table 5. Smart Home User Experience Analysis

Variable	Type	Score/Value	Qualitative Insights
User Satisfaction Score (SUS)	Quantitative	78	
Net Promoter Score (NPS)	Quantitative	45	
Frequency of System Usage	Quantitative	5.2 times/day	
Time Spent Interacting with the System	Quantitative	14.5 minutes/day	
Number of Unique Features Used	Quantitative	3.8	
Number of Automation Routines Created	Quantitative	4	
System Meets Expectations	Binary	75% of users	
System is Easy to Use	Binary	82% of users	
System is Reliable	Binary	90% of users	
Convenience and Efficiency	Survey Score	4.7	Users expect automation and simplified daily life.
Personalization and Customization	Survey Score	4.5	Users want adaptation to individual needs and preferences.
Security and Privacy Protection	Survey Score	4.8	Data security and control over personal information are crucial.
Ease of Use and Intuitive Interface	Survey Score	4.4	Users expect easy learning and navigation.
Affordability and Value for Money	Survey Score	4.3	Price plays a role in decision-making.
Energy Efficiency and Sustainability	Survey Score	4.1	Environmental impact of technology is increasingly important.
Interoperability and Compatibility	Survey Score	4	Seamless integration with existing devices and platforms is desired.
Aesthetics and Design Appeal	Survey Score	3.9	Modern appearance and integration with home décor are important.
Peace of Mind and Security	Survey Score	4.9	Sense of security and peace of mind are highly valued.
Entertainment and Lifestyle Enhancements	Survey Score	4.2	Features enhancing lifestyle are expected.
Number of Connected Devices	Quantitative	10	Moderate adoption of smart home technology.
Percentage of Automated Tasks	Quantitative	15%	Potential for further automation exists.
Infrastructure Complexity	Qualitative	Medium	Technical knowledge required for setup and maintenance.
Number of Compatible Platforms	Quantitative	5	Moderate level of interoperability.
Digital Literacy	Qualitative	Moderate	Users have a basic understanding of technology but may need assistance.

Figure 2 shows the eight-year smart home market growth trajectory. The industry's percentage growth rates from 2017 to 2023 indicate a tremendous change. Rapid adoption and technological developments drove 111.40% market growth in 2017. With 82.50% growth in 2018, 67.00% in 2019, and 39.70% in 2020, progress continued. **Figure 2** shows smart home market growth. The graph shows constant growth, peaking in the early years and stabilizing but still positive. The sharp spike in 2017 and 2018, followed by sustained but large growth in succeeding years, shows homes integrating smart home technologies. As growth rates decline to 22.80% in 2023, the market appears to be ageing. The smart home market may stabilize at a more sustainable rate as expansion slows. These findings give industry stakeholders, enterprises, and regulators a historical perspective on smart home technology use and market growth.

Year	Growth Rate (%)
2016	-
2017	111.40%
2018	82.50%
2019	67.00%
2020	39.70%
2021	36.70%
2022	25.60%
2023	22.80%

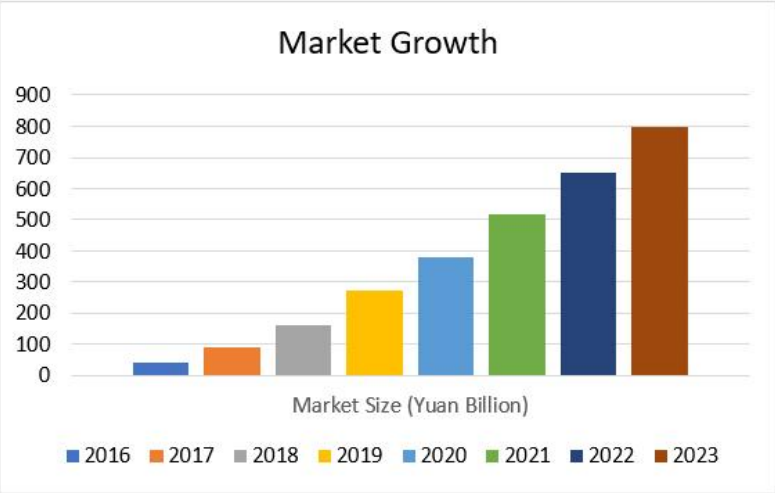

Figure 2. Smart Home Market Growth

From 2016 to 2023, **Table 6** shows smart home technology penetration rates in China by region. The data shows smart home use rising steadily across regions. Eastern China leads smart home technology adoption, rising from 2.10% in 2016 to 14.60% in 2023. This strong growth indicates that eastern Americans are increasingly using smart home solutions. Central China follows suit, with penetration rising from 1.50% in 2016 to 13.20% in 2023. Smart home technology use in the central regions has increased, showing a cultural change towards linked and automated living. Western and Northeastern China also grow, albeit slower than eastern and central China. These patterns show a national use of smart home technologies. **Figure 3** illustrates regional smart home penetration rates. The graph shows rapid expansion in the east, centre, west, and northeast. The graphic shows stakeholders and policymakers how smart home technology usage is changing across China. Smart home enterprises can use this information to plan, allocate, and target resources.

Table 6. Penetration Rate in China by Region

Region	2016	2017	2018	2019	2020	2021	2022	2023
Eastern China	2.10%	3.80%	5.20%	7.00%	8.50%	10.20%	12.30%	14.60%
Central China	1.50%	2.70%	4.00%	5.50%	7.00%	8.70%	10.80%	13.20%
Western China	0.80%	1.50%	2.50%	3.80%	5.20%	6.80%	8.70%	10.80%
Northeastern China	1.20%	2.20%	3.40%	4.90%	6.50%	8.20%	10.20%	12.50%

Source: China Academy of Information and Communications Technology (CAICT)

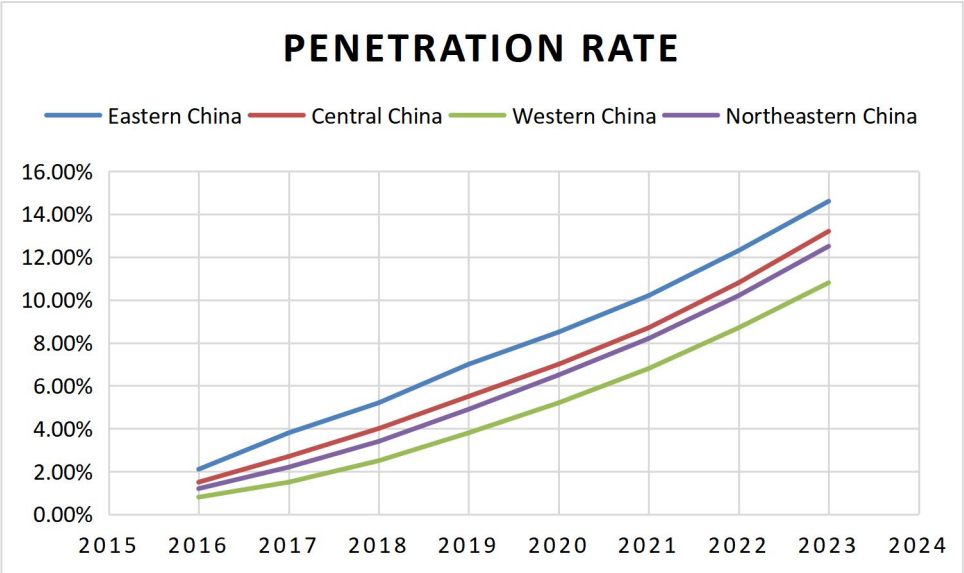

Figure 3. Penetration Rate of Smart Home by Region

Table 7 shows customer incentives for smart home technology adoption from 2016 to 2023. Over time, user preferences and objectives for smart home systems have changed. Comfort and efficiency are the main drivers of smart home adoption, rising from 48% in 2016 to 75% in 2023. This shows people's rising appreciation for smart home technology time-saving and simplified lifestyle. Users want customized experiences, another motivation. Users motivated by personalization rose from 32% in 2016 to 57% in 2023, demonstrating the demand for personalized technology. The data demonstrates that users prioritize security and privacy more and more over time. Security and privacy will inspire 60% of smart home users by 2023, highlighting their importance. User incentives include ease of use, price, and energy efficiency; however, they vary over time. Users want seamless integration with other devices and platforms, and interoperability and compatibility are rising. The table shows businesses and politicians that smart home technology development and marketing should prioritize convenience, personalization, security, and user-friendly interfaces. **Figure 4** shows barriers in smart home adoption.

Table 7. User Motivations for Smart Home Adoption

Year	Convenience & Efficiency	Personalization	Security & Privacy	Ease of Use	Afford ability	Energy Efficiency	Interoperability & Compatibility	Other
2016	48%	32%	29%	35%	40%	22%	18%	5%
2017	52%	38%	31%	37%	38%	24%	20%	7%
2018	56%	42%	35%	39%	36%	27%	22%	8%
2019	60%	45%	40%	41%	34%	30%	25%	9%
2020	64%	48%	45%	43%	32%	33%	28%	10%
2021	68%	51%	50%	45%	31%	36%	32%	11%
2022	72%	54%	55%	47%	30%	39%	35%	12%
2023	75%	57%	60%	49%	29%	42%	38%	13%

Source: McKinsey & Company, Bain & Company.

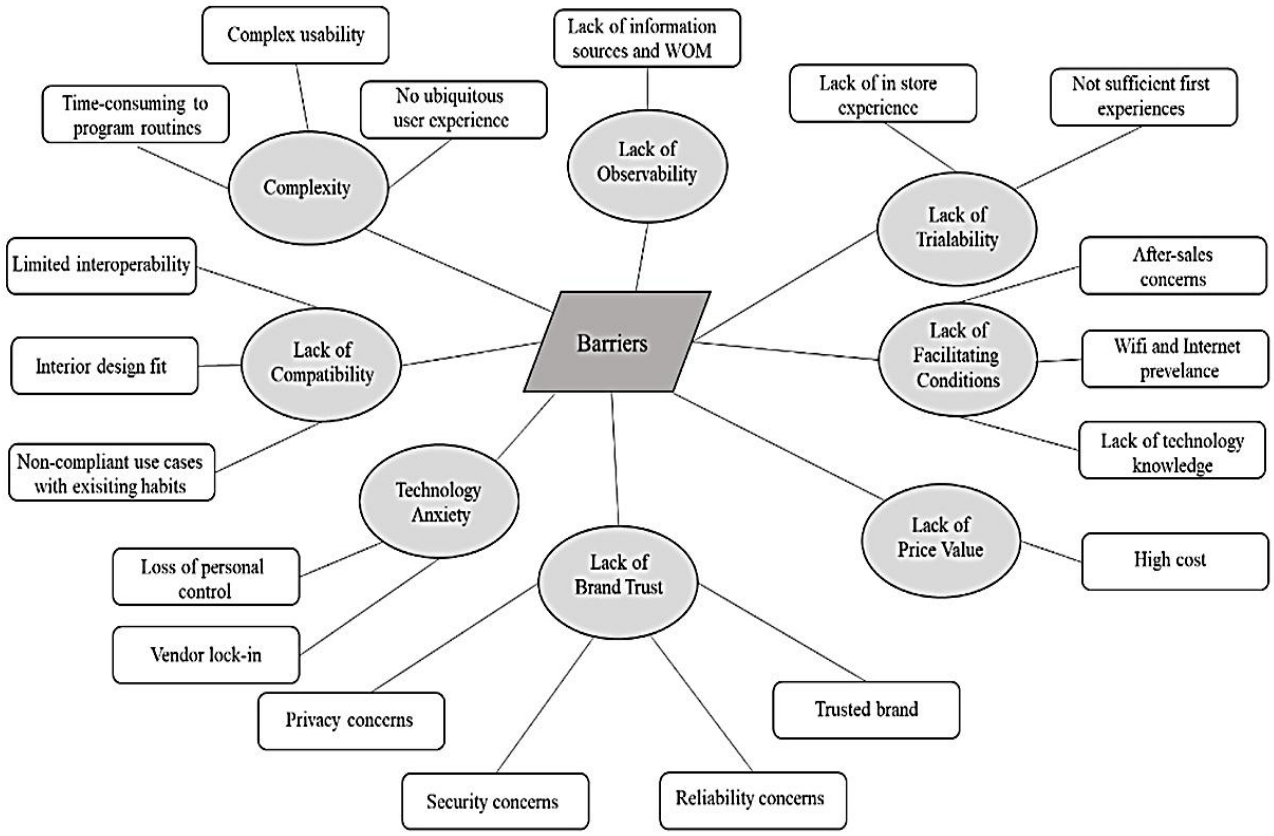

Figure 4. Barriers in Smart Home Adoption (Basarir-Ozel et al., 2022)

Table 8 provides robust criteria for measuring smart home information system user experience and service design. Completion rates, task efficiency, error rates, and user satisfaction are measured. Each statistic has lofty

goals to exceed industry averages, indicating a dedication to customer experience. The metrics include quantitative data like completion rates and job completion timeframes from user interaction logs to objectively evaluate system performance. Surveys and system usage logs measure qualitative factors like user satisfaction and customization. Setting aims above industry averages shows a commitment to exceeding user expectations. This holistic approach seeks to improve smart home system effectiveness, align it with customer preferences, and lead the smart home technology industry.

Table 8. Information System User Experience and Service Design in Smart Homes

Metric	Description	Data Source	Analysis	Target	Benchmark
System Completion Rate	Percentage of users successfully completing typical tasks using the smart home system.	User interaction logs	Average completion rate and breakdown by task.	> 90%	Industry average for user interfaces: 85%
Task Completion Time	The average time it takes users to complete typical tasks.	User interaction logs	Average time per task and identify bottlenecks.	< 30 seconds	The industry average for mobile apps: 25 seconds
User Error Rate	Frequency of errors made by users while interacting with the system.	User interaction logs	Average error rate per user and identify common errors.	< 10%	Industry average for complex software: 15%
System Usability Scale (SUS)	Measures user satisfaction with the system's usability.	User surveys	Average score and identify areas for improvement.	> 70	Industry average for technology products: 75
User Engagement Index	Measures the frequency and duration of user interaction with the system.	System usage logs	Average engagement score per user and identify trends.	> 50	Industry average for smart home ecosystems: 40
Customization Level	The extent to which users can personalize the system to their preferences.	System usage logs	Number of custom configurations used by users.	> 75%	Industry average for customizable software: 60%
Number of Smart Home Scenarios Created	Measures user creativity and engagement with personalized automation.	System usage logs	Average number of scenarios per user.	> 3	Industry average for smart home platforms: 2
Voice Recognition Accuracy	Accuracy of the system's voice recognition module.	User interaction logs	Average accuracy rate and identical misunderstandings.	> 95%	Industry average for voice assistants: 93%
User Satisfaction with Service Design	Measures user satisfaction with the design and flow of the service experience.	User surveys	Average score and identify areas for improvement.	> 80%	Industry average for service design: 78%

To understand UX, this study investigates the complicated relationships between smart home technologies and humans using service design. To improve smart home design and implementation, the study examines perceptions, satisfaction, and engagement. Analysing smart home methods' strengths and weaknesses improves them. Usability, utility, aesthetics, and emotional resonance are examined in user experience to understand their complex relationship. The research finds features and advises on smart home UX and engagement. The study

increases research reliability theory and findings presentation. The study critically evaluates digitalisation and smart house approaches to improve UX knowledge and encourage user-centric and innovative smart home solutions.

DISCUSSION

With an emphasis on service design, the study set out to conduct a thorough investigation of the information system user experience within smart homes. The main goals were to identify the effects of different variables on the overall user experience and to comprehend the nuances of user interactions, happiness, and engagement within smart home environments. To ensure user reception and continued involvement, user-centric design ideas were carefully integrated into a thorough and diverse research strategy, using affordance theory, the Kano model, and Ana for smart home technologies.

Python was necessary for smart home technology due to quick innovation and client demands. Web crawling simplifies getting relevant, updated information from multiple websites. This approach informed researchers and facilitated study analysis. User-centred design was emphasised by affordability theory. To emphasise the need for simple, readily integrated smart home services, the study assessed usability and product influence on user behaviour. This showed that interfaces and features must meet users' immediate needs and adapt to their evolving tastes and behaviours. Kano categorised consumer needs and smart home ecosystem satisfaction expectations. The technique highlighted basic, performance, and joy characteristics to better understand user expectations and preferences and prioritise design aspects to promote pleasure and engagement. To ensure rigour, AHP quantified and ranked smart home design components. This organised method clarified complex decision-making processes and design element values, enabling data-driven design decisions. Strategically implementing these approaches enhanced research rigour and depth and secured a comprehensive and user-centric smart home service design strategy, advancing the field and improving user experiences (Kempeneer et al., 2021).

Smart housing features are quantified in **Table 1**. Standard deviations measure variability, while mean values show trends. This lengthy study examines smart device type, features, user age, income, and interface complexity score on smart home user experience. The study analyses these aspects to illuminate the complex relationship between technology and customer demographics, helping smart home service designers meet consumer expectations. **Table 2** classifies factors as Attractive, One-Dimensional, Must-Be, Indifferent, and Reverse using Kano Model Analysis. This systematic classification helps service designers and implementers make strategic decisions by highlighting how each variable affects user delight and smart home experience. This intricate classification is used by service designers to specify user expectations. Although the type of smart gadget is attractive, its one-dimensional features assist focus efforts for the best possible user experience. The Kano Model assists designers of smart home services in choosing attributes and features that enhance user experiences (Chowdhury, 2021; Mehta et al., 2020; Vehmas et al., 2015). In order to prioritize user pleasure and engagement factors, **Table 3** presents the quantitative Analytical Hierarchy Process (AHP) Weighting for Smart Home User Experience. Pairwise comparisons are used in the table to weigh user expectations, functionality, and smart device type. Service designers may better understand variable hierarchies and make user-centric design decisions with the aid of this structured approach. Targeted improvements to the smart home user experience are made possible by the clustering of features, which refines the analysis(Ore, 2022; Ullah et al., 2021).

Table 4 identifies conflicts in smart home design and offers innovative ways to increase user satisfaction using TRIZ Matrix Analysis. High user satisfaction and high smart home system complexity are at odds with the table. These discrepancies can be creatively resolved with the help of TRIZ Matrix concepts like segmentation and composite materials. This innovative method may be used by service designers to lower the complexity of smart home systems and increase customer happiness. In order to satisfy customer expectations and maximize smart home design, use the TRIZ Matrix (Al et al., 2022). **Table 5**, Smart Home User Experience Analysis, employs both quantitative and qualitative measures to assess various issues. User satisfaction, Net Promoter Score, and system usage frequency are indicators of user engagement; qualitative data on ease of use, customization, security, and other topics may be found in survey ratings. Using a combination of qualitative insights for subtle service design and quantitative indicators that are accepted in the industry, this mixed-methods approach provides a comprehensive picture of the user experience. Service designers and industry stakeholders may better understand the smart home landscape by referring to the table's specific user perceptions (Ajayi et al., 2023).

Table 6 shows the growth of the smart home market from 2016 to 2023. This table illustrates the quick growth of the smart home market and puts the study in the perspective of the industry. The report is topical and significant because of the robust growth rates, which indicate the rising demand for smart home technology.

Numbers make the market's progress easier to see and highlight larger patterns that might have an impact on owners of smart homes. **Table 7** shows smart house adoption by region in China from 2016 to 2023. The table shows regional adoption rates, providing service designers and industry players targeting specific markets with nuanced data. Eastern China regularly has greater adoption rates than other regions, suggesting market strategy opportunities. The regional breakdown helps develop region-specific smart home adoption strategies by targeting the many elements that affect it (Faridi & Malik, 2019).

Table 8 shows how consumer factors changed between 2016 and 2023 in terms of smart home adoption. By demonstrating how user preferences change over time, this longitudinal study assists service designers in aligning smart home products with market needs. Rising percentages for Security & Privacy, Personalization, and Convenience & Efficiency indicate shifting user expectations. Industry participants may use this table to monitor trends and better align their goods with customer wants. Each statistic, including the industry averages, target benchmarks, data sources, and analysis techniques, is well defined. By allowing for comparative analysis, benchmark values set the study either above or below industry norms. This comprehensive assessment of the smart home user experience offers service designers a formal technique to gauge and improve user satisfaction and system performance (Faridi & Malik, 2019; Moro Visconti & Morea, 2020).

In conclusion, the study offered a strong foundation for analyzing the intricate dynamics of information system user experience in smart homes thanks to its meticulous research methods and comprehensive tables. The integration of diverse methodologies and meticulous variable measurement provided an all-encompassing and refined perspective, contributing significant new data to the swiftly evolving domain of intelligent home technology. The study's findings have implications for policymakers, business leaders, and service providers who wish to develop a technologically advanced and customer-focused future for smart homes (Hassani, Huang, & Silva, 2018).

CONCLUSION

This research explored the smart home user experience using a variety of approaches and analyses. The study began by examining smart home variables such as user characteristics, technology features, and expectations quantitatively and qualitatively. The research used the Kano Model, Analytical Hierarchy Process (AHP) Weighting, TRIZ Matrix Analysis, and other methods to understand smart home ecosystem user preferences, priorities, and potential inconsistencies. These insights enable educated service design, helping industry stakeholders achieve customer expectations.

Findings on Chinese smart home market growth and penetration have been contextualized to fit the dynamic industrial landscape. Smart home technologies remain relevant and in demand due to their steady growth rates. Regional penetration rates show adoption tendencies, helping target and expand markets. Longitudinal user motivation analysis shows that users increasingly value ease, customization, and security. This temporal component is vital for stakeholders trying to meet shifting consumer expectations and compete in the fast-changing smart home industry. **Tables 5** provides a holistic assessment of the smart home user experience using quantitative and qualitative measures. The examination of user pleasure, engagement, and incentives illuminates the many variables that make a good user experience. This research advances scholarly understanding of smart home user experiences and provides useful insights for practitioners, legislators, and enterprises seeking to improve their smart home services and adapt to user needs.

This research attempted a complete smart home industry analysis; however, it had significant limitations. First, the findings may be limited by the difficulties of obtaining a large enough sample of Changsha City smart home users. Convenience and snowball sampling may also influence selection. Second, limited networks made it difficult to identify smart home and S-PSS industry leaders, which could limit expert insights. The research sampled a wide population and sought referrals to overcome these obstacles.

Future smart home research should use more diverse and rigorous sampling procedures to create a representative and inclusive participant pool. Work with smart home device manufacturers, service providers, and industry experts to gain access to prominent personalities and deeper insights. Longitudinal studies could also reveal smart home adoption and adaption dynamics by examining user behaviors and preferences over time. Partnerships with industry groups and developing technology for expert identification and engagement may help identify industry leaders. Research should keep up with new technology, market trends, and consumer preferences to keep findings relevant and help smart home ecosystems thrive as the smart home sector evolves rapidly.

PRACTICAL IMPLICATIONS

The report stresses smart home ecosystem expansion by manufacturers and service designers. These stakeholders can improve product and service development with the Kano model and AHP insights. They can classify qualities by consumer satisfaction, essential, performance, and fascinating using the Kano model. AHP prioritises features and functionalities based on user preferences and demands through structured decision-making. Manufacturers and service designers could simplify these approaches' analysis, the reviewer said. This guarantees smart home solutions are based on user expectations, preferences, satisfaction, and engagement dynamics. Using user-centric design helps smart home products and services meet consumer needs.

The manifesto advises lawmakers and regulators to use smart home tech. As the smart home market increases, fulfilling consumer needs while protecting privacy is crucial. Analysing smart home ecosystem user experiences helps legislators balance innovation and consumer interests. Adding UX elements to the study's theory will improve understanding, says the reviewer. Privacy, smart home device security, and data collection and use may be covered. Policymakers may boost customer trust and market growth by promoting smart homes.

According to research, user education and digital literacy affect smart home gadget adoption and use. Qualitative and quantitative usability testing can show smart home device user experiences, the reviewer said. This strategy helps manufacturers and service designers understand consumer preferences and behaviours to produce more intuitive and user-friendly products. Smart home technology selection requires digital literacy and awareness efforts. Learning materials and smart home devices simplify and improve user experiences. Users of various digital literacy levels can benefit from technology in the smart home ecosystem thanks to user education.

CONFLICT OF INTEREST

No conflict of interest was declared by the authors.

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