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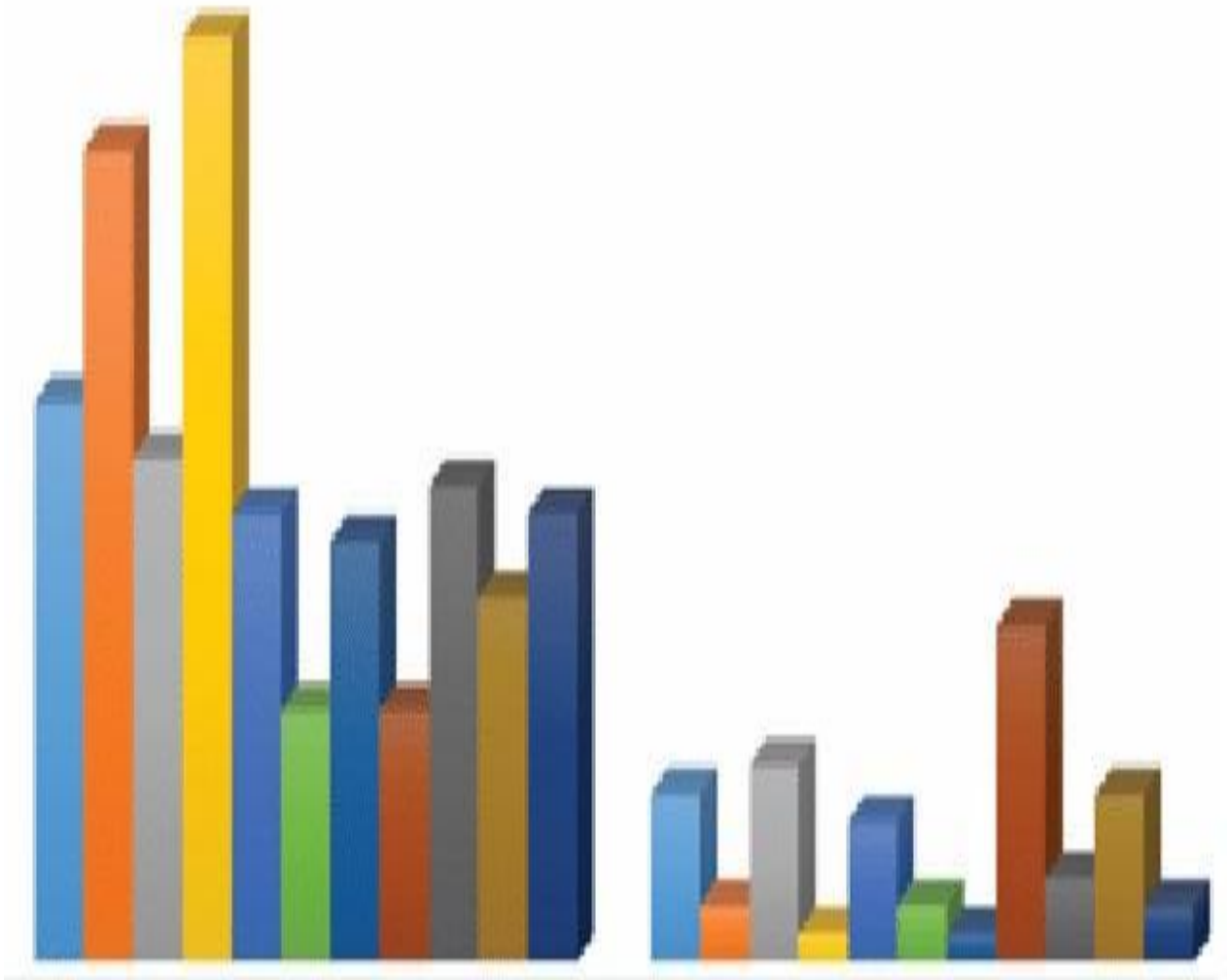

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Research Article

Qualitative Analysis of Designer Attitudes Toward AI-Assisted Sustainable Space Optimisation Tools

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ABSTRACT

The integration of Artificial Intelligence (AI) into spatial design practices is transforming how designers approach sustainability and space optimisation. This study presents a qualitative analysis of designer attitudes toward AI-assisted sustainable space optimisation tools, drawing on secondary data from recent academic literature. Grounded in the Technology Acceptance Model (TAM), Theory of Planned Behaviour (TPB), socio-technical systems theory, and human-AI collaboration frameworks, the research explores how designers perceive the benefits and challenges of AI integration. The findings reveal a dual perspective: designers acknowledge AI's capacity to enhance efficiency, support data-driven decision-making, and improve sustainability outcomes, while simultaneously expressing concerns about diminished creative autonomy, algorithmic opacity, and ethical risks. The study emphasises the importance of human-centred AI approaches that prioritise transparency, usability, and collaborative engagement. It further highlights the need for aligning technological innovation with professional practices and values. By synthesising interdisciplinary insights, this research contributes to the evolving discourse on AI in sustainable design and provides a conceptual foundation for future empirical investigations.

Keywords: artificial intelligence, sustainable design, space optimisation, designer attitudes, human-ai collaboration, technology acceptance, socio-technical systems

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1. Introduction

The rapid evolution of Artificial Intelligence (AI) has significantly reshaped contemporary design practices, particularly within architecture, interior design, and urban planning. AI-assisted tools are increasingly being integrated into spatial design processes, enabling designers to generate, evaluate, and optimise spatial configurations with unprecedented speed and precision. These technologies utilise machine learning algorithms, generative design frameworks, and data analytics to produce design alternatives that align with functional, aesthetic, and environmental requirements (Albukhari, 2025; Li et al., 2025). As a result, AI is no longer a peripheral tool but a central component in the transformation of design methodologies in the twenty-first century.

Simultaneously, the growing urgency of environmental sustainability has positioned sustainable design as a critical priority across the built environment. Issues such as climate change, urban population growth, and resource depletion demand innovative solutions that minimise environmental impact while maximising spatial efficiency. Sustainable space optimisation, defined as the strategic arrangement and utilisation of space to reduce energy consumption, enhance occupant well-being, and improve resource efficiency, has become a focal point in design research and practice (Xu, 2025). AI technologies are uniquely positioned to support this objective by enabling designers to simulate environmental conditions, predict building performance, and optimise layouts based on sustainability metrics.

AI-assisted sustainable space optimisation tools offer several advantages. They can process vast amounts of data related to climate conditions, material properties, and user behaviour, allowing designers to make informed decisions grounded in empirical evidence. For instance, generative design systems can produce multiple spatial configurations based on predefined sustainability criteria, such as energy efficiency, daylight access, and ventilation performance (Sedrez & Pitts, 2025). Additionally, AI-driven simulations can evaluate the environmental impact of design choices across the building lifecycle, thereby facilitating more sustainable outcomes.

However, the integration of AI into design processes is not without challenges. While AI enhances efficiency and analytical capacity, it also introduces complexities related to human creativity, professional identity, and ethical responsibility. Designers are increasingly required to interact with intelligent systems that influence decision-making processes, raising questions about authorship, control, and the role of human intuition in design (Shahid, 2025). This shift from traditional design practices to AI-assisted workflows represents a paradigm change that extends beyond technical implementation to encompass cognitive, social, and cultural dimensions.

A growing body of research suggests that designers' attitudes toward AI play a critical role in determining the success of its adoption. Attitudes are shaped by factors such as perceived usefulness, ease of use, trust, and social influence (Jiao & Cao, 2024). While many designers recognise the

potential of AI to enhance productivity and sustainability, others express concerns about over-reliance on technology, loss of creative autonomy, and lack of transparency in algorithmic processes. These concerns highlight the importance of understanding the human dimension of AI integration in design.

Furthermore, AI-assisted tools challenge traditional notions of creativity and innovation. Design has historically been viewed as a human-centric activity characterised by intuition, imagination, and subjective interpretation. The introduction of AI raises questions about whether creativity can be partially or fully delegated to machines. Some scholars argue that AI can augment human creativity by providing novel insights and expanding the design space, while others caution that excessive reliance on AI may lead to homogenization and reduced originality (Doğan & Zengin, 2025).

In addition to creative concerns, ethical issues surrounding AI in design are increasingly prominent. These include algorithmic bias, data privacy, and accountability for design outcomes. Designers must navigate these challenges while ensuring that AI systems are used responsibly and transparently. The need for ethical guidelines and regulatory frameworks is particularly critical in the context of sustainable design, where decisions have long-term environmental and social implications.

Despite the growing interest in AI-assisted design, there remains a gap in understanding how designers perceive and engage with these technologies, particularly in relation to sustainable space optimisation. Existing studies have primarily focused on technical capabilities and performance outcomes, with limited attention to the subjective experiences and attitudes of designers. This study addresses this gap by conducting a qualitative analysis of secondary data to explore designers' attitudes toward AI-assisted sustainable space optimisation tools.

The research is guided by three key questions: How do designers perceive AI-assisted tools in sustainable space optimisation? What factors influence their attitudes toward these tools? And what are the perceived benefits and challenges associated with their use? By addressing these questions, the study aims to contribute to the broader discourse on AI in design and provide insights into the human factors that shape technology adoption.

Ultimately, understanding designer attitudes is essential for the successful integration of AI into sustainable design practices. As AI continues to evolve, fostering a collaborative relationship between human designers and intelligent systems will be critical for achieving both creative excellence and environmental sustainability. This study seeks to provide a comprehensive and theoretically grounded analysis of this emerging field, offering valuable insights for researchers, practitioners, and policymakers.

2. Literature Review

Artificial Intelligence has emerged as a transformative force in architectural and spatial design, enabling new forms of computational creativity and performance optimisation. AI technologies, including

machine learning, deep learning, and generative algorithms, have expanded the capabilities of designers by allowing them to explore complex design spaces and evaluate multiple alternatives simultaneously (Albukhari, 2025). These tools are particularly valuable in addressing the increasing complexity of modern design challenges, which often involve balancing aesthetic, functional, and environmental considerations.

Generative design, a key application of AI, allows designers to input specific constraints and objectives, such as spatial dimensions, material limitations, and sustainability targets. The system then generates a wide range of design options that meet these criteria. This approach not only accelerates the design process but also introduces novel solutions that may not have been conceived through traditional methods (Sedrez & Pitts, 2025). Moreover, AI-driven parametric modelling enables real-time adjustments to design parameters, facilitating iterative exploration and refinement.

Another significant application of AI in design is predictive analytics, which allows designers to anticipate building performance under various conditions. For example, AI models can simulate energy consumption, thermal comfort, and daylight distribution, providing valuable insights that inform design decisions (Li et al., 2025). These capabilities are particularly important in the context of sustainable design, where performance optimisation is a key objective.

Despite these advantages, the adoption of AI in design is not uniform. Variations in technological infrastructure, organisational culture, and individual competencies influence the extent to which AI is integrated into design practices. Understanding these variations requires a closer examination of designer attitudes and perceptions.

2.1 AI and Sustainable Space Optimisation

Sustainable space optimisation is a multidisciplinary concept that integrates principles of environmental sustainability, spatial efficiency, and user-centred design. AI technologies play a critical role in advancing this concept by enabling data-driven decision-making and performance-based design strategies (Xu, 2025). Through the use of advanced algorithms, AI tools can analyse environmental data, optimise spatial layouts, and recommend sustainable materials and construction techniques.

One of the primary contributions of AI to sustainable design is its ability to simulate environmental conditions and predict the impact of design choices. For instance, AI-driven tools can model airflow patterns, solar radiation, and energy consumption, allowing designers to optimise building performance before construction (Artificial Intelligence for Sustainable Architectural Design, 2025). This capability reduces the need for trial-and-error approaches and enhances the efficiency of the design process.

AI also supports resource optimisation by minimising material waste and improving construction efficiency. By analysing data on material properties and structural requirements, AI tools can recommend optimal material combinations that reduce environmental impact while maintaining

structural integrity (Xu, 2025). Additionally, AI can facilitate adaptive design strategies that respond to changing environmental conditions and user needs.

However, the implementation of AI in sustainable design is not without challenges. Data quality and availability are critical factors that influence the accuracy and reliability of AI models. In many cases, incomplete or biased data can lead to suboptimal design outcomes. Furthermore, the complexity of AI systems may limit their accessibility to designers who lack technical expertise.

2.2 Designer Attitudes Toward AI

The success of AI integration in design depends largely on the attitudes and perceptions of designers. The Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (TPB) provide useful frameworks for understanding these attitudes. According to TAM, perceived usefulness and perceived ease of use are key determinants of technology adoption (Jiao & Cao, 2024). In the context of AI-assisted design, usefulness is often associated with efficiency gains, improved design quality, and enhanced sustainability outcomes.

The TPB framework adds additional dimensions, including subjective norms and perceived behavioural control. Designers are influenced by the expectations of peers, clients, and professional organisations, as well as their own confidence in using AI tools. These factors collectively shape their willingness to adopt and engage with AI technologies.

Empirical studies indicate that designers generally hold positive attitudes toward AI when it is perceived as a supportive tool rather than a replacement for human creativity. However, concerns about loss of autonomy and creative control remain significant barriers to adoption (Doğan & Zengin, 2025). Designers often value the intuitive and experiential aspects of design, which they perceive as difficult to replicate through algorithms.

Trust is another critical factor influencing designer attitudes. The “black box” nature of many AI systems makes it difficult for users to understand how decisions are made, leading to scepticism and resistance. Enhancing transparency and explainability is therefore essential for building trust and encouraging adoption (Shahid, 2025).

2.3 Human-AI Collaboration in Design

Recent research emphasises the importance of human-AI collaboration as a paradigm for integrating AI into design practices. Rather than replacing designers, AI systems are increasingly viewed as collaborative partners that augment human capabilities. This approach aligns with the concept of co-creation, where humans and machines work together to generate innovative solutions.

Human-AI collaboration offers several benefits, including increased efficiency, enhanced creativity, and improved decision-making. By leveraging the strengths of both humans and machines, designers can achieve outcomes that are greater than the sum of their parts. For example, AI can handle data-intensive tasks and generate design

alternatives, while humans provide contextual understanding, ethical judgment, and creative insight.

However, effective collaboration requires careful design of user interfaces, workflows, and interaction mechanisms. Designers must be able to understand and interpret AI outputs, as well as provide feedback that guides the system. This iterative process is essential for ensuring that AI tools align with human intentions and values.

2.4 Research Gap

Despite the growing body of literature on AI in design, several gaps remain. First, most studies focus on technical aspects and performance metrics, with limited attention to the subjective experiences of designers. Second, there is a lack of research specifically addressing AI-assisted sustainable space optimisation tools. Third, existing studies often rely on quantitative methods, leaving a need for qualitative insights that capture the complexity of designer attitudes.

This study addresses these gaps by conducting a qualitative analysis of secondary data, providing a nuanced understanding of how designers perceive and engage with AI in sustainable design contexts.

3. Theoretical Framework

The integration of Artificial Intelligence (AI) into sustainable spatial design necessitates a robust theoretical foundation to understand how designers perceive, interpret, and engage with these technologies. This study adopts a multi-theoretical framework that synthesises the Technology Acceptance Model (TAM), the Theory of Planned Behaviour (TPB), socio-technical systems theory, and emerging perspectives on human-AI collaboration. Together, these frameworks provide a comprehensive lens for examining designer attitudes toward AI-assisted sustainable space optimisation tools.

3.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), originally proposed by Davis (1989), remains one of the most widely used frameworks for analysing user acceptance of new technologies. TAM posits that two primary factors, perceived usefulness and perceived ease of use, determine an individual's attitude toward adopting a technology, which in turn influences behavioural intention and actual usage.

In the context of AI-assisted sustainable design, perceived usefulness refers to the extent to which designers believe that AI tools enhance their performance, particularly in terms of improving spatial efficiency, sustainability outcomes, and decision-making accuracy. AI systems capable of generating optimised layouts, simulating environmental performance, and reducing design time are likely to be perceived as highly useful (Li et al., 2025). Conversely, perceived ease of use relates to the usability and accessibility of these tools, including interface design, learning curve, and integration with existing workflows.

Empirical research suggests that designers are more inclined to adopt AI technologies when they perceive them as intuitive and

beneficial to their practice (Jiao & Cao, 2024). However, complexities associated with advanced AI systems may hinder ease of use, thereby negatively affecting adoption. Thus, TAM provides a foundational framework for understanding the cognitive and perceptual factors that shape designer attitudes.

3.2 Theory of Planned Behaviour (TPB)

While TAM focuses on technological perceptions, the Theory of Planned Behaviour (TPB), developed by Ajzen (1991), extends the analysis by incorporating social and behavioural dimensions. TPB posits that behavioural intention is influenced by three factors: attitudes toward the behaviour, subjective norms, and perceived behavioural control.

In this study, attitudes refer to designers' positive or negative evaluations of using AI-assisted tools. Subjective norms capture the influence of peers, clients, and professional communities, which can either encourage or discourage the adoption of AI technologies. For instance, increasing industry acceptance of AI-driven design practices may create normative pressure for designers to adopt these tools. Perceived behavioural control relates to designers' confidence in their ability to use AI tools effectively, which is influenced by factors such as technical skills, training, and access to resources.

The integration of TPB with TAM provides a more holistic understanding of technology adoption by accounting for both individual perceptions and social influences (Jiao & Cao, 2024). This combined framework is particularly relevant in design contexts, where professional norms and collaborative practices play a significant role.

3.3 Socio-Technical Systems Theory

Socio-technical systems theory offers a broader perspective by emphasising the interdependence between social and technical components within organisational and professional contexts. According to this theory, technological systems cannot be fully understood in isolation; they must be analysed in relation to the social structures, cultural values, and institutional practices in which they are embedded (Baxter & Sommerville, 2011).

In the context of AI-assisted design, socio-technical systems theory highlights how AI tools reshape workflows, decision-making processes, and professional roles. Designers do not merely use AI tools; they interact with them within complex socio-technical environments that include organisational policies, collaborative networks, and cultural expectations. For example, the adoption of AI in sustainable design may require changes in organisational practices, such as integrating data-driven workflows and fostering interdisciplinary collaboration.

This perspective also underscores the importance of aligning technological capabilities with human values and needs. AI systems that fail to account for social and ethical considerations may encounter resistance from designers, regardless of their technical advantages. Therefore, socio-technical systems theory provides a critical lens for understanding the broader

implications of AI integration in design practices.

3.4 Human-AI Collaboration Framework

Recent advancements in AI research have shifted the focus from automation to collaboration, emphasising the role of AI as a partner rather than a replacement for human designers. The human-AI collaboration framework conceptualises AI systems as co-creative agents that augment human capabilities and support collaborative decision-making (Shahid, 2025).

In design contexts, this framework is particularly relevant because creativity, intuition, and contextual understanding remain inherently human strengths. AI systems excel in processing large datasets, identifying patterns, and generating design alternatives, but they lack the experiential and interpretive qualities that characterise human creativity. Effective collaboration between humans and AI requires the integration of these complementary strengths.

Human-AI collaboration also involves issues of trust, transparency, and control. Designers must be able to understand how AI systems generate outputs and retain the ability to intervene in the design process. Explainable AI (XAI) is, therefore, a critical component of this framework, as it enhances transparency and facilitates meaningful interaction between designers and AI systems.

Furthermore, this framework aligns with the concept of co-creation, where human designers and AI systems jointly contribute to the design process. This approach not only enhances creativity but also supports more sustainable outcomes by combining human insight with data-driven analysis.

3.5 Conceptual Integration

By integrating TAM, TPB, socio-technical systems theory, and human-AI collaboration frameworks, this study develops a comprehensive conceptual model for analysing designer attitudes toward AI-assisted sustainable space optimisation tools. TAM and TPB provide insights into individual and social determinants of technology adoption, while socio-technical systems theory and human-AI collaboration frameworks address the broader contextual and relational dimensions.

This integrated approach allows for a nuanced understanding of how designers perceive AI technologies, how they are influenced by social and organisational factors, and how they engage in collaborative interactions with intelligent systems. It also highlights the importance of designing AI tools that are not only technically effective but also socially acceptable and ethically responsible.

4. Research Methodology

This study adopts a qualitative research design based on secondary data analysis to explore designers' attitudes toward AI-assisted sustainable space optimisation tools. Qualitative research is particularly suitable for this study because it allows for an in-depth exploration of subjective experiences, perceptions, and meanings associated with technology adoption (Creswell & Poth,

2018). Unlike quantitative approaches, which focus on numerical measurement and statistical analysis, qualitative methods emphasise interpretation and contextual understanding.

The use of secondary data analysis involves the systematic examination of existing literature, including peer-reviewed journal articles, conference proceedings, and academic books. This approach enables the researcher to synthesise a wide range of perspectives and identify overarching themes without the need for primary data collection. Secondary qualitative analysis is especially valuable in emerging research areas, such as AI-assisted design, where a substantial body of literature already exists (Johnston, 2017).

4.1 Data Sources and Selection Criteria

The data for this study were collected from reputable academic databases, including Scopus, Web of Science, and Google Scholar. The selection of sources was guided by specific inclusion and exclusion criteria to ensure relevance and quality.

Inclusion Criteria:

- Publications between 2020 and 2025
- Peer-reviewed journal articles, conference papers, and academic books
- Studies focusing on AI in design, sustainability, or technology adoption
- Articles addressing designer perceptions, attitudes, or experiences

Exclusion Criteria:

- Non-academic sources (e.g., blogs, opinion pieces)
- Studies unrelated to design or sustainability
- Articles lacking methodological rigour

A purposive sampling strategy was employed to select relevant studies that provide rich and meaningful insights into the research topic. This approach ensures that the selected data are aligned with the research objectives and theoretical framework.

4.2 Data Analysis Method

The study employs thematic analysis as the primary method for analysing qualitative data. Thematic analysis is a widely used approach that involves identifying, analysing, and interpreting patterns or themes within textual data (Braun & Clarke, 2006). It is particularly suitable for secondary data analysis because it allows for systematic synthesis of diverse sources.

The analysis followed six key steps:

- **Familiarisation with Data:** The researcher thoroughly reviewed the selected literature to gain an overall understanding of the content.
- **Initial Coding:** Relevant segments of text were coded based on key concepts related to designer attitudes, AI adoption, and sustainability.
- **Theme Development:** Codes were grouped into broader themes, such as perceived benefits, challenges, ethical concerns, and collaboration.

- **Reviewing Themes:** Themes were refined to ensure coherence and consistency across the dataset.
- **Defining and Naming Themes:** Each theme was clearly defined and aligned with the research questions.
- **Interpretation:** The themes were interpreted in relation to the theoretical framework, providing insights into designer attitudes and behaviours.

This systematic approach enhances the credibility and rigour of the analysis.

4.3 Trustworthiness and Rigour

To ensure the quality and reliability of the research, the study follows established criteria for qualitative rigour, including credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985).

- **Credibility:** Achieved through careful selection of high-quality sources and thorough analysis.
- **Transferability:** Ensured by providing detailed descriptions of the research context and findings.
- **Dependability:** Maintained through a transparent and systematic research process.
- **Confirmability:** Supported by grounding interpretations in existing literature and theoretical frameworks.

4.4 Ethical Considerations

As a secondary data study, this research does not involve direct interaction with human participants. However, ethical considerations remain important. All sources are properly cited to acknowledge intellectual contributions and avoid plagiarism. The study also critically evaluates the ethical implications of AI in design, including issues of bias, transparency, and accountability (Mannan & Farhana, 2026).

4.5 Limitations of the Methodology

Despite its strengths, the use of secondary data analysis has certain limitations. The study relies on existing literature, which may not fully capture current or context-specific experiences of designers. Additionally, the findings are influenced by the scope and quality of the selected sources.

Future research could address these limitations by incorporating primary data collection methods, such as interviews or surveys, to validate and extend the findings.

5. Findings and Analysis

The qualitative thematic analysis of secondary data reveals a multifaceted and often ambivalent set of attitudes among designers toward AI-assisted sustainable space optimisation tools. Five major themes emerged: perceived efficiency and performance enhancement, sustainability-driven value recognition, concerns regarding creativity and autonomy, ethical and transparency challenges, and evolving professional identity and human-AI collaboration. These themes reflect a complex negotiation between technological potential and human-centred design values.

5.1 Perceived Efficiency and Performance Enhancement

One of the most consistently reported positive perceptions among designers is the

efficiency gained through AI-assisted tools. AI technologies enable the rapid generation of multiple design alternatives, significantly reducing the time required for iterative processes traditionally performed manually. Designers highlight the ability of AI systems to process large datasets, evaluate constraints, and produce optimised spatial configurations as a major advantage (Li et al., 2025).

This efficiency is particularly relevant in complex projects involving multiple variables such as spatial constraints, environmental conditions, and user requirements. AI-driven generative design tools allow designers to explore a broader solution space, enhancing both productivity and innovation. For instance, algorithms can simultaneously consider factors such as daylight access, ventilation, and spatial flow, producing solutions that balance competing objectives.

From the perspective of the Technology Acceptance Model (TAM), these benefits contribute to high perceived usefulness, which positively influences designers' attitudes toward AI adoption (Jiao & Cao, 2024). Designers who experience tangible improvements in workflow efficiency are more likely to integrate AI tools into their practice.

However, the findings also suggest that efficiency gains are not uniformly experienced. Some designers report difficulties in integrating AI tools into existing workflows, particularly when tools require specialised technical knowledge or disrupt established design processes. This highlights the importance of usability and compatibility in shaping positive attitudes.

5.2 Sustainability-Driven Value Recognition

A central theme in the literature is the recognition of AI's potential to enhance sustainability outcomes in spatial design. Designers increasingly view AI as a critical tool for achieving environmentally responsible design solutions. AI systems can simulate energy performance, optimise material usage, and evaluate environmental impacts across the building lifecycle (Xu, 2025).

Designers appreciate the ability to make data-driven decisions that align with sustainability goals. For example, AI tools can identify optimal building orientations, recommend energy-efficient materials, and minimise waste during construction. These capabilities contribute to more sustainable and resilient built environments.

The integration of AI into sustainable design also aligns with global sustainability frameworks, such as the United Nations Sustainable Development Goals (SDGs). Designers recognise that AI can support efforts to reduce carbon emissions, improve energy efficiency, and promote sustainable urban development (Artificial Intelligence for Sustainable Architectural Design, 2025).

Despite these positive perceptions, some designers express concerns about the reliability of AI-generated sustainability assessments. The accuracy of AI models depends on the quality and completeness of input data, which may vary across contexts. Inadequate or biased data can lead to

suboptimal design outcomes, undermining trust in AI systems.

Furthermore, the emphasis on quantifiable sustainability metrics may overshadow qualitative aspects of design, such as cultural relevance and user experience. This tension highlights the need for a balanced approach that integrates both quantitative and qualitative considerations.

5.3 Concerns Regarding Creativity and Autonomy

A recurring concern among designers is the potential impact of AI on creativity and professional autonomy. Design has traditionally been understood as a creative and intuitive process, characterised by originality and subjective interpretation. The introduction of AI challenges this paradigm by introducing algorithmically generated solutions.

Some designers perceive AI as a threat to creativity, arguing that reliance on predefined algorithms may lead to homogenization and reduced originality. AI-generated designs often reflect patterns derived from existing data, which may limit the exploration of unconventional or innovative ideas (Doğan & Zengin, 2025).

From a theoretical perspective, this concern can be understood as a tension between human-centred creativity and machine-driven optimisation. While AI excels at identifying efficient solutions, it may lack the ability to capture the nuanced and experiential aspects of design.

However, other designers view AI as a tool that enhances creativity rather than constrains it. By generating multiple design alternatives, AI can inspire new ideas and expand the creative horizon. This perspective aligns with the concept of augmented creativity, where human designers leverage AI-generated insights to enhance their creative processes (Shahid, 2025).

The divergence in perceptions suggests that attitudes toward AI are influenced by individual beliefs about the nature of creativity and the role of technology in design. Designers who view creativity as a collaborative process are more likely to embrace AI, while those who emphasise individual authorship may resist its adoption.

5.4 Ethical and Transparency Challenges

Ethical concerns represent a significant barrier to the acceptance of AI in design. One of the primary issues is the lack of transparency in AI algorithms, often referred to as the “black box” problem. Designers may find it difficult to understand how AI systems generate outputs, leading to scepticism and reduced trust (Shahid, 2025).

Transparency is particularly important in sustainable design, where decisions have long-term environmental and social implications. Designers need to ensure that AI-generated solutions are not only efficient but also ethically responsible. The inability to interpret algorithmic processes can hinder accountability and decision-making.

Another ethical concern is algorithmic bias. AI systems are trained on historical data, which may contain biases that are inadvertently embedded in design outputs. For example, biased datasets may lead to

design solutions that favour certain user groups or overlook marginalised communities.

Data privacy is also a critical issue, especially when AI tools rely on user data to optimise design outcomes. Designers must navigate the ethical implications of data collection and usage while ensuring compliance with regulatory standards.

These challenges highlight the need for ethical frameworks and guidelines that govern the use of AI in design. Designers emphasise the importance of transparency, accountability, and inclusivity in the development and implementation of AI systems.

5.5 Professional Identity and Role Transformation

The integration of AI into design practices is reshaping the professional identity of designers. Traditionally, designers have been viewed as creators who rely on intuition, experience, and creativity. AI introduces a new paradigm in which designers act as collaborators with intelligent systems.

This shift requires the development of new skills, including data literacy, computational thinking, and the ability to interpret AI-generated outputs. Designers must also adapt to new workflows that integrate AI tools into the design process.

While some designers embrace this transformation as an opportunity for professional growth, others perceive it as a threat to their identity. Concerns about job displacement and loss of control are particularly prominent among designers who are less familiar with AI technologies.

The findings suggest that professional identity is a key factor influencing attitudes toward AI. Designers who view AI as a tool for augmentation are more likely to adopt it, while those who perceive it as a replacement may resist its integration.

5.6 Human-AI Collaboration as a Mediating Factor

The concept of human-AI collaboration emerges as a critical factor in shaping designer attitudes. Rather than viewing AI as a replacement for human designers, many scholars advocate for a collaborative approach in which AI augments human capabilities.

Designers express a preference for AI systems that support decision-making without undermining creative control. Collaborative systems enable designers to leverage AI insights while maintaining authorship and responsibility for design outcomes.

This approach aligns with socio-technical systems theory, which emphasises the integration of social and technical elements. Effective collaboration requires not only advanced AI technologies but also supportive organisational structures and user-centred design interfaces (Baxter & Sommerville, 2011).

6. Discussion

The findings of this study reveal a nuanced and often paradoxical set of attitudes among designers toward AI-assisted sustainable

space optimisation tools. These attitudes are shaped by a dynamic interplay of technological, cognitive, social, and ethical factors. By interpreting these findings through the lens of the theoretical framework, this section provides deeper insights into the implications of AI integration in design practices.

6.1 Interpreting Designer Attitudes Through TAM and TPB

The application of TAM and TPB provides a comprehensive understanding of the determinants of designer attitudes. Perceived usefulness emerges as a dominant factor driving positive attitudes, particularly in relation to efficiency and sustainability outcomes. Designers who recognise the practical benefits of AI are more likely to adopt these tools (Jiao & Cao, 2024).

However, perceived ease of use remains a critical barrier. Complex interfaces, steep learning curves, and a lack of interoperability with existing tools can hinder adoption. This suggests that developers must prioritise user-centred design to enhance usability and accessibility.

The TPB framework highlights the role of social influence and perceived behavioural control. Designers are influenced by professional norms, industry trends, and peer expectations. As AI becomes more prevalent in design practice, normative pressures may encourage wider adoption.

Perceived behavioural control is also significant, as designers must feel confident in their ability to use AI tools effectively. Training and education play a crucial role in enhancing this confidence and facilitating adoption.

6.2 The Creativity Paradox

One of the most significant insights from the findings is the "creativity paradox," where AI is perceived as both a facilitator and a constraint on creativity. This paradox reflects broader debates in the literature about the nature of creativity and the role of technology in creative processes.

On one hand, AI expands the design space by generating multiple alternatives and providing data-driven insights. This can enhance creativity by exposing designers to new possibilities. On the other hand, reliance on algorithmic outputs may limit originality and lead to standardised solutions.

This paradox can be understood through the lens of human-AI collaboration. Rather than viewing AI as a replacement for creativity, it should be seen as a tool that complements human intuition. Designers must develop strategies for integrating AI outputs into their creative processes without becoming overly dependent on them.

6.3 Ethical Implications and the Need for Responsible AI

The ethical challenges identified in the findings underscore the importance of responsible AI in design. Transparency, accountability, and fairness are essential for building trust and ensuring ethical outcomes.

The "black box" nature of AI systems poses a significant challenge, as designers may be unable to fully understand or justify AI-generated decisions. This raises questions about accountability, particularly in projects

with significant social and environmental impacts.

Addressing these challenges requires the development of explainable AI (XAI) systems that provide insights into algorithmic processes. Additionally, ethical guidelines and regulatory frameworks must be established to govern the use of AI in design.

6.4 Socio-Technical Transformation of Design Practice

The integration of AI into design practices represents a socio-technical transformation that extends beyond individual tools to encompass broader organisational and cultural changes. Designers must adapt to new roles, workflows, and skill requirements.

Socio-technical systems theory emphasises the importance of aligning technological innovation with social structures and human values (Baxter & Sommerville, 2011). Successful integration of AI requires not only advanced technologies but also supportive organisational environments and collaborative cultures.

This transformation also has implications for design education. Educational institutions must incorporate AI-related skills into curricula to prepare future designers for evolving professional demands.

6.5 Toward a Human-Centred AI Design Paradigm

The findings suggest the need for a human-centred approach to AI in design. Rather than prioritising technological capabilities alone, designers and developers must focus on creating systems that align with human needs, values, and practices.

Human-centred AI emphasises collaboration, transparency, and user empowerment. Designers should be actively involved in the development of AI tools to ensure that they meet practical and ethical requirements.

This approach also supports sustainable design by integrating human insights with data-driven analysis. By combining the strengths of humans and AI, it is possible to achieve more innovative and sustainable design outcomes.

6.6 Implications for Practice and Research

The study has several implications for practice and research. For practitioners, the findings highlight the importance of developing skills in AI and data analysis while maintaining a strong focus on creativity and ethical responsibility.

For researchers, the study identifies the need for further investigation into designer attitudes, particularly through empirical studies that capture real-world experiences. Future research should also explore cross-cultural differences and the impact of organisational contexts on AI adoption.

7. Conclusion

This study has provided a comprehensive qualitative analysis of designer attitudes toward AI-assisted sustainable space optimisation tools, drawing upon a wide range of secondary data sources and theoretical perspectives. The findings demonstrate that designers' perceptions of AI are inherently complex, shaped by both the transformative potential of the technology

and the challenges it introduces to established design practices.

On the one hand, AI is widely recognised as a powerful enabler of efficiency, innovation, and sustainability. Designers value its ability to process large datasets, generate optimised spatial configurations, and support environmentally responsible decision-making. These capabilities align closely with the increasing demand for sustainable design solutions in the face of global environmental challenges. AI-assisted tools facilitate performance-based design approaches, allowing designers to anticipate and mitigate environmental impacts across the lifecycle of built environments.

On the other hand, the integration of AI raises critical concerns related to creativity, autonomy, and ethical responsibility. Designers express apprehension about the potential loss of creative control and the risk of over-reliance on algorithmic outputs. The "black box" nature of many AI systems further complicates their adoption, as a lack of transparency undermines trust and accountability. Ethical issues such as algorithmic bias and data privacy also present significant challenges that must be addressed to ensure responsible use of AI in design.

Importantly, the study highlights the role of human-AI collaboration as a key pathway for reconciling these tensions. Rather than replacing human designers, AI should be conceptualised as a collaborative partner that enhances human creativity and decision-making. This perspective aligns with a human-centred approach to AI, which emphasises transparency, usability, and alignment with professional values.

The study also underscores the need for a socio-technical approach to AI integration, recognising that technological adoption is influenced by organisational, cultural, and educational factors. Designers must develop new competencies, including data literacy and computational thinking, while educational institutions and professional organisations must adapt to support these evolving requirements.

While this research provides valuable insights, it is limited by its reliance on secondary data. Future studies should incorporate primary data collection methods, such as interviews and surveys, to capture real-world experiences and validate the findings. Additionally, comparative studies across different cultural and professional contexts would further enhance understanding of designer attitudes.

In conclusion, the successful integration of AI into sustainable spatial design depends not only on technological advancements but also on the alignment of these tools with human creativity, ethical principles, and professional practices. By fostering a collaborative and human-centred approach, AI has the potential to significantly enhance both the sustainability and innovation of design processes.

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