

Application of AI in Urban Design Education: A Case Study of Master Studio

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Abstract

This paper explores the transformative potential of AI in urban design studios through a case study where 28 master's students were tasked with simulating an urban design plan for Nusantara - Indonesia's new capital city. The studio was designed to allow students to engage with each phase of the urban design process using manual techniques, AI-driven tools, or a combination of both, creating a comparative framework to evaluate the advantages and disadvantages of AI in each stage. The goal of this research is to investigate how AI-augmented instruments are being used in educational settings, particularly in creative design courses, and to assess the potential advancements that these tools may offer to the subject. The research further intends to analyse how AI tools affect students' design thinking and technical abilities, leading to strategic recommendations for successfully incorporating these technologies into design education while keep adhering to the ethical guidelines in academic works.

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INTRODUCTION

The application of Artificial Intelligence (AI) in urban design education marks a significant shift in pedagogical approaches. By equipping students with advanced tools and innovative methodologies, AI enables them to engage more effectively with the complex and evolving challenges of contemporary urban planning (Bibri et al., 2024). However, the rapid adoption of these tools necessitates a critical examination of their impact on design processes and student learning. While the potential of AI to enhance creativity and efficiency is widely discussed, there is a research gap in comparative studies that evaluate different modes of AI integration within a real-world educational setting. Previous research has examined AI applications in architectural education (Jin et al., 2024; Fareed et al., 2024) as well as in professional urban planning practice (Kurniawan et al., 2024). In professional contexts, AI has been shown to support data-driven analysis, scenario generation, and sustainable development (Kurniawan et al., 2024). In the broader educational context, AI has also been reported to improve learning performance and student engagement, while raising debates around ethics and academic integrity (Katsamakos et al., 2024). Yet studies rarely address the pedagogical implications of AI integration in urban design studios, where architectural form-making intersects with planning theory (Ozgun & Caliskan, 2025). This gap is particularly evident in comparative analyses of manual, AI-driven, and hybrid workflows within real-world educational settings.

This paper explores the transformative potential of AI in urban design studios through a case study in which master's students were tasked with simulating an urban design plan for Indonesia's new capital city. The studio was designed to allow students to engage with each phase of the urban design process using manual techniques, AI-driven tools, or a combination of both, thereby creating a comparative framework to evaluate the advantages and disadvantages of AI at each stage. The goal of this research is to investigate how AI-augmented tools are used in educational settings, particularly in creative design courses, and to assess the potential advancements these tools may offer to the discipline. The research further intends to examine the implications of AI integration in academic settings, with a strong emphasis on upholding academic honesty and originality.

LITERATURE REVIEW

AI in Education

The discourse surrounding AI in design education is characterised by both enthusiasm for its potential and caution regarding its challenges. AI has been shown to hold significant promise for enhancing technical support and improving student learning outcomes (Alshahrani & Mostafa, 2025). AI-embedded teaching models have demonstrated a positive influence on student learning, particularly in enhancing innovative capability and work efficiency (Jin et al., 2024). In the broader higher education context, AI has been reported to improve learning performance and engagement while simultaneously raising debates about academic integrity, ethics, and overreliance on automation (Katsamakos et al., 2024).

Within architectural and urban design education, the integration of AI technologies is a subject of intense debate, with some advocating for comprehensive curriculum reforms and others urging a more cautious approach to fully understand its potential impact (Asfour, 2024). The use of AI image generators has been identified as a potentially revolutionary pedagogical tool, capable of visually depicting architectural concepts and historical structures, thus enabling students to go beyond traditional cognitive limitations (Fareed et al., 2024). Generative AI is seen to be especially helpful in the early phases of the design process for fostering creativity, but less so in the later stages when adjustments and optimizations are required (Fang, 2024). The application of AI extends beyond mere automation, fostering new avenues for creative expression and design exploration (Chen et al., 2024). However, the adoption of AI in education also presents challenges, including the need to ensure that AI complements traditional learning methods and promotes critical thinking (Nguyen, 2025).

Recent studies indicate a substantial disparity between AI's potential and its actual application in educational environments. Although 73% of professionals currently utilize AI in their regular work routines, architectural and urban design education encounters certain obstacles that set it apart from other fields. Research reveals significant faculty opposition to AI integration, with educators voicing apprehensions that excessive dependence may undermine students' creativity and independent thinking skills. This opposition is especially evident among faculty members who, although recognizing the significance of AI, exhibit only modest trust in their own AI literacy and voice apprehensions regarding the preservation of academic integrity (Filiz, O., et al., 2025).

A paradoxical effect of AI on critical thinking has been found in the literature. Studies repeatedly suggest that students who frequently use AI tools have worse critical-thinking scores, with younger participants (ages 17-25) displaying stronger dependency and lower analytical abilities. This is problematic for design education, because critical evaluation, spatial thinking, and contextual awareness are essential to professional competency (Kaderavek & Henbest, 2025). According to Szmyd and Mitera (2024), 83% of students worry that overusing AI could impair their decision-making and independence. The same studies show that AI can help students analyse massive datasets and explore alternate answers when appropriately integrated with human oversight. The literature shows that AI tool integration into design pedagogies is poorly understood. AI is successful in certain parts of design education, such as concept generation with Midjourney or urban design using stepwise generative frameworks, but full curricular integration strategies are understudied (Mingyi He, et al., 2025). Urban design education is especially difficult since social, environmental, and cultural elements require sophisticated human judgment that AI systems cannot handle (Shan Tong & Shaoikang Li, 2024).

AI in Urban Design

Helping designers address ill-defined urban problems remains a major challenge in the urban design field. In this context, AI has emerged as a promising tool to support problem-solving in urban design (Casakin, 2018). Traditional urban planning and design methods, which rely on experience, may have limitations in addressing complex and comprehensive factors in urban construction (Wan & Ma, 2022). The conventional design process, which often falls short in capturing the exploratory and flexible nature of design thinking, commonly observed in practical applications, can be improved using AI (Li, 2024).

The integration of AI can enhance various facets of the urban design process (Zhang, 2022). AI tools can be utilized to analyse large datasets, simulate different design scenarios, and generate optimized solutions (Liao et al., 2020). Moreover, AI fundamentally reshapes the design interaction and enhances efficiency across all phases, particularly in ensuring that it complements traditional methods and fosters critical thinking rather than replacing human ideas (Sabono, 2025). AI has potential to revolutionize the design process by enabling quick exploration of design ideas and generating context-sensitive and creative designs (Ko et al., 2023). By forecasting trends and generating design alternatives, AI fosters innovation while streamlining the urban design process (Rane et al., 2023). This can lead to more efficient and effective urban design outcomes (Jiang, 2020). By introducing AI into the design workflow, designers could generate many options, and this can give a better solution (Jin et al., 2021).

Generative design, which uses AI to explore the design space based on user-defined requirements, is one such application that can significantly accelerate the design process and facilitate the exploration of a wider range of design options (Plathottam et al., 2023). However, it is crucial to acknowledge the challenges associated with AI integration, including the need for new skills, evolving data requirements, and ethical considerations (Sanchez et al., 2024). Despite these challenges, AI-based methods also present opportunities to support interdisciplinary collaboration and the integration of local knowledge into urban design processes, which are often overlooked in traditional practices.

METHODS

Research Design and Paradigm

This study employs a comprehensive mixed-methods comparative case study design. The research is grounded in the pragmatic paradigm, which prioritizes the research problem over rigid methodological silos, allowing for the integration of multiple data collection and analysis strategies. This flexibility is essential for urban design, where "unstructured problems" involve multiple stakeholders, conflicting values, and high uncertainty.

Experimental Framework: The Three-Track Approach

The study centers on an experimental trial of the urban design process using three distinct approaches:

1. Fully Manual: Traditional hand-drawn or non-automated digital processes.
2. Fully AI: A process executed entirely via generative AI tools.
3. Hybrid: A collaborative approach integrating AI automation with human creative input and decision-making.

Context, Sampling, and Case Study

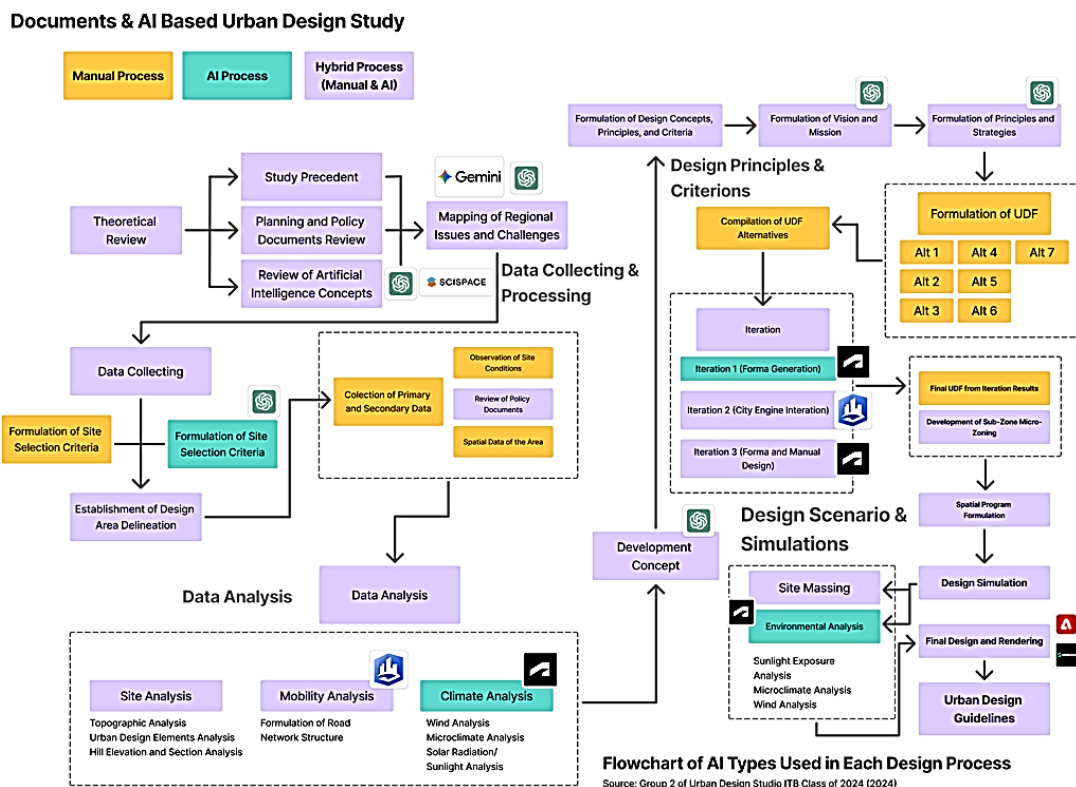


Fig. 1. Studio Design Framework and approaches detail in each step (Source: Urban Design Studio ITB Class of 2024)

- Participants: The study sampled 28 students enrolled in the Urban Design Studio II course (Urban Design Master Program) at Institut Teknologi Bandung (ITB), Indonesia.
- Site Location: The simulation focused on Nusantara, Indonesia's new capital city in Kalimantan.
- Task Allocation: Four adjacent areas within Nusantara were redesigned by four student groups, each testing the three methods across different design stages.

- **Workflow Flexibility:** The experiment was structured into five stages—data analysis, concept development, 3D modelling, evaluation, and rendering. Groups were permitted to switch methods between stages to explore workflow efficiencies.

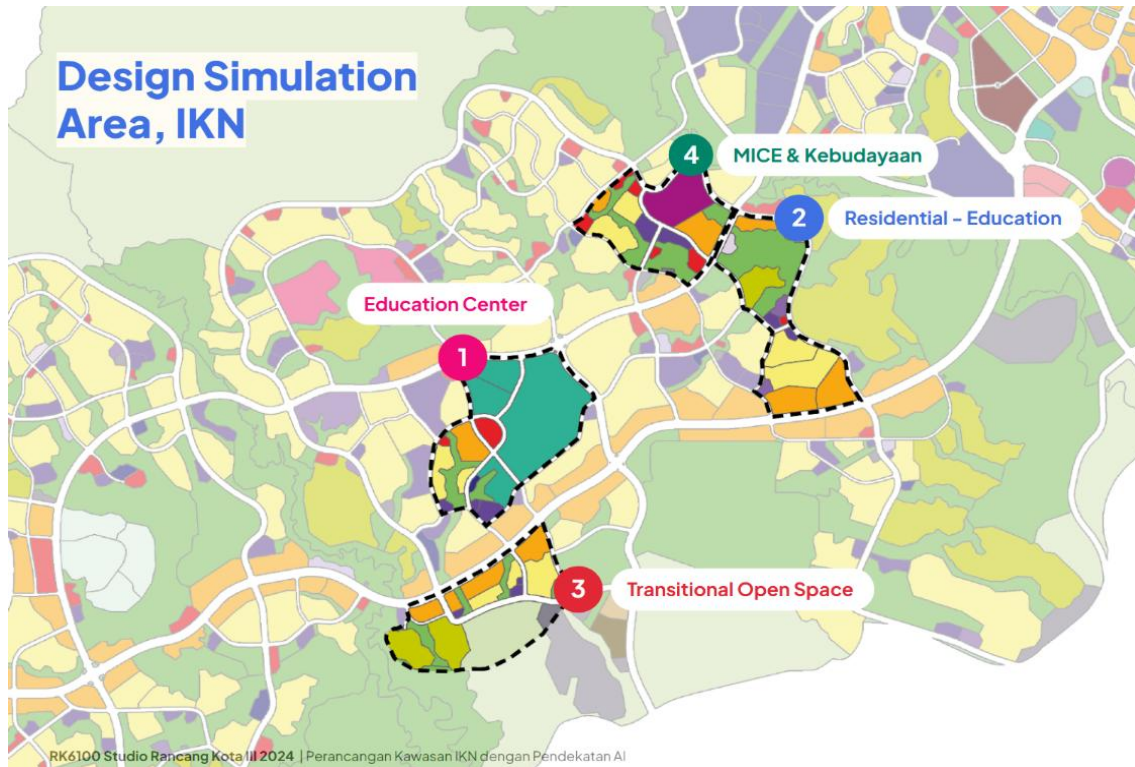


Fig. 2. Map of urban design simulation area within the Nusantara city
(Source: Paparan Studio Rancang Kota II. 2024)

Data Collection and Procedures

To ensure methodological transparency and replicability, data were gathered through two primary channels:

1. **Direct Observation:** Real-time tracking of the design process, including the sequence of tasks and time-to-completion for specific elements.
2. **Open-Ended Questionnaire:** The questionnaire included open-ended questions designed to capture reflective insights and subjective experiences related to the use of manual, AI-assisted, and hybrid workflows, AI limitations-challenges, and ethical considerations. These open-ended responses allowed participants to elaborate on their design strategies, perceived strengths and weaknesses of each workflow, and considerations related to future design practices and ethical implications.
3. **Structured Questionnaire (Likert Self-Assessment) :** A structured questionnaire was administered to all participants following the completion of the studio activities. The questionnaire included a Likert-scale self-assessment, allowing students to evaluate their experience with each workflow method.

Participants rated workflow performance across three predefined parameters:

- Quality of Results (Local Context Sensitivity & Final Design Quality)
- Process Speed (Time Efficiency & Creative Control)
- Level of Difficulty (Ease of Use & Critical Thinking Support)

Each parameter was rated using a five-point Likert scale, where a score of 1 represented very low performance, 2 represented low performance, 3 represented moderate performance, 4 represented high performance, and 5 represented very high performance. This structured self-assessment allowed participants to reflect critically on their workflow experiences while generating standardized quantitative data suitable for comparative analysis.

4. **Semi-Structured Interviews:** To deepen understanding of participant experiences, selected participants participated in semi-structured interviews conducted after the completion of the design tasks to capture subjective experiences regarding difficulty and tool utility.

Data Analysis and Evaluation Criteria

The study utilizes a comparative analysis framework based on three primary pillars:

Table 1. Criteria, Measure Type, and Indicators

Criteria	Measure Type	Indicators
Quality of Results	Quantitative	Mean scores derived from Likert self-assessment parameters including local context sensitivity, final design quality, and Environmental thermal performance.
	Qualitative	Design coherence, functional relationships between zones, contextual responsiveness, and reflections obtained from open-ended questionnaire responses and semi-structured interviews.
Process Speed	Quantitative	Likert self-assessment ratings and measured by the time required to complete task sequences (e.g., detailing design criteria).
	Qualitative	Reflections obtained from open-ended questionnaire responses and semi-structured interviews.
Level of Difficulty	Quantitative	Likert self-assessment ratings related to ease of use and perceived complexity.
	Qualitative	Reported workflow challenges, usability barriers, learning adaptation, and technical limitations derived from open-ended questionnaire responses and interview narratives.

Qualitative Analysis (Open-Ended Responses and Interviews)

Qualitative data derived from open-ended questionnaire responses and semi-structured interviews were analyzed using thematic coding procedures. The qualitative coding process followed three stages:

- **Open Coding**
Meaning units were identified from participant responses and assigned descriptive codes representing key ideas or experiences.
- **Axial Coding**
Related codes were grouped into sub-categories to identify patterns and relationships among recurring responses.
- **Selective Coding**
Sub-categories were synthesized into broader thematic categories representing key experiential dimensions of the workflow.

To enhance interpretability, coded relationships among responses were visualized using Sankey diagram representation, illustrating the distribution and flow of themes across workflow methods.

Quantitative Analysis (Likert Self-Assessment)

All quantitative responses were compiled and summarized using mean value calculations to determine the average performance of each workflow across parameters and stages. The use of mean scores enabled systematic comparison among workflows and provided a standardized measure of performance differences. These averaged values were subsequently presented in comparative tables and graphical summaries to highlight trends in workflow effectiveness, efficiency, and usability.

Process speed data collected through direct observation were also analyzed quantitatively based on recorded time duration required to complete design tasks.

Rigor, Validity, and Reliability

To ensure the findings are robust and minimize researcher bias, the following measures are implemented:

- **Triangulation:** Validity is achieved by cross-referencing observational data (what students did) with interview responses (what students said) and quantitative outcomes (thermal performance and time logs).
- **Qualitative Coding Procedure:** Interview transcripts and observation notes are analysed using thematic coding. To ensure reliability, an inter-coder agreement protocol is established where multiple researchers independently code a subset of the data to ensure consistency in identifying "difficulty" and "quality" themes.
- **Systematic Comparison:** The comparative nature of the three-track approach (Manual vs. AI vs. Hybrid) provides an internal control, allowing for a direct assessment of AI's impact on the design outcome.

IMPLEMENTATION OF AI IN THE URBAN DESIGN MASTER STUDIO

The application of AI in the urban design master studio can be done in various ways. One promising approach is the use of AI as a tool to generate design alternatives. In order to explore the optimal urban design process,

experiments were conducted through stages followed by four groups in the Urban Design Studio of the Urban Design Master Program, Institut Teknologi Bandung. Each group selected a different method for each design stage according to the needs and context faced, with the aim of achieving the best design results. This approach allows experimentation with various methods, whether manual, fully AI-based, or a combination of the two, to find the most effective solution at each design stage. The stages in this experiment include:

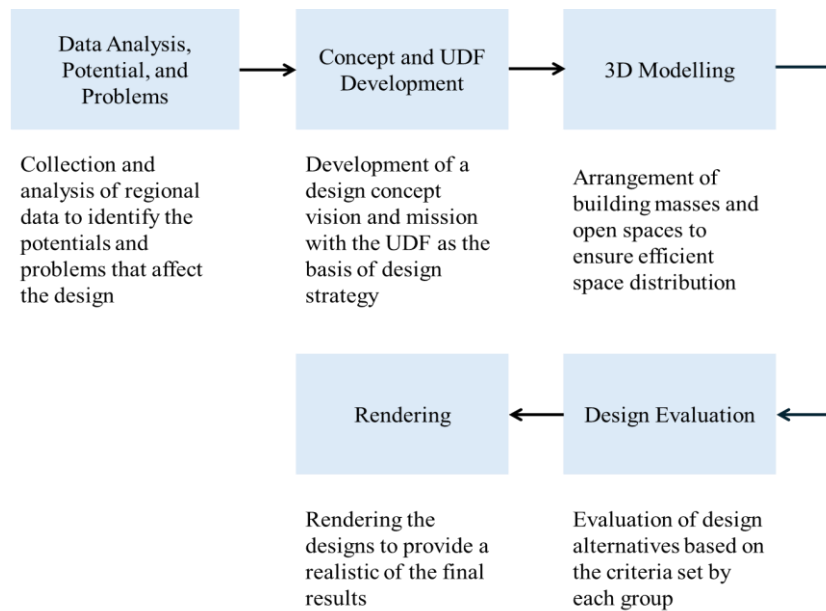


Fig. 3. Flowchart of Implementation of AI in the Urban Design Master Studio ITB

RESULTS AND ANALYSIS

This study evaluated the application of manual, full AI, and combination methods across a multi-stage urban design process. Based on studio observations and student interviews, the three methods were compared across three primary criteria: (1) the quality of results, (2) time required, (3) and the level of difficulty. Based on the observation of the work of the four groups in the studio, it can be concluded that all three methods are used in the analysis stage. The following table summarizes the observed effectiveness and application of each method as practiced by the student cohort.

Table 2. Comparative Effectiveness of Design Methods by Stage

Design Stage	Manual Method	Full AI Method	Combination Method
Analysis	High depth; used for local interpretation.	High speed; identifies big data patterns.	Balanced; uses AI for speed and manual for SWOT.
Concept Development	Indispensable for vision and framework	Generates diverse alternatives rapidly	Integrates manual vision with AI exploration
Initial Design	High effort; relies on intuition.	Rapid layout and form generation.	AI creates initial ideas; humans refine.
Final Design	Preferred for specific details.	Limited; often lacks local specificity.	Humans use manual touches for finality.
Evaluation	Qualitative and criteria-based.	Parameter-driven and objective.	Mixed; AI assesses, humans decide.
Visualization	High control; software-dependent.	Photorealistic and immersive.	AI-accelerated with manual adjustments.

The qualitative strand of the study was developed through an extensive process of content analysis, wherein students' written responses were systematically segmented, coded, grouped into sub-categories, and subsequently synthesized into overarching thematic domains. This methodological research strategy made it possible to uncover not only recurring patterns of meaning but also subtle variations in perspective that reveal how students conceptualize the interplay between manual methods, AI-mediated practices, and hybrid approaches within the pedagogical framework of urban design education. Through this lens, five major focal areas emerged: experiences with manual

design, perceptions of AI interaction, strategies for combining methods, visions for the future, and ethical considerations. Each of these areas demonstrates the complexity of student engagement and the multilayered nature of their reflections.

Analysis of Quantitative Data

The quantitative analysis employed a five-point Likert scale (1 = very low, 5 = very high) to interrogate students' evaluations of manual, AI-driven, and hybrid design approaches across five canonical stages of the design process: analysis, concept development, design detailing, evaluation, and visualization. The quantitative data from the five-point Likert scale provides indicative trends for this cohort:

- Manual techniques received the highest scores in analysis and concept development (ratings of 4 or 5), suggesting their perceived necessity for methodological rigor.
- AI methods peaked in the visualization and evaluation phases (ratings of 3 to 5), reflecting their utility in delivering graphically persuasive outputs.
- Hybrid workflows sustained the most consistent distribution of strengths across all stages, reconciling the deficiencies of the singular approaches.

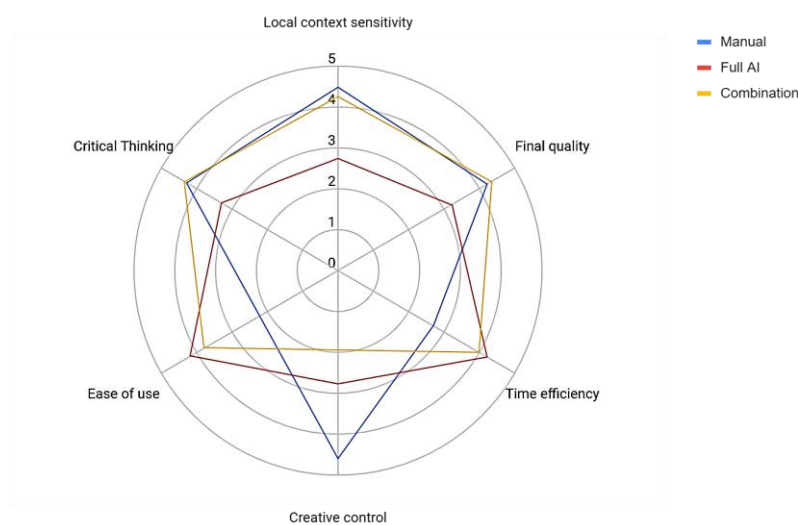


Fig. 4. Radar Diagrams Comparative Analysis (Source: Author)

An examination of modal responses reinforced these associations. Manual methods were most frequently aligned with depth, originality, and contextual sensitivity. AI methods were consistently linked with speed, operational efficiency, and representational fluency. Hybrid approaches were most strongly associated with integration, adaptability, and complementarity. Collectively, these associations reflect an emergent consensus that hybrid modalities not only reconcile the deficiencies inherent in singular approaches but also establish a more robust and adaptive framework for design pedagogy.

The quantitative findings substantiate and extend the qualitative results; manual practices remain indispensable for cultivating analytical and conceptual rigor; AI affords unparalleled efficiency in visualization and iteration; and the deliberate integration of both constitutes the most effective and sustainable trajectory for contemporary design education.

Analysis of Qualitative Data

Manual Method

In the manual approach, the urban design process is carried out by relying entirely on human skills and intuition. This approach is applied at various stages, starting from data collection, problem analysis, concept development, final building mass arrangement, to design visualization.

- At the analysis stage, groups using manual methods collect data conventionally, such as through literature, journals, and other information sources.
- At the concept stage, the manual approach emphasizes the development of a detailed vision and mission and Urban Design Framework (UDF).

- In the design phase, the manual method is applied to the final design. This is because the final design requires more in-depth details and more specific adjustments. All design processes are done manually.
- At the evaluation stage, design evaluation is carried out manually to assess each design alternative based on predetermined criteria, such as functionality, aesthetics, and sustainability.
- At the rendering stage, the design is manually visualized using rendering software.

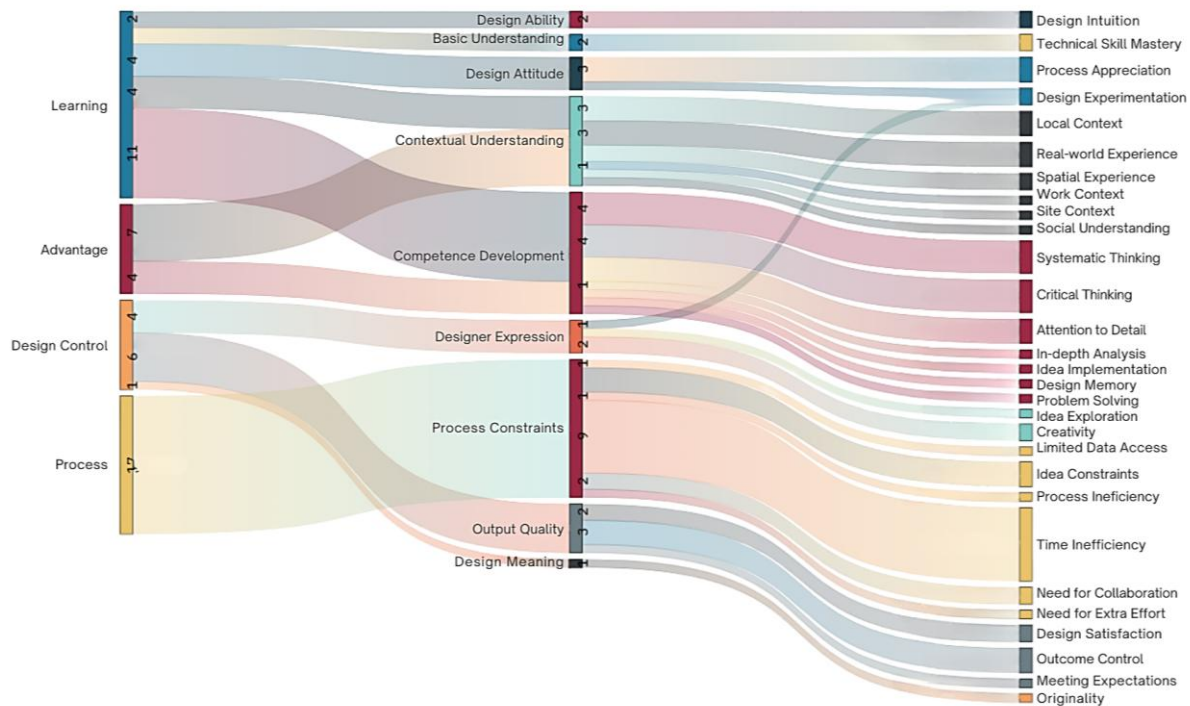


Fig. 5. Manual Method Sankey Diagrams
(Source: Author)

The findings on manual approaches reveal that traditional design methods continue to serve as a cornerstone in students' engagement with urban design education. The Sankey diagram shows dense flows originating from categories such as Learning, Process, Advantage, and Design Control, which connect to multiple sub-categories and codes, indicating the multifaceted role of manual practice.

A major cluster is observed around Learning, which includes sub-categories such as Design Ability, Basic Understanding, Design Attitude, and Contextual Understanding. Codes linked to these sub-categories—such as Systematic Thinking, Critical Thinking, Process Appreciation, and Design Experimentation—highlight the intellectual richness attributed to manual methods. Students repeatedly emphasized that manual design encourages a deeper engagement with context, fosters analytical thinking, and promotes reflective reasoning. Beyond technical mastery, manual practice is seen as a vehicle for cultivating social understanding, local sensitivity, and real-world immersion, which are essential for urban design education that values contextual responsiveness.

The dimension of Advantage is closely tied to Competence Development, which includes codes such as Critical Thinking, Systematic Thinking, and Social Understanding. These codes demonstrate how students associate manual practice with the cultivation of long-term professional values—such as interpretive depth, originality, and creative autonomy. Manual design is perceived as more than a set of technical tasks; it is seen as a mode of thinking that nurtures design intuition and the ability to critically interrogate problems, thereby reinforcing the designer's intellectual agency.

On the other hand, the Process category exposes structural challenges inherent in manual workflows. Sub-categories like Process Constraints and Output Quality are strongly connected to negative codes such as Time Inefficiency, Process Inefficiency, Limited Data Access, and Extra Effort Requirements. These codes reflect students' awareness that while manual methods deepen contextual understanding, they simultaneously impose significant burdens in terms of workload and iteration speed. Manual workflows, by their nature, require substantial physical energy, careful attention to detail, and extended time investment, which can hinder productivity in fast-paced design studios. This pragmatic tension highlights the limitations of manual methods in educational settings where deadlines and efficiency pressures are pronounced.

Another critical dimension is Design Control, where students expressed appreciation for the creative agency afforded by manual practice. Codes such as Originality, Outcome Control, and Satisfaction indicate that manual work

allows designers to maintain a stronger sense of authorship and alignment with their own intentions. Students viewed manual methods as providing a direct channel for expressing design ideas without the mediation of algorithms or automated systems. This sense of control was often contrasted against AI workflows, which some participants perceived as prone to bias or unpredictability. The manual process, despite its inefficiencies, was framed as a safeguard for design authenticity and originality.

The findings on manual approaches portray a dual narrative, on one side, manual methods are celebrated for cultivating critical inquiry, contextual immersion, and creativity, which remain indispensable for forming a reflective and contextually responsive designer. On the other side, students voiced strong critiques about the temporal inefficiency, physical demands, and limited scalability of manual workflows. This tension underscores the ongoing debate in design pedagogy: while manual practice fosters intellectual rigor and interpretive depth, its limitations pose significant challenges in adapting to the demands of contemporary design education, where speed, flexibility, and productivity are increasingly valued. To provide a structured overview of the research findings, the following tables systematically categorize the complex relationships in Manual Method.

Table 3. Manual Method Category Summary

Category	Sub-Category	Detail
Learning	Design Ability	Design Intuition,
	Basic Understanding	Technical Skill Mastery
	Design Attitude	Process Appreciation, Design Experimentation
	Contextual Understanding	Local Context, Real-world Experience
	Competence Development	Systematic Thinking, Critical Thinking, Attention to Detail,
Advantage	Contextual Understanding	Real-world Experience, Spatial Experience, Work Context, Site Context, Social Understanding
	Competence Development	In-depth Analysis, Idea Implementation, Problem Solving, Design Memory,
Design	Designer Expression	Idea Exploration, Creativity, Design Experimentation
Control	Output Quality	Design Satisfaction, Outcome Control, Meeting Expectations,
	Design Meaning	Originality
Process	Process Constraints	Limited Data Access, Idea Constraints, Process Inefficiency, Time Inefficiency, Need for Collaboration, Need for Extra Effort.

(Source: Author)

Full AI Method

In the full AI method, the urban design process is conducted entirely with the help of AI technology. The full AI method is used to collect and analyse data, develop concepts, and produce design alternatives.

- In the analysis stage, AI automatically collects, cleans, and analyses big datasets (spatial, demographic, environmental) to identify patterns and contextual insights.
- In the concept stage, AI helps in formulating vision and mission and formulating UDF by automatically generating various design alternatives.
- At the design stage, AI produces preliminary layouts, building forms, and urban patterns, enabling many iterations in a short time.
- Evaluation is performed by AI to assess designs based on predetermined parameters.
- In the rendering stage, AI is used to visualize designs, visualized using ai rendering software. AI transforms text into photorealistic renderings and immersive visualizations.

The Sankey diagram of AI-based approaches reveals a nuanced distribution of both opportunities and limitations in the integration of artificial intelligence within the design process. Several key themes emerge—advantages and benefits of AI, process-oriented gains, and inherent challenges. Students highlighted that AI offers multiple advantages in supporting the design process through categories such as AI Development, Data Access, Process Support, and Idea Support, demonstrating its role in broadening reference bases, enabling data-driven insights, and generating initial design alternatives. This capability allows designers to rapidly explore diverse scenarios, expanding creative horizons while reducing repetitive workloads.

At the same time, AI serves as a collaborative partner, providing technical and conceptual support that enhances idea generation and facilitates conceptual development. Process-oriented benefits—such as Efficiency, New Skills, and Process Dynamics—illustrate operational improvements when AI is used. Students identified Design Acceleration, Work Efficiency, and Ease of Process as key outcomes, emphasizing that AI not only increases productivity but also encourages skill development in prompt engineering and data analysis as part of the evolving designer’s toolkit.

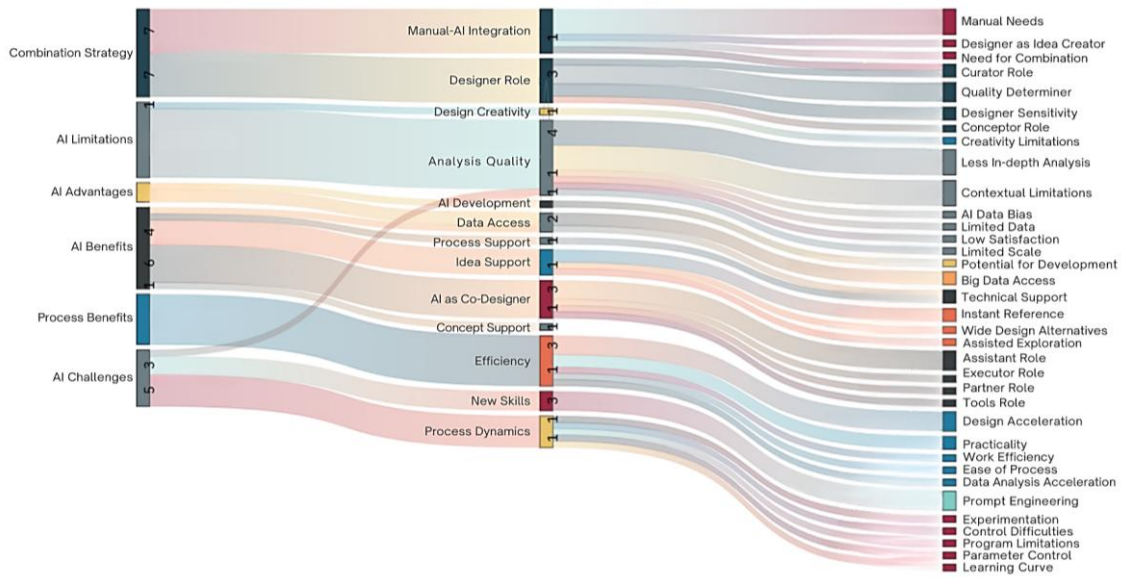


Fig. 6. Full AI Method Sankey Diagrams
(Source: Author)

Despite these perceived advantages, students were consistently aware of AI’s limitations. Sub-categories such as Analysis Quality and Contextual Limitations revealed concerns about creativity constraints, less in-depth analysis, and contextual bias. Codes like AI Data Bias, Limited Data, and Low Satisfaction point to an understanding that AI outputs often lack depth and reliability, particularly when local or cultural specificity is required. This reflects a critical view that while AI can accelerate processes, it cannot yet replicate the contextual sensitivity and ethical grounding of human judgment.

Students also articulated specific challenges in applying AI. These included Experimentation, Control Difficulties, Program Limitations, Parameter Control, and Learning Curve. Such codes reveal a dual challenge: on one hand, the technical limitations of AI itself, and on the other, the learning demands placed on students to effectively integrate AI into their workflows. The prompt dependency issue was highlighted, showing that the quality of AI output is directly tied to how well students can craft and refine input prompts. This aligns with broader anxieties about loss of authorship and reduced control, suggesting that while AI expands possibilities, it simultaneously requires careful curation and oversight to avoid superficial or misleading outcomes.

Overall, the diagram illustrates a balanced ambivalence. On one hand, AI is viewed as a powerful tool for efficiency, exploration, and process acceleration, offering tangible benefits in data access, conceptual variation, and technical support. On the other side, students remain critical of its shallow analysis, dependency on prompts, and contextual insensitivity, recognizing that these challenges necessitate stronger human oversight.

Table 4. Full AI Method Category Summary

Category	Sub-Category	Detail
Combination Strategy	Manual-AI Integration	Manual Needs, Designer as Idea Creator, Need for Combination, Curator Role,
	Designer Role	Curator Role, Quality Determiner, Designer Sensitivity, Conceptor Role
AI Limitations	Design Creativity	Creativity Limitations
	Analysis Quality	Less In-depth Analysis, Contextual Limitations, AI data bias, Limited Data, Low Satisfaction, Limited scale
AI Advantages	AI Development	Potential for Development
	Data Access	Big Data Access, Technical Support,
AI Benefits	Data Access	Big Data Access
	Process Support	Technical Support,
	Idea Support	Instant Reference, Wide Design Alternatives, Assisted Exploration
	AI as Co-Designer	Assistant Role, Executor Role, Partner Role, Tools Role
Process Benefits	Concept Support	Tools Role
	Efficiency	Design Acceleration, Practicality, Work Efficiency, Ease of Process, Data Analysis Acceleration
AI Challenges	New Skills	Prompt Engineering
	Process Dynamics	Experimentation, Control Difficulties, Program Limitations, Parameter Control, Learning Curve

(Source: Author)

The findings reinforce that students position AI as an assistant or co-designer rather than a replacement for human creativity and judgment. The perception of AI is thus defined by duality, opportunity through acceleration and diversity, yet risk through superficiality and dependency. To provide a structured overview of the research findings, the following tables systematically categorize the complex relationships in Full AI Method.

Combination Method (Manual & AI)

In the combination approach, humans and AI work are combined in every stage of design. At each stage, AI is used to accelerate and improve efficiency, while creative and contextual decisions are made by humans. Most of the urban design process is carried out using a hybrid approach, combining humans and AI, which involves two main methods: Human Adaptation to AI Design Support and AI Augmentation to the Design Process.

- In the analysis stage, AI is used to process data quickly, while SWOT analysis and contextual understanding are still done manually to ensure the accuracy of local interpretation.
- In the concept stage, this combination integrates manually developed visions and missions with AI exploration results to produce a broader and more comprehensive Urban Design Framework.
- At the design stage, AI is used to create initial designs, which are then refined by humans for use in the final design.
- Evaluation is conducted in a combined manner, with AI assisting in objectively assessing designs, while the final decision involves more contextual and creative human judgment.
- In rendering, AI speeds up the visualization process, but there are still manual adjustments to ensure the final result matches the design vision.

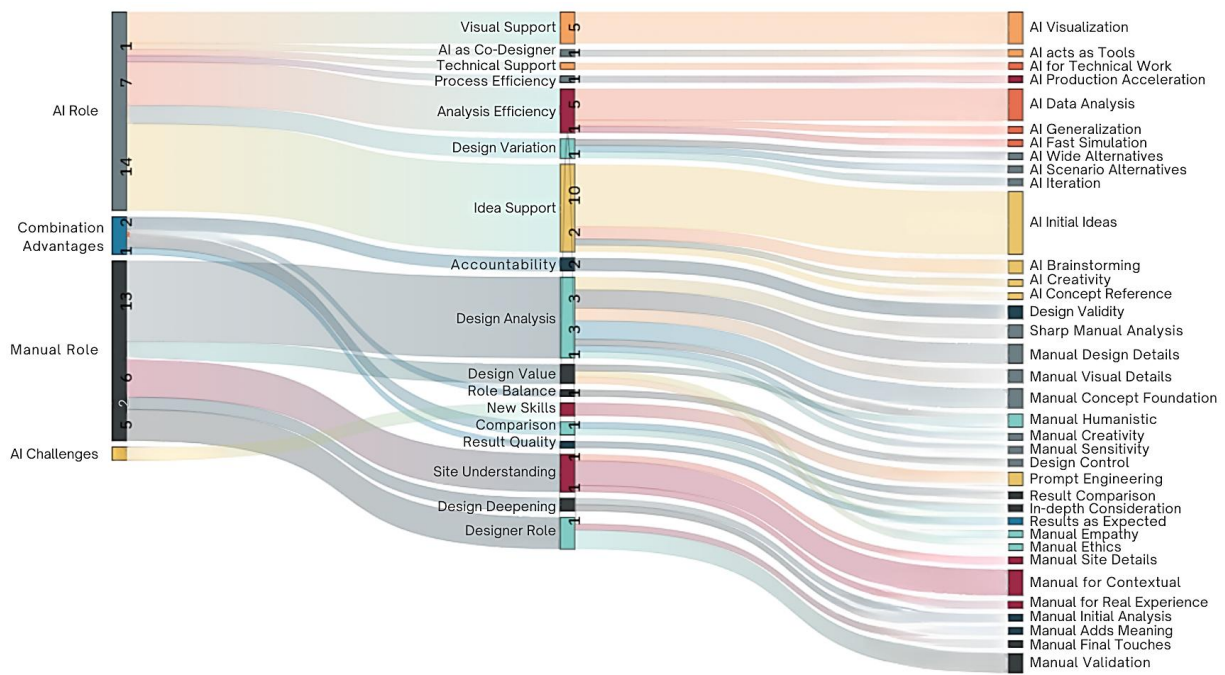


Fig. 7. Combination Method Sankey Diagrams (Source: Author)

The findings reveal that combination strategies represent the most balanced and widely acknowledged approach in urban design, where artificial intelligence and manual methods are deliberately integrated to complement one another. The diagram illustrates that AI plays an essential role in providing speed, efficiency, and technical support—particularly in data analysis, visualization, design variation, and idea generation. Through tools such as generative design software, AI visualization platforms, and data-driven simulation systems, AI is able to produce multiple alternatives rapidly, simulate scenarios, and accelerate design iteration. This allows students and designers to explore a broader spectrum of ideas within a shorter time, while maintaining the flexibility to adapt those ideas to evolving project needs.

At the same time, the manual role remains central in preserving creativity, contextual sensitivity, and design authenticity. Manual processes ensure that design decisions are deeply rooted in cultural, spatial, and social contexts that AI cannot fully interpret. Critical human contributions include sharp manual analysis, detailed conceptual

development, and the infusion of empathy, creativity, and originality into design work. Moreover, humans maintain accountability for final decisions, validating AI outputs and ensuring that the results align with expectations, site realities, and broader design values. In this hybrid model, the human designer emerges not only as a creator but also as a curator, validator, and ethical decision maker.

The combination of AI and manual methods provides distinct advantages by merging the strengths of both: the computational efficiency of AI and the interpretive depth of manual approaches. This hybrid workflow enables accountability and credibility, as AI-driven outputs are balanced and refined through human judgment, resulting in designs that are both innovative and contextually grounded. Students frequently described this process as co-creation, in which AI assists in brainstorming, visualization, and rapid simulation, while humans focus on refining, contextualizing, and ensuring originality.

Nevertheless, the integration of both methods is not without challenges. Respondents noted the difficulties of prompt engineering, the risk of overdependence on AI, and the technical limitations of algorithms that sometimes lead to superficial or biased outputs. Manual efforts are still needed to compare, validate, and adjust AI-generated designs, which can add layers of complexity to the workflow. Furthermore, the learning curve associated with mastering AI tools requires students to adapt quickly while not losing sight of foundational design skills.

The combination strategies highlight a model of interdependence between AI and human creativity. Rather than positioning one as superior to the other, the hybrid approach demonstrates that design processes are most productive when technology accelerates routine and technical tasks, while human judgment ensures depth, originality, and contextual relevance. This balance underscores the future trajectory of design pedagogy and practice: one where efficiency and creativity coexist, and where human-centered values remain at the core of technologically supported urban design. To provide a structured overview of the research findings, the following tables systematically categorize the complex relationships in Combination Method.

Table 5. Combination Method Category Summary

Category	Sub-Category	Detail
AI Role	Visual Support	AI Visualization
	AI as Co-Designer	AI acts as Tools
	Technical Support	AI for Technical Work
	Process Efficiency	AI Production Acceleration
	Analysis Efficiency	AI Data Analysis, AI Generalization, AI Fast Simulation
	Design Variation	AI Wide Alternatives, AI Scenario Alternatives, AI Iteration
	Idea Support	AI Initial Ideas, AI Brainstorming, AI Creativity, AI Concept Reference
Combination Adv.	Accountability	Design Validity,
	Role Balance	Design Control
	Comparison	Result Comparison, In-depth Consideration,
	Result Quality	Results as Expected,
Manual Role	Design Analysis	Sharp Manual Analysis, Manual Design Details, Manual Visual Details, Manual Concept Foundation,
	Design Value	Manual Humanistic, Manual Creativity, Manual Sensitivity, Manual Empathy, Manual Ethics
	Site Understanding	Manual Site Details, Manual for Contextual, Manual for Real Experience,
	Design Deepening	Manual Initial Analysis, Manual Adds Meaning, Manual Final Touches
	Designer Role	Manual Validation, Manual Final Touches
AI Challenges	New Skills	Prompt Engineering

(Source: Author)

DISCUSSION

The findings from this specific cohort reveal a dual narrative across the three approaches:

- **Manual Method:** These findings indicate that traditional methods remain a cornerstone for students. Trends suggest manual practice is tied to Competence Development, fostering critical thinking and social understanding. However, the data highlights significant Process Constraints, specifically time and physical energy demands.
- **Full AI Method:** Observations show that AI is primarily valued for Design Acceleration and Work Efficiency. Despite these gains, students expressed consistent awareness of AI Limitations, such as data bias and a lack of depth in contextual analysis.
- **Combination Method:** This approach emerged as the most widely acknowledged strategy among the participants. It allows students to operate as Curators, using AI for computational efficiency while manual intervention ensures design authenticity and empathy.

Interpretive Discussion: The Future of Pedagogy

When envisioning the future of urban design education and practice, participants articulated scenarios where AI and human designers operate in synergy. The future designer was consistently described as a strategic decision maker, navigator, and ethical gatekeeper, while AI was framed as a supporting collaborator that provides technical efficiency, generative variation, and analytical capacity. Respondents highlighted opportunities for expanded professional value, as AI could streamline repetitive processes and free designers to focus on critical thinking, creativity, and contextual adaptation. This vision situates the human role not as diminished, but rather as elevated—directing the overall process while leveraging AI to enhance productivity and broaden conceptual exploration.

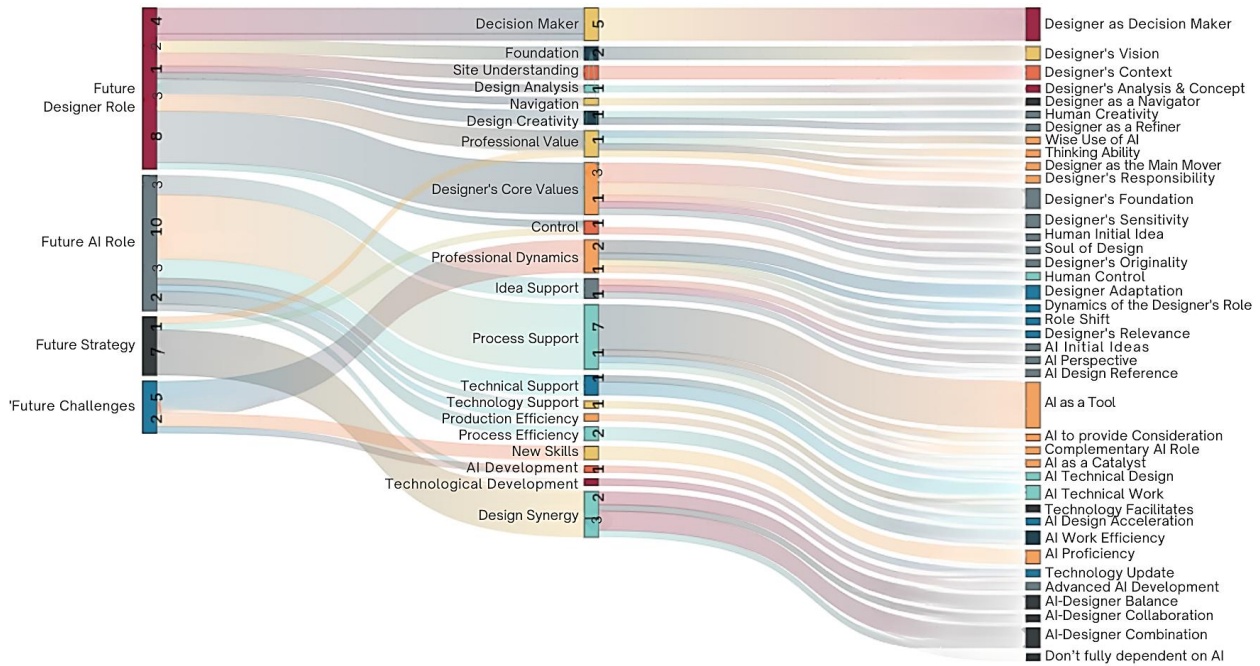


Fig. 8. Visions for The Future Sankey Diagrams (Source: Author)

At the same time, participants recognized challenges that may accompany this transformation. Concerns included the possibility of role shifts, overdependence on automation, and the erosion of originality if AI becomes overly dominant in design workflows. Nevertheless, students also anticipated positive developments, such as design synergy, process efficiency, advanced technical support, and new skill acquisition that would prepare them for evolving professional demands. Many positioned AI as a tool for acceleration and augmentation, not as a replacement, reinforcing the centrality of human sensitivity, responsibility, and creativity in shaping meaningful urban environments. Collectively, these reflections suggest that the future of urban design lies in a balanced hybrid paradigm, where AI amplifies capability, but human designers define direction and values.

The ethical dimension of AI in urban design emerged as one of the most prominent themes across the responses. Participants frequently raised concerns related to data protection, intellectual property rights, and the preservation of creativity and originality. Risks such as AI plagiarism, homogenization of design outcomes, data bias, misinformation, and erosion of authorship were identified as critical issues that threaten both academic integrity and professional practice. Moreover, the responses revealed apprehension regarding the loss of human creativity and authenticity in design, as AI may generate outputs that are efficient but lack depth and contextual sensitivity. Students consistently emphasized that without strong ethical frameworks, AI could shift design practice away from its humanistic and contextual roots.

In parallel with these concerns, participants also articulated solutions and counterbalances to ensure responsible AI integration. Proposed measures included the establishment of clear ethical codes, transparency protocols, regulatory oversight, labelling of AI-generated work, and the strengthening of professional ethics in design education. Many respondents stressed the need for human oversight and ethical filters to validate AI outputs and safeguard against misuse. Interestingly, even students who expressed relatively low levels of concern acknowledged the necessity of institutional safeguards to manage potential risks. This indicates a collective awareness that the application of AI is not solely a matter of technical efficiency but also an issue of professional responsibility, accountability, and governance in the discipline.

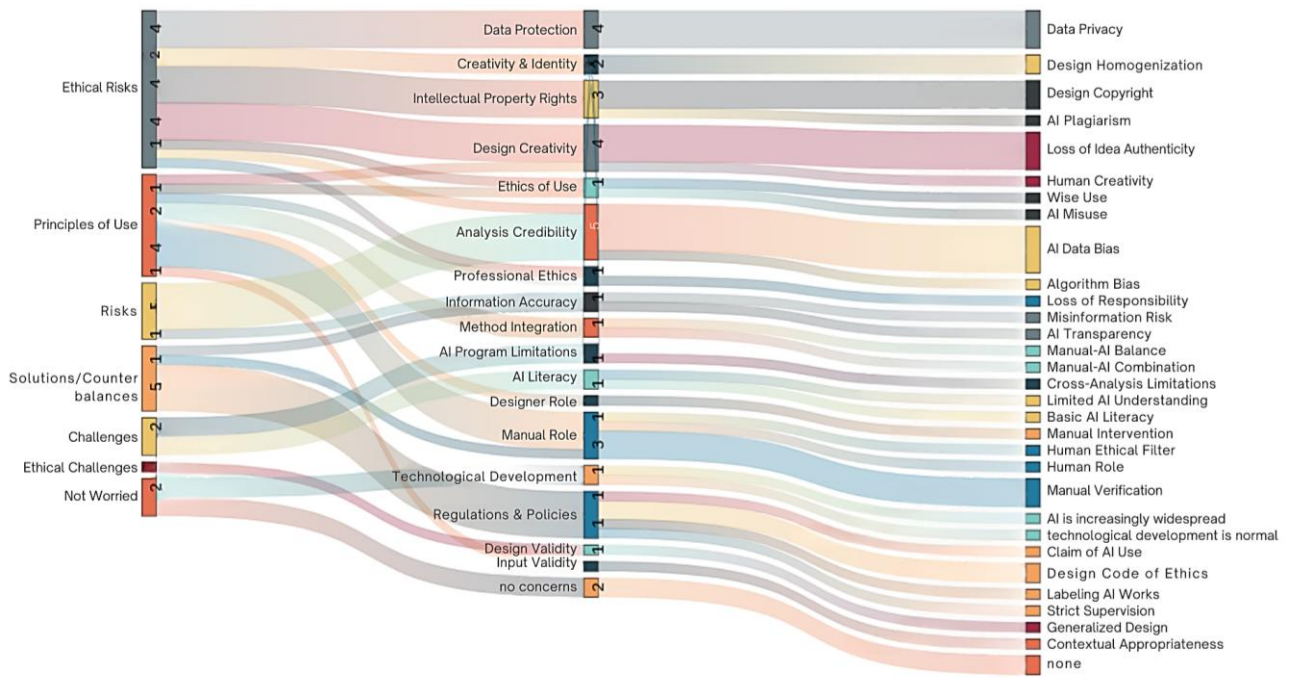


Fig. 9. Ethical Dimension of AI in Urban Design Sankey Diagrams (Source: Author)

Table 6. Ethical Risks and Proposed Strategic Solutions

Category	Identified Risks & Challenges	Proposed Solutions & Counterbalances
Intellectual Integrity	AI plagiarism, erosion of authorship, and loss of idea authenticity.	Establishing clear ethical codes and mandatory labelling of AI-generated work.
Data & Governance	Data privacy concerns, algorithmic bias, and misinformation risks.	Implementation of transparency protocols and institutional regulatory oversight.
Design Quality	Homogenization of design outcomes and lack of contextual sensitivity/depth.	Strengthening professional ethics in education and utilizing humans as "ethical filters".
Human Agency	Overdependence on automation and loss of human creativity/identity.	Human-led validation of all outputs and maintaining a "manual-AI balance" in workflows.

These findings characterize the students as critically engaged agents who view AI with a mix of curiosity and caution. While AI offers unparalleled speed and representational fluency, the cohort's responses indicate that manual practice remains indispensable for fostering the depth and rigor required in urban design. Collectively, these insights suggest that the most sustainable trajectory for design pedagogy is one that embraces technological innovation while strictly safeguarding the intellectual and ethical traditions of the field.

The findings from this specific cohort provide an indicative mandate for pedagogical evolution in urban design education. The true value of a hybrid method lies in its ability to prepare students for a professional reality where they must act as critical mediators of technology. We frame this discussion around the three interconnected pillars that must form the foundation of this new pedagogy. We structure this discussion around three core themes: (1) the necessary pedagogical shift towards a new designer role, (2) the ethical imperatives arising within the studio, (3) and the call for a balanced framework for AI integration.

Theme 1 - Pedagogical Shift: Cultivating the "Designer Arbiter"

When students in the full AI workflow encountered outputs they described as generic or contextually insensitive, they were forced into a position of arbitration: they had to judge, select, and curate, rather than simply create. This arbitration was not a simple act of selection; it involved a critical deconstruction of AI's outputs, questioning the underlying assumptions of the generated forms, and synthesizing AI's raw potential with their own contextual knowledge—a process that was absent in the more passive 'full AI' workflow. Thus, the study demonstrates the necessity to shift the educational focus from merely mastering design tools for creation to critically assessing the quality of alternative design outputs using different AI prompts. Our most significant finding is that meaningful AI integration is contingent on shifting the educational focus from training tool-users to cultivating "Designer Arbiters" (Yu, 2025).

This new role requires what Naik et al. (2025) describe as a "complex negotiation" between established design principles and emergent technological considerations. In our studio, this negotiation was palpable. Students had to balance the allure of AI's rapid generation against their own slower, more deliberate design intuition. They had to weigh data-driven suggestions against their qualitative understanding of place and negotiate between the global aesthetics embedded in the AI's training data and the local identity demanded by the Indonesian context. The curriculum must therefore be redesigned to explicitly teach this skill, focusing on strategic questioning, critical evaluation of algorithmic outputs, and the synthesis of human and machine intelligence.

However, fostering this role requires navigating significant risks. The primary danger is an over-reliance on AI, which could lead to cognitive dependency and an atrophy of foundational design skills (Yu, 2025). As Al-Zahrani (2024) warns, this may impede the development of students' critical thinking and creativity. The "productive struggle" inherent in the traditional design process—where students grapple with ambiguity and complexity—is a fertile ground for learning. If AI is used as a shortcut that bypasses this struggle, we risk graduating designers who are proficient at generating options but deficient in the critical judgment needed to produce meaningful architecture. Therefore, the role of the educator must also evolve, shifting from a purveyor of knowledge to a facilitator of critical dialogue. This requires new competencies and dedicated institutional support, as educators need to be prepared for these AI-rich environments (Gentile et al., 2023).

Theme 2 - Ethical Imperatives in the Design Studio

The analysis indicates that the student have some concerns regarding data bias. The design studio must be reconceptualized as the first line of defense where the ethical complexities of AI in urban design are confronted. The macro-level ethical concerns of bias, equity, and accountability (Sanchez et al., 2024) are not abstract future problems; they are embedded in the datasets and algorithms students use today. The studio is a controlled environment where students can "fail safely" in their ethical reasoning. They can see the results of a biased algorithm firsthand—for example, generating culturally inappropriate buildings for the Indonesian context—without real-world consequences, making the lesson more potent and memorable. This transforms the use of AI from a passive act into an active critical inquiry, teaching students to interrogate their tools by asking, "On what data was this model trained? Whose aesthetics and values are represented? What cultural contexts are missing?"

This pedagogical responsibility is intrinsically linked to academic integrity. A comprehensive understanding of AI principles is essential to prevent misuse and ensure students can ethically account for their design process (Chan, 2023). We propose that this goes beyond simply citing AI as a source. Instead, we advocate for making ethical reflection a core, graded component of the design process. This could take the form of an AI Process Journal, where students document their prompts, critique the AI's outputs, and justify their own design decisions in response. This practice reframes academic integrity not as a punitive measure against cheating, but as a formative exercise in professional transparency and intellectual accountability. It makes the student's own intellectual contribution visible and reinforces the value of human judgment, originality, and ethical reasoning in an age of generative content (Al-Zahrani, 2024).

Table 7. Pedagogical Guidelines for Ethical AI Integration

Component	Practical Guidelines & Policies
Documentation	AI Process Journal: Students must document prompts, critique AI outputs, and justify human interventions to ensure transparency.
Assessment	Reflective Evaluation: Grading should include the student's ability to deconstruct AI outputs and synthesize them with contextual knowledge.
Studio Policy	Data Interrogation: Policy should mandate that students explicitly state the source and cultural limitations of datasets used.
Integrity	Authorship Identification: Clear labelling of AI-assisted vs. manual components to reinforce intellectual accountability.

Theme 3 - Towards a Balanced and Comprehensive Framework for AI Integration

In conclusion, the urban design studio's experiment in using AI to simulate an urban design plan for Indonesia's new capital city provided valuable insights into the potential and challenges of integrating AI into urban design education. This paper is the empirical demonstration that the central task of design education in the AI era is to shift its focus from teaching software proficiency to cultivating students as "Designer Arbiters." This pedagogical model emphasizes the development of students' critical capacity to direct, question, and ethically integrate AI-generated outputs into a coherent and responsible design vision.

The comparison of manual, AI-assisted, and fully AI-driven design processes revealed the benefits and risks of each approach, emphasizing the importance of human oversight and judgment in maintaining design standards and academic integrity. The integration of AI in urban design education necessitates a comprehensive approach that addresses ethical considerations, supports teachers, and promotes critical thinking skills.

LIMITATIONS AND FUTURE RESEARCH

While providing valuable insights, this study has inherent limitations that must be acknowledged to avoid overgeneralization:

- **Sample Specificity:** The findings are based on a single case study with a specific cohort of 28 students. Consequently, the results should be viewed as indicative trends rather than universal conditions of common practice. Future research should validate these findings with larger cohorts and incorporate more robust quantitative metrics for performance evaluation.
- **Contextual Bias:** The experiment was conducted within the specific socio-cultural context of Indonesia's new capital city. Different urban or cultural settings might yield different student perceptions of AI's "contextual insensitivity."
- **Measurement Metrics:** The evaluation of design quality was primarily qualitative. Future research should incorporate robust quantitative metrics and larger cohorts to validate these findings.
- **Long-term Effects:** Longitudinal studies are necessary to assess whether AI integration leads to long-term atrophy of foundational design thinking skills or if it successfully fosters new forms of cognitive synergy.

By embracing this balanced and critical approach, design education can prepare a generation capable of harnessing AI not just effectively, but wisely to create more inclusive, sustainable, and human-centered urban environments.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The author(s) used Gemini AI and Jenni AI for enhancing readability during manuscript preparation. The author(s) reviewed and edited content as necessary and accept full responsibility for the published work.

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APPENDIX: A Synthesis of Student-Generated Prompt Engineering Strategies

To ensure high-quality context-aware output from Large Language Models (LLMs), students transitioned from intuitive inquiries to the following structured prompting frameworks:

- CARE (Context, Action, Result, Example):

- Context: Provides the background of the situation (e.g., "Designing a cultural center in IKN").
- Action: Defines the specific task for the AI (e.g., "Formulate a vision statement").
- Result: Specifies the desired format or quality (e.g., "Must reflect specific keywords").
- Example: Offers references or styles to guide the AI's tone (e.g., "Based on these study cases").
- **TAG** (Task, Action, Goal):
 - Task: Assigns a specific persona or role to the AI (e.g., "Act as a literary assistant").
 - Action: Provides the specific work instruction (e.g., "Develop an engaging tagline").
 - Goal: Defines the intended objective or impact (e.g., "Create a 'smart city' infrastructure").

Table A.1 A Synthesis of Student-Generated Prompt Engineering

Design Phase	Category	Framework	Representative Prompt Content Bilingual (Original in Bahasa Indonesia)	Outcome Assessment
Visioning	Sub-optimal (failure)	Basic Inquiry	"Bantu kami merumuskan visi pengembangan kawasan pusat kebudayaan di IKN." "Help us formulate a development vision for the cultural center area in IKN."	Produced generic urban concepts that lacked specific local identity or "Forest City" nuances.
Visioning	Successful	CARE	"Kami sedang menyusun perancangan kawasan pusat kebudayaan di IKN - Bantu kami menjadi asisten penulis untuk merumuskan visi pengembangan kawasan - Visi yang dirumuskan harus dapat mencerminkan 'keyword' - dengan beberapa contoh yang baik adalah berikut 'contoh dari beberapa studi'. "We are developing an urban design for the cultural center area in IKN - Help us as a writing assistant to formulate a development vision for the area - The vision formulated must reflect the 'keywords' - with some good examples as follows 'examples from several studies'."	Effectively balanced cultural richness with ecological harmony, leading to the vision.
Tagline Creation	Successful	TAG	"Bantu kami menjadi asisten penulis sastra - Tolong kembangkan tagline yang menarik dengan bahasa lokal untuk kawasan A yang bernuansa kebudayaan - Tujuan yang ingin dicapai adalah terciptanya semangat kehidupan kota yang lovable dengan tetap berharmoni dengan alam." "Help us by acting as a literary writing assistant – Please develop an engaging tagline using local language for Area A, which has a cultural nuance – The objective is to create a spirit of 'lovable' city life while remaining in harmony with nature."	Generated evocative and culturally resonant branding such as Joy in Culture (<i>Bersukaria dalam Berbudaya</i>).
UDF & Spatial Program	Successful	Structure Iteration	"Tugasmu adalah membuat strategi serta program ruang pada kawasan berdasarkan visi dan misi yang telah disebutkan dengan fungsi tata ruang: budaya seni & keagamaan, komersial niaga, campuran kepadatan tinggi... Tolong buat program ruang yang lebih kreatif." "Your task is to create strategies and spatial programs for the area based on the vision and mission mentioned with spatial functions: arts & religious culture, commercial trade, high-density mixed-use... Please create a more creative spatial program."	Produced detailed and creative spatial strategies like the "Nusantara Art Residency" and "Smart Biodome".

The evidence from student reports indicates that "Fail" or sub-optimal cases were characterized by a lack of persona, missing spatial constraints, and the absence of reference examples. In contrast, "Success" cases demonstrated that providing clear

Context and Goals through CARE and TAG frameworks enabled the AI to function as a specialized design assistant, producing contextually relevant urban design strategies for the new capital city.